1982
FEDERAL
ACQUISITION RESEARCH
SYMPOSIUM

"INTEGRATING THEORY AND EXPERIENCE: THE ACQUISITION RESEARCH CONNECTION"

Co-Sponsored by:
DEPARTMENT OF DEFENSE
OFFICE OF FEDERAL PROCUREMENT POLICY

Host:
DEPARTMENT OF THE ARMY

Held at:
THE GEORGE WASHINGTON UNIVERSITY
WASHINGTON, D.C.
5—7 MAY, 1982

PREFACE

I feel that the 1982 Federal Acquisition Research Symposium effectively focused the attention of the Federal acquisition community on the need for thorough procurement research efforts.

Procurement research is both a means by which new theories are conceived and a risk reducing venture. You are all aware of the many efforts currently underway to improve the procurement process, not the least of which are those directed by Executive Order 12352 which mandates Federal Procurement Reform. It is particularly important that changes be thoroughly researched prior to implementation. Unnecessary problems must be avoided to the maximum extent possible if we are to achieve the ultimate goal of insuring that public funds are used most wisely, prudently, and efficiently. Procurement research programs are a key factor in achieving this goal. I fully endorse continuation of a strong procurement research program and look forward to its development of innovative solutions to both present and future procurement problems.

William A. Long

WILLIAM A. LONG
Deputy Under Secretary of Defense
for Research and Engineering
(Acquisition Management)

I have for many years been a strong proponent of procurement research as a means to improve the system and make it more effective. Therefore, I am especially pleased to endorse the results of the 1982 Federal Acquisition Research Symposium. I strongly encourage continued procurement research to help analyze and resolve our common procurement problems and assist in implementing the procurement reforms called for in the Uniform Federal Procurement System proposal and Executive Order 12352 on Federal Procurement Reforms. The Office of Federal Procurement Policy, through the Federal Acquisition Institute, will continue to promote and coordinate research in procurement concepts, techniques, systems, policies, regulations, standards, procedures, forms and the so called "unknown unknowns."

Correspondence relating to procurement and acquisition research should be addressed to Mr. William Hunter, Director, Federal Acquisition Institute. 726 Jackson Place, N.W., Washington, D.C. 20503. The FAI will monitor follow-up actions and render all assistance possible to assure maximum effective results from the coordinated actions of all concerned.

Donald E. Sowle

DONALD E. SOWLE
Administrator for Federal
Procurement Policy
Office of Management and Budget

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ACQUISITION RISK AND UNCERTAINTY

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RISK AND UNCERTAINTY: STATE-OF-THE-ART IN APPLICATION

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ABSTRACT

This paper provides a review of the state-of-the-art in application of risk and uncertainty analysis within the acquisition process and provides an evaluation of selected obstacles to its use. Two distinct but closely related aspects of the risk and uncertainty issue are discussed. One aspect is technical analysis. The other is acceptance of the analysis and implementation of the results. Subjective assessments of input data receive major emphasis because they place a primary constraint on acceptance and implementation of risk and uncertainty analysis.

INTRODUCTION

Most individuals involved in program management for acquisition of major weapons systems are curiously aware of the recent emphasis on risk and uncertainty analysis. Only a limited number, however, have been adequately involved in development and application of risk and uncertainty analysis. The intent of this paper is to review the state-of-the-art in application of risk and uncertainty analysis and to discuss some obstacles to its use in the acquisition process.

Two clearly distinct but closely related aspects of the risk and uncertainty issue exist. One is technical analysis. The other is acceptance of the analysis and implementation of the results. Technical aspects are discussed in this paper, but primary emphasis is placed on the discussion of the acceptance and implementation issues.

EMPHASIS ON RISK AND UNCERTAINTY

The Secretary of Defense in the early 1970s recognized the need: 1) to identify areas of high technology risk; 2) to accomplish formal risk and uncertainty analysis; and 3) to expand program management practices to include explicit consideration of risk and uncertainty assessment, risk reduction, and risk avoidance. In response to this recognized need, a USAF Academy Study Team undertook in 1971 an evaluation of risk and uncertainty analysis.

The Academy study team determined that, in its state of evolution at that time, risk analysis was not yet a science and consequently did not readily lend itself to application. (1) Furthermore, in the systems acquisition process risk analysis was so nebulous and ill-defined that identifying basic concepts, developing meaningful guidelines, and describing effective methodologies were difficulties of the first magnitude. The study team concluded that formal attention to the matters of risk and uncertainty was a vital, missing element in the conduct of an effective and efficient systems acquisition process. In the area of quantitative assessment, the study team determined that mechanical aggregation techniques (such as network and decision analysis) were far more advanced than techniques for obtaining the data to be used in these techniques. For instance, techniques for obtaining subjective probability of certain events occurring at a given time are only now being developed.

In April 1976, Office of Management and Budget (OMB) Circular No. A-109 on major systems acquisitions clearly placed emphasis on ensuring that appropriate trade-offs among investment costs, ownership costs, schedules, and performance characteristics were made. It also emphasized the need for acquisition strategy to include methods for analyzing and evaluating contractor and government risks. (2)

DOD further emphasized the intent of OMB Circular No. A-109 with DOD Directive Number 5000.1, dated January 18, 1977. This directive requires program managers to "ensure that contract types are consistent with program characteristics including the risks to be shared by the contractor and the government, and that the investment of resources to accomplish successive program objectives is based on demonstrated achievement and acceptable risk." (3, pg. 6) The directive states that schedules and funding plans shall be prepared to accommodate areas of program uncertainty and risk, and that productivity considerations shall be included in the evaluation of alternative design concepts to determine production risks and the actions necessary to eliminate risks. In response to these directives, it is necessary that all person involved in the acquisition process understand pertinent concepts and be able to use available methodologies to solve risk and uncertainty problems.

RISK, UNCERTAINTY AND PROBABILITIES

As a generalized definition, risk is characterized by a distribution of events occurring according to reasonably well-known probabilities, even though their sequence and time of occurrence cannot be determined. Predictable risks are based on past experience and predictable or foreseeable trends. Uncertainty on the other hand is characterized by the absence of any known probability distribution of events. It is a situation where the probabilities of the possible outcomes are completely unknown--a reasonably well-known probability does not exist. Some authors look at uncertainty as being concerned with risky choice--the problem that prevails when a decision maker must choose between alternatives, some or all of which have consequences that are not certain. In a strict theoretical sense, the concept of risk is differentiated from that of uncertainty. But for purposes of the present discussion we will treat the two concepts as synonymous.

An understanding of probability theory is basic to the application of risk and uncertainty analysis for estimation of the chances of meeting a goal or having a successful program. Probability theory has been used to estimate randomness of events occurring in such activities as cost, performance, and schedule. Probability theory permits development of a distribution of the likelihood of different events occurring. For example, a distribution of cost for any activity will give a minimum and a maximum cost. Also, cost can be bounded or given a range over which the true cost will most likely occur.

CURRENT STATUS

A review of relevant literature which has been published since the 1971 USAF Academy report indicates that a great deal of effort has been devoted to development and understanding of the technical aspects of risk and uncertainty analysis. From an academic perspective, these technical aspects have become a reasonably well-defined process as is demonstrated by the recently published body of knowledge. (4 and 5) Numerous examples exist of the application of risk and uncertainty analysis to problems of specific nature and generally within a narrow area of interest. The following discussion is not all inclusive but is indicative of current applications.

The first category of models is the stochastic/probabilistic group which includes PERT, VERT and a Risk Analysis Model. (5, pg. 53) The Program Evaluation and Review Technique (PERT) model examines uncertainties involved in answering questions (such as, how time delays in certain elements influence completion) and provides a basis for evaluation of alternatives. The technique has been primarily used on large, complex systems where the high cost of operating the analysis is of minor concern.

The Venture Evaluation and Review Technique (VERT) has been used to determine best balance between cost, schedule and performance. Probability or decision rules are based on specific relationships. This technique employs a Monte Carlo simulation to develop a trial solution to the problem. The program generates frequency distributions, scatter diagrams, and probabilities of exceeding given values. The Risk Analysis Models provide statistical and probability distributions for schedule, cost and performance variables and represents the risk factor as a utility or preference functions. As an example of this category, Worm provides an excellent discussion of a specific pricing model developed for performing a risk analysis on Air Force Systems Command contracts. (6)

The second category is general models. Within this category, parametric cost estimating has been the primary costing methodology for DOD. Cost estimates are based on historical data of previous or similar systems and the analysis utilizes statistical relationships between cost and performance parameters developed from these previous or similar systems. Although this method has many advantages, collection of data is time consuming as well as subjective. Also, keeping the cost data-base relevant is a major problem.

Dynamic modeling is a third category and is based on a complex system of mathematical models and works well for complex, continuous systems. All decision variables are included in a continuous information-feedback system and all variables must be quantified. It is a complex, costly technique that needs considerable data and knowledgeable people to employ it.

The fourth category is the causal integrative model (CIM) which is used to determine how a change in economic uncertainty affects the level of environmental uncertainty which, in turn, affects mission, scope, and funding. Economic and environmental conditions affect changes in three identified activities within which risk and uncertainty occurs--organizational slack, technological uncertainty, and customer urgency.

These above modeling methodologies are fairly well-developed and provide a good framework for future work. Each of these methodologies have been applied in a limited sense with respect to technical risk, cost risk, and schedule risk.

A primary conclusion of a group of speakers at a recent workshop on management of risk and uncertainty was that, even though technical aspects have been well-developed, a primary need still exists to develop an awareness and a better understanding of risk and uncertainty in order to enhance its application in the acquisition process. (5) Practical application has been hindered by a general lack of an adequate framework to allow effective consideration of all factors which are important to this decision process.

In a logical analysis of decisions under risk and uncertainty, emphasis must be placed not only on a correct formulation of the problem and correct use of statistical analysis, but also on the development of methods by which the persons who are responsible for a program can most effectively provide input for the analysis. Certain inputs can only be supplied on a subjective basis by a select group of individuals.

In analyzing the decision process, Strauch demonstrates that technical methodology and judgment must aid and support each other rather than compete as so often has happened in the past. (7) Consequently, we need to develop better tools for the use of intuition and subjective judgment. This intuition and subjective judgment most often must come from professional assessment and expert opinions of those working close to the activity. In acquisition, this group generally includes engineers, budgeting, pricing and cost estimators, buyers or contract personnel, and various levels of program management.

In the final analysis, many decisions depend on management's own preferences for the possible consequences of the various courses of action. We must, therefore, learn how to incorporate management's judgments concerning the chances of those consequences into the analysis. Consequently, the major constraint to application of risk and uncertainty analysis is how to deal with expert opinion and subjective judgment.

THE APPROACH

Three general types of subjective factors are important for analysis of decisions under uncertainty. (8) The first is the structure of the decision itself. The second deals with subjective probability assessment. The third deals with evaluation of outcomes.

Structure of the Decision

Much of risk and uncertainty analysis has been discussed in the literature as an integral part of the very broad topic called decision analysis. Decision analysis has emerged as a highly valuable technique for allowing decision makers to formulate important problems in a logical framework which incorporates factual as well as judgmental information to arrive at a consistent, realistic solution. (9)
Successful decision analysis which includes prior probabilities, consequences, choice criteria and strategy factors is not a single event but a complex, prolonged sequence of behavior. Several approaches, some more detailed than others, have been proposed for structuring of the decision situation. Aspects of these approaches are presented here as a logical approach which emphasizes the subjective factors:

(a) Statement of the problem to be solved. The objective or multi-objective must be delineated and specified. Critical decisions must be identified. A broad set of ground rules for gathering information which includes consideration of decision-makers' preferences must be established.

(b) Evaluation of measures to be used. A level of priority for each goal and each objective must be established. Relationship between project risk and individual professional risk must be clearly specified. Measures of effectiveness in achieving objectives must be established. Quantitative tools must be reviewed and needed estimates by specialists identified.

(c) Correct formulation of interactions. Analysis and judgments must be based on economic and political as well as technical aspects. Analysis must include interactions among all sources of uncertainty--logistics, pricing, budgeting, scheduling, etc.

(d) Select viable and achievable alternatives. Appropriate sub-elements of each alternative must be identified and defined. A range of eventualities and future possibilities must be determined. Experienced judgment must be used to determine what is likely or highly unlikely to occur.

(e) Obtain and understand objective and subjective inputs. The influence of decision makers' preferences or choice among alternatives must be determined. Key variables must be isolated and defined. The analysis should utilize multi-attribute utility assessment.

(f) Apply risk and uncertainly analysis. Use of expectations and likelihood concepts must be understood. Appropriate utility and preference models must be selected. The degree of risk must be judged and evaluated. Uncertainty must be translated into trade-off options. Evaluation of alternatives should be displayed.

Many individuals and groups are involved in the analysis and decision process. Certainly the decision analyst is a key figure. While the actual decision makers are not decision analysts, they nevertheless need to learn basic decision analytic concepts and feel comfortable providing the inputs required for analysis. They need to learn more about interpreting the output of the analysis before they will use it on a routine basis.

Subjective Probability Assessment

Statistical probabilities are limits of relative frequencies of events and occurrences. They are used routinely in decision analysis. But, in many cases, available probabilities are not relevant to a current acquisition decision process because the data base is outdated or the current system does not have a close counterpart upon which to base estimates. Subjective probability then becomes the valid concept where probabilities must be formulated from the opinion and experience of experts and specialists.

In almost all cases in the weapons systems acquisition process, the opinions of experts and specialists have been critical to the measurement of risk and uncertainty. These opinions have been used to develop the subjective probability that an event will occur and have allowed analysts to attach a specific probability to those events. Even in the narrowest concept of the acquisition process where risk factors in schedule, cost, and performance activities are treated, estimation has been largely a matter of polling professional judgment.

In order to use grouo opinion, analysts find themselves faced with the problem of aggregating probability assessments of group opinion. Recent research has clearly demonstrated that groups have repeatedly outperformed individuals at these estimation and assessment tasks. Consequently, methodology must be refined for using group opinions as entering estimates in risk and uncertainty analysis. A concerted effort is needed to win the acceptance of professional judgment as a valued assessment of risk and uncertainty analysis. (4, pg. 7)

The most comprehensive effort to evaluate behavior aspects of risk and uncertainty decision analysis within the DOD acquisition process was published by Sweeney and Rippey in 1980. (10) They concluded that subjective judgments are used in almost all cases throughout the acouisition organization. However, documentation on evaluation of the application of group decisions and use of consensus building techniques to develop subjective judgments is almost nonexistent in the acquisition organization. Very little information exists anywhere that directly addresses group behavior in certain decision environments such as the acquisition process.

Information is available, however, on several behavioral interaction techniques. But the major concern in using these techniques to arrive at a decision is to eliminate undue influence of persuasion, previous expressed opinion, majority opinion, and higher level arm twisting.

Much of the work on group decisions and consensus building techniques has been academic exercises designed to demonstrate that group decisions are better than individual decisions when subjective judgments are used. Most of the demonstrations have used the application of statistical averaging techniques to show the benefit of statistical averaging. Another technique, scoring rules, has been used to motivate honest assessments and to evaluate quality of assessments in such activities as point spreads for ball games, weather forecasting, stock market projections, and purchase of new automobiles.

The most well known consensus building technique is the delphi method. It is a method of elicitation of opinions with the object of obtaining a group response. The delphi method has been applied since the early 1960s to a large number of acquisition related problems such as industrial target systems, number of A-bombs required, forecast of business conditions, and forecast of economic indices. The technique relies on successive iterations in which judges make anonymous assessments and are then given anonymous statistical feedback about the assessments of other judges to arrive at a final assessment. Some variations of the delphi method allow for group interaction rather than statistical feedback. The technique has been expanded from its original objective of providing judgments on technological forecasting to include judgments about values, goals and alternatives. The delphi technique has not been scientifically tested. (11)

The other major consensus building technique is classed under the heading of social judgment analysis. In this analysis the integration of information to form a judgment includes: (a) placing a particular degree of importance (weight) on each piece of information; (b) developing a specific functional relation between each piece of information and final judgment; and (c) using a selected technique for integrating all dimensions of the problem. But the combining of individual judgments into a grouo consensus is a formidable task. Individuals often disagree in judgment because of the importance that each assigns to the available information and because of the manner in which each relates the data to his final judgment.

While social judgment analysis may be an effective means of reducing disagreement in group decision making, the problem of structuring the group process in order to improve actual group performance remains an open issue. (11) Many group methods are subject to the serious drawback that the consensus may be more a reflection of the relative strengths of the personalities of the group members. With this method one very forceful individual may be able to impose his point of view on the group. Some group methods involve a tradeoff between calibration and extremeness of responses. Interaction among group members reduces differences, reduces calibration of judgments but increases the extremeness of judgments. (12)

Martin, et al., describes a successful use of subjective assessment. For several years the Boeing Vertol Company has used a subjective assessment of probability distributions for application to program elements considered to have moderate risk. (5, pg. 228) Estimates and associated probabilities are used to construct a "probability curve". Interpretation of the probability curves is, of course, subjective evaluation based on personal experience. Probability curves are used to help determine the final cost estimate for a contract.

Fischer found general agreement that subjective probability distributions can be substantially improved by aggregating the opinions of a group of experts rather than relying on a single expert. (8) From a practical standpoint, he contends that there is no evidence to suggest that the method used to aggregate these opinions will have a substantial effect on the quality of the resulting subjective probability distribution.

Sweeney and Rippy found that much disagreement exists concerning optimization of group performance in weapon systems acquisition. (5, pg. 76) Researchers such as Sweeney and Rippy, and users of these techniques such as pricing personnel, cost estimators, contracting-buying personnel and program managers all agree that in order to improve group consensus the training of experts, specialists, decision-makers, and managers at all levels in probabilistic thinking and consensus building could lead to significant improvement in the use of the techniques and the application of risk and uncertainty analysis. (13)

The study of individual and group judgment has become the focal point for analysis of subjective values and tradeoffs in finding solutions to many complex acquisition problems. Kaplan has identified the components of any "judgment" as the person forming the judgment, information about the judgment, information about the judged object, and situational requirements associated with the judgment. (14) The process of aggregation of individual judgments into group decisions remains a problem. In this aggregation process one must be concerned with verifying the assumptions made, which value functions or utility functions to use, and who assesses and weighs relevant factors.

A primary assumption in aggregation of individual judgments is that people make probability judgments in much the same way they make estimates of other quantities (such as distance) by using certain perceptual clues. For instance, Anderson believes any rational person will strive to achieve consistency in his whole network of degree of belief. (15) Furthermore, assumptions about expertise in a given subject area may not be the important factor in performance of a probabilistic task. Maybe the ability to deal with probabilistic thought is what produces good probabilistic assessments. (12)

Many mathematical and behavioral techniques have been used to combine individual judgments into a single group estimate when several individuals have been able to influence a decision. But scientific testing of the value of these techniques has been inconclusive. The future success of group decision technology must lie in its ability to focus attention to individual value-relevant factors. Thus, group value functions in risk and uncertainty thinking must be based on individual beliefs and preferences. A most formidable task is to find procedures which permit the combining of utility functions of the group members before proceeding to an analysis of a decision using group beliefs and preferences. (15) In the selection of techniques one must be aware that more complicated assessment procedures may not provide better overall success. (16)

At the present level of development, the final decision maker often must combine the expert's distributions into a group type consensus. Most often this is done separately from the group efforts. The lack of more active involvement of the decision maker has been defended by arguments of his inaccessibility or unidentifiability, his unwillingness or inability to reveal his preferences, and his lack of clarity about his own preferences and the subsequent problems this implies for assessment procedures. But in those instances where the decision maker is relatively ignorant of issues under consideration, he may not be well equipped to evaluate the opinions expressed by the experts.

A missing link in subjective assessment and probabilistic analysis is the unavailability of utility theory to reflect uncertainties, values, and preferences relevant to risk and uncertainty decision. (17) Since determination of an objective function is necessarily closely tied to measure of consequences, one must be concerned with criterion of maximizing expected utility which in fact reflects preferences. But utility is something unique to the individual that cannot be measured on an absolute scale. Individual differences are expressed through differences in information evaluation, differences in use of additional characteristics, differences in integrating information, and differences in pre-existing response dispositions. (14) Only if the group becomes well integrated with a strong common interest can it be expected to form a group utility function.

Evaluation of Outcomes

It is generally agreed that risk and uncertainty analysts must deal with preferences and judgments of experts and specialists as well as persons responsible for decisions. In turn, decision makers must obtain a basic understanding of risk and uncertainty and the meaning of a solution because as they choose between probability distributions of consequences they are trying to balance a number of possible consequences simultaneously. (5, pg. 258) This implies the use of the concept of expected utility (which is simply a concept of expressed preferences). The utility function is simply a device for assigning numerical utility values to consequences in such a way that a decision maker should act to maximize subjective expected utility. For instance, in economic terms, only when we can assume something about preferences can we identify decisions that are efficient.

We must recognize that decisions will always depend on the decision makers' own preferences for the possible consequences of the various courses of action and, therefore, must depend on his own judgments concerning the chances of those consequences. But, the important point is that he must be educated in the handling of those preferences and judgments.

SUMMARY

In the acquisition process, the program managers' most difficult task will be to cope with the scarce and incomplete information which is available about those factors which have uncertain aspects. Even though a great deal of concern exists relative to the accuracy and adequacy of estimates, improved use of techniques for getting subjective input into the analysis will help gain acceptance of risk and uncertainty analysis. A primary benefit of risk and uncertainty analysis in its current state of evolution is that it shows the relative impact of uncertainties associated with selected factors. It also reveals where we ought to spend more time refining the data.

Bibliography

1. USAF Academy. Final Report of the USAF Academy Risk Analysis Study Team (August 1, 1971).

2. Office of Management and Budget. Circular Number A-109 (April 5, 1976).

3. Department of Defense. DOD Directive Number 5000.1 (January 18, 1977).

4. G. E. Fisher and E. P. Gay. An Approach to Risk Analysis: A Process View, Air Force Studies and Analysis (June 1981).

5. M. D. Martin, et al. Management of Risk and Uncertainty in the Acquisition of Major Programs, Proceedings of a Conference, February 9-11, 1981, at Colorado Springs, Colorado, University of Southern California (1981).

6. George H. Worm. "Application of Risk Analysis in the Acquisition of Major Weapon Systems", Air Force Office of Scientific Research (August 1, 1980).

7. Ralph Strauch. "Risk Assessment as a Subjective Process", The Rand Paper Series, Rand Corporation, California (March 1980).

8. Gregory Fischer, "An Experimental Study of Four Procedures for Aggregating Subjective Probability Assessments", NTIS, AD A020 455 (December 1975).

9. Leonard Adelman, et al. Issues in the Design and Evaluation of Decision-Analytic Aids, DTIC Technical Report TR81-1-304 (February 1981).

10. D. Rippy and P. Sweeney. Behavioral Aspects of Decisions Under Uncertainty During Weapon System Acquisition, DTIC, AD A098 934 (January 1980).

11. John Rohrbaugh. "Improving the Quality of Group Judgment: Social Judgment Analysis and the Delphi Technique", Organizational Behavior and Human Performance, Volume 24, pp. 73-92, 1979.

12. Ward Edwards, et al. Research on the Technology of Inference and Decision, DTIC AD A056921, 1978.

13. Based on personal interviews at Aeronautical Systems Division, WPAFB, during 3-5 November 1981.

14. M. F. Kaplan and S. Schwartz, ed., Human Judgment and Decision Processes in Applied Settings, Academic Press, 1977.

15. J. R. Anderson, et al. Agricultural Decision Analysis, Iowa State Press, 1980.

16. L. C. Eils and R. John, "A Criterion Validation of Multiattribute Utility Analysis and a Group Community Strategy", Organizational Behavior and Human Performance, 1980.

17. John Hwang, Analysis of Risk for the Material Acquisition Process, Part II: Utility Theory, DTIC, AD 747-365, 1971.

NEW APPROACHES FOR QUANTIFYING RISK AND DETERMINING SHARING ARRANGEMENTS

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ABSTRACT

The probability density function which is used to define the variability in the cost of an acquisition also defines the risk involved in the contractual action. This paper describes how continuous, variable sharing arrangements can be developed through the use of mathematical transforms of the probability density function representing cost. Two procedures are presented. The first procedure is practical when the negotiations use a total cost or price basis for settlements. The second method should be used when learning curves are used as the settlement basis.

INTRODUCTION

The purpose of this paper is to introduce a new theoretical approach for quantifying contractual risk and determining cost/savings sharing arrangements which is currently under consideration for use in the Deputy for Propulsion's Technology Modernization Program. It begins by focusing on the problem of defining risk and uncertainty in an acquisition environment. Probability density functions, cumulative probability functions, and cumulant functions are introduced as methods of quantifying risk and uncertainty within the acquisition environment. From this discussion on risk and uncertainty, the paper provides two practical methods of measuring risk and uncertainty. One method is based upon PREDICT 2000, the other is based upon Underlying Learning Curves. These methods provide a means of quantifying risk and uncertainty. With these tools in hand, it is then possible to address some innovative methods of incentivization giving consideration to both the management responsibilities of the seller and the risk and uncertainties surrounding the business deal. Use of these techniques should enhance the negotiation process and help attain its goal of a fair and reasonable price.

ACQUISITION RISK AND UNCERTAINTY

While the cost of a specific product or service is usually treated as a constant, most people recognize intuitively that the cost is variable and is dependent upon many different factors. The variability of cost can be described using either a probability density function as shown in Figure 1 or a cumulative probability function as shown in Figure 2. The cumulative probability function is the integral of the probability density function. While the probability density function relates directly to human perceptions of cost, the cumulative probability function serves as a basis for analytical applications.

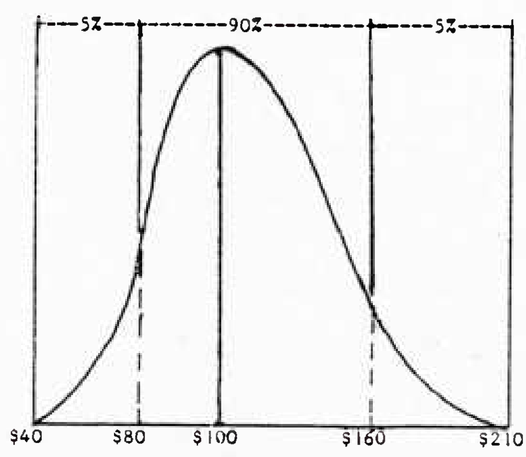

FIGURE 1. PROBABILITY DENSITY FUNCTION SHOWING COST IN THOUSANDS OF DOLLARS

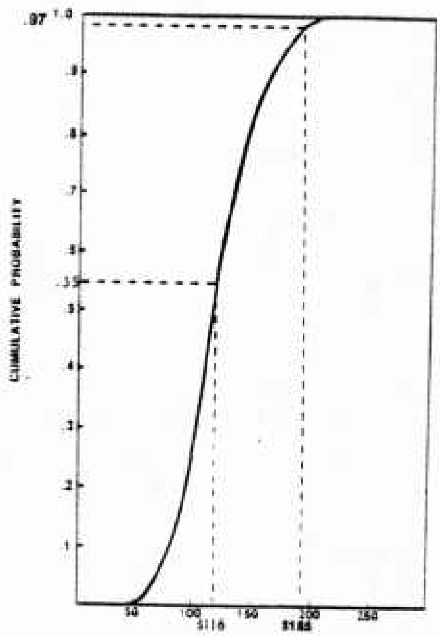

FIGURE 2. CUMULATIVE PROBABILITY FUNCTION SHOWING COST IN THOUSANDS OF DOLLARS

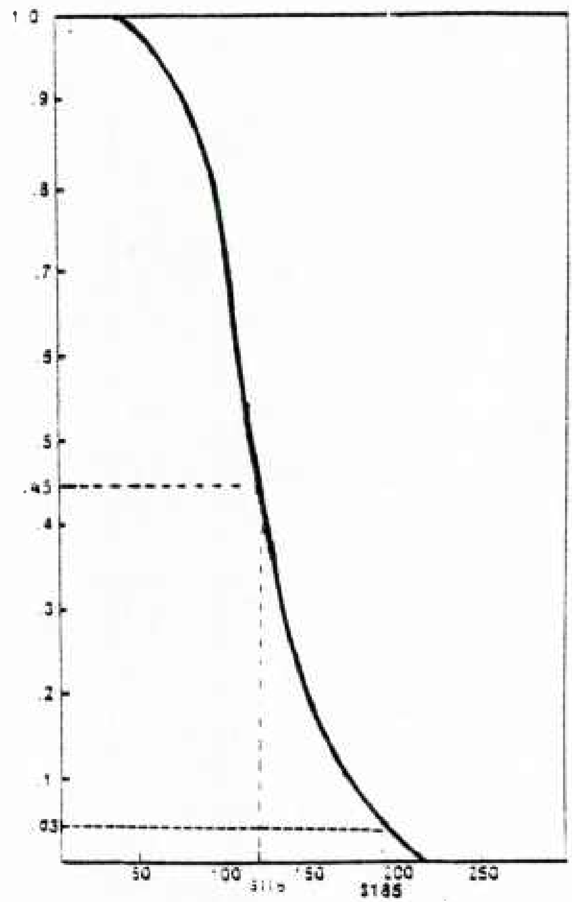

FIGURE 3. CUMULANT PROBABILITY FUNCTION SHOWING COST IN THOUSANDS OF DOLLARS

The typical acquisition environment has two parties - a buyer and a seller. Within that environment, the variability of the cost relates to the seller's risk associated with producing the product or service at a specific price. This risk can best be described using a cumulant function which is shown in Figure 3. The cumulant function is derived by subtracting the cumulative probability function from one. As shown in the cumulant function, the seller's risk is highest at the lowest possible cost and lowest at the highest possible cost. The seller's determination of what is fair and reasonable relates to this risk and a determination of what the market will bear. If the market will bear a cost which is near but below the highest cost, the seller will normally settle the negotiation at a point which will at least create a break-even situation at the highest cost. The buyer's perception of a fair and reasonable cost is usually based upon the lowest possible cost with some consideration for the seller's risk and the uncertainty surrounding the production of the product or service. Since it is usually the buyer's purpose to acquire the product or service at as low a price as is feasible, and the seller usually desires to settle at as high a price as is feasible, the negotiation process can become quite lengthy. While a negotiated settlement provides a practical definition of a fair and reasonable price, a study of statistics suggests that the mean or average value of the cost probability density function provides the best value upon which to base the contract price. Using the example shown in Figures 1, 2, and 3, the average cost is $116,860. However, if a 13.5% profit under a firm-fixed price non-competitive contractual environment is assummed, the seller would probably not settle under $185,022. This value is obtained by dividing $210,000 (the highest value) by 1.135 (the factor for cost + profit). The $185.022 has a cumulative probability of 97% and a cumulant value of 3%, while the mean value has a cumulative probability of 55% and a cumulant value of 45%. The difference of $68,162 between the mean value and the probable FFP settlement represents a 58% opportunity loss.

It is the thesis of this paper that the negotiation process can be enhanced and the dialogue improved by quantifying the cost realistically as a variable using statistical techniques. However, traditional statistical tools possess two problems which must be overcome for a statistical tool to be practical for use in negotiations:

(1) a substantial amount of relevant history is required to quantify the variable,

(2) simplifying assumptions must be made concerning the basic mathematical shape of the function.

This paper presents two approaches which solve those problems allowing the development of sharing arrangements based upon the probability density function. The first technique which is presented uses PREDICT 2000, a software package developed by the author that generates probability density functions from sparse data. The second method is based upon using the error function of the Underlying Learning Curve. The Underlying Learning Curve concept provides the methodology to make past data relevant to new programs. Both techniques quantify the risk and provide a basis for sharing arrangements based upon the risk.

MAKING RISK ASSESSMENT PRACTICAL IN NEGOTIATIONS - PREDICT 2000 AND UNDERLYING LEARNING CURVES

PREDICT 2000 solves a major operations research problem which concerns how one generates an appropriately shaped probability density function when only sparce data is available. PREDICT 2000 can generate cumulative probability distributions based upon the thirty-seven different generic shapes shown in Figure 4 from experiential data. Although each of the twenty-five group II shapes is shown unskewed (that is, 50% of the function is on each side of the mode), each shape can assume any level of skewness.

The PREDICT 2000 computer software interacts with user through a mini-computer. It uses one measure of central tendancy (the mode) and two measures of dispension (a 100% percentile range and another range specified by the user) to provide its output. The mode was chosen as the PREDICT 2000 measure of central tendancy both because people can estimate the mode more accurately than the mean and because the mode has analytical importance in determining the probability density function's shape. The ranges are also easy for people to estimate and provide a basis for determining the shape of the probability density function. In summary, PREDICT 2000 requires eight pieces of data to provide an output:

(1) The variable's name which is used to identify the output.

(2) The variable's dimension which is used to label the output. For this application, the dimension is dollars.

(3) The user defined percentile range. This percentile range is symbolized by R and lies between points R_1 and R_2. These points will be identified by the user. The value of R is used to define the area below R_1 and above R_2. N has a value of ((1-R)/2) X 100%.

(4) The lowest possible value (cost).

(5) The value (cost) associated with R_1. This is the value above which N% of the function is found.

(6) The most likely value (cost), this is the mode of the probability density function.

(7) The value (cost) associated with R_2. This is the value below which N% of the function is found.

(8) The highest possible value (cost).

These eight data points, which are defined through the negotiation process, generate the cumulative probability function for the cost of the product. PREDICT 2000 also calculates the mean or average cost. It is the mean cost which is identified as the negotiated target cost.

The underlying learning curve technique provides a method of defining the cost of an acquisition based upon the cost of previous similar programs. The technique eliminates the impact of any costs due to "work expanding to fill the time alloted" (Parkinson's Law). This is accomplished using the following procedure:

The first step of underlying learning curve analysis is to review the contractor's work measurement system. This is done at the contractor's plant. It is important that each industrial engineer setting time standards via time study be required to demonstrate rating proficiency within a known accuracy at least annually.

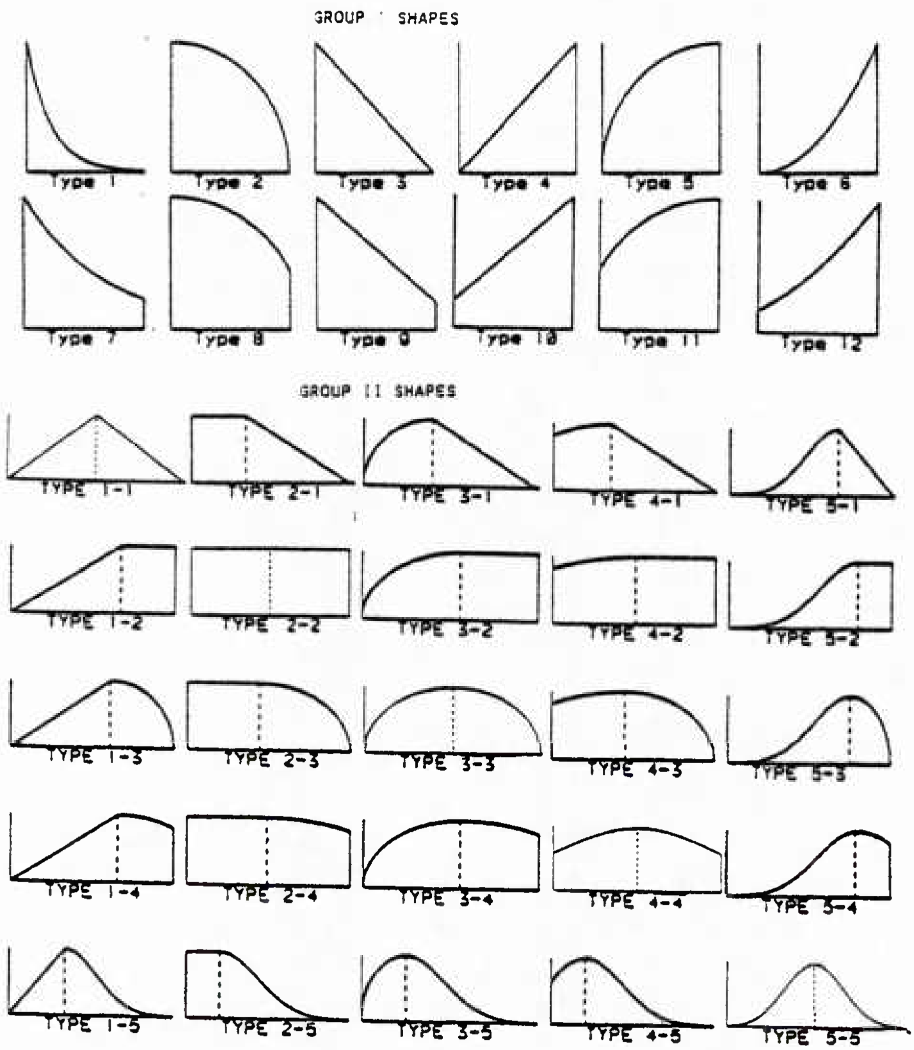

FIGURE 4. PREDICT 2000 SHAPES

The second step in the analysis is to gather the data required for the underlying learning curve analysis. This requires an understanding of the contractor's cost accounting system as well as an understanding of the work measurement system.

The third step is to perform the underlying learning curve analysis. This consists of four different learning curve calculations:

(a) The earned hours learning curve.

(b) The worker learning curve.

(c) The underlying learning curve.

(d) The standard learning curve (actual hours).

The learning curve technique is used for earned hours because the industrial engineers use a classic Pareto analysis in implementing methods improvements. The learning curve technique is used for worker learning because a tremendous number of studies suggest that the power form of the learning curve describes worker learning. The analysis of the worker learning is based upon a regression analysis of the reciprocal of the ratings in the time studies. This provides a reliable method of measuring the actual worker learning during a production program, providing the industrial engineers maintain their capabilities to accurately rate the worker's efficiency through proficiency examinations. However, the worker efficiency measured by the cost accounting system is an unreliable measure of worker efficiency since it may contain nonproductive time due to Parkinsons Law (Parkinson's time). Parkinson's time can be eliminated by changing the target hours. The legitimate non-productive time that is charged to nonproductive cost account codes can not be eliminated so easily; it can only be reduced through aggressive management. Parkinson's time exists because management believes that the workers perform at a lower level of efficiency than the level experienced as an average efficiency in the time studies. These expectations concerning worker efficiency exist becauae any analysis using standard learning curves also contained Parkinson's time. Underlying learning curves provide management with a tool which can be used to establish realistic targets for (1) methods improvement, (2) worker efficiency, and (3) total manhours.

This tool is made more valuable because of the statistical nature of the regression analysis. The error functions for the (1) earned hours (2) worker efficiency and (3) total hours can be used to establish tolerance bands for management by exception using traditional statistical quality control methods.

The use of nonlinear regression analysis provides an added benefit when the regression analysis is to establish target hours. For the purpose of this discussion, the error function will be assummed to be normally distributed. The actual distribution does not effect the overall results of this discussion, however it is easier to provide a graphic illustration of the process if the normality assumption is made. Usually the error function is attributed with the property of showing the relative likelihood of achieving the average cost and costs around the average cost. However, if the average cost which is the cost identified by the learning curve is called the target cost, then the error function can also be thought of as demonstrating the relative difficulty in achieving a value which differs from the target. Thus, the error function can serve as a basis of either an award fee which varies proportionally to that difficulty.

INCENTIVE SHARING AND AWARD FEE ARRANGEMENTS

The object of either an award fee or an incentive sharing arrangement is to provide the contractor with an incentive to manage the program so that the actual hours expended to produce each system are reduced to a level below the target hours. The determination of whether the basis is an award fee or incentive is dependent upon whether the action will be subject to the disputes clause. Either PREDICT 2000 or an underlying learning curve error function will provide a cumulative probability function which is related to the program risk and uncertainty. Given the cumulative probability function (Figure 5), it is only a two step procedure to transform it into either an award for or incentive sharing arrangements. The first step is to divide the values between zero probability (corresponding to the lowest value) and the probability of the mean by the probability of the mean. This provides a new function that is zero at the mean minus three standard deviations and one at the mean. For the values between the mean and one (corresponding to the highest value) subtract the probability of the mean from each value and divide by one minus the probability of the mean to form the new function. This step is shown by Figure 6. Next, subtract the first function derived in the second step from one. Multiply the values from the mean to the highest value by a negative 1. This step is shown by Figure 7. This provides functions with a value of one at the mean plus or minus three standard deviations and zero at the mean; these functions correspond

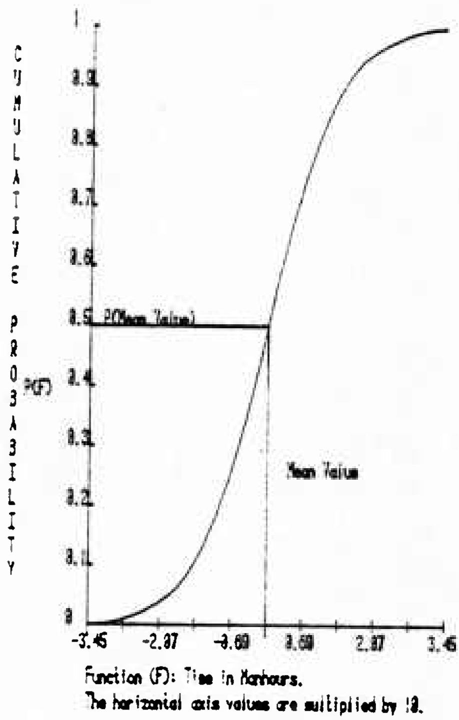

FIGURE 5. CUMULATIVE PROBABILITY FUNCTION FROM UNDERLYING LEARNING CURVE

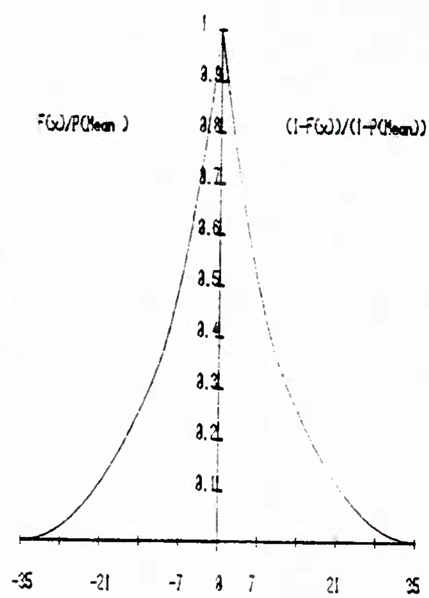

FIGURE 6. INTERIM STEP IN CALCULATING SHARE CURVES

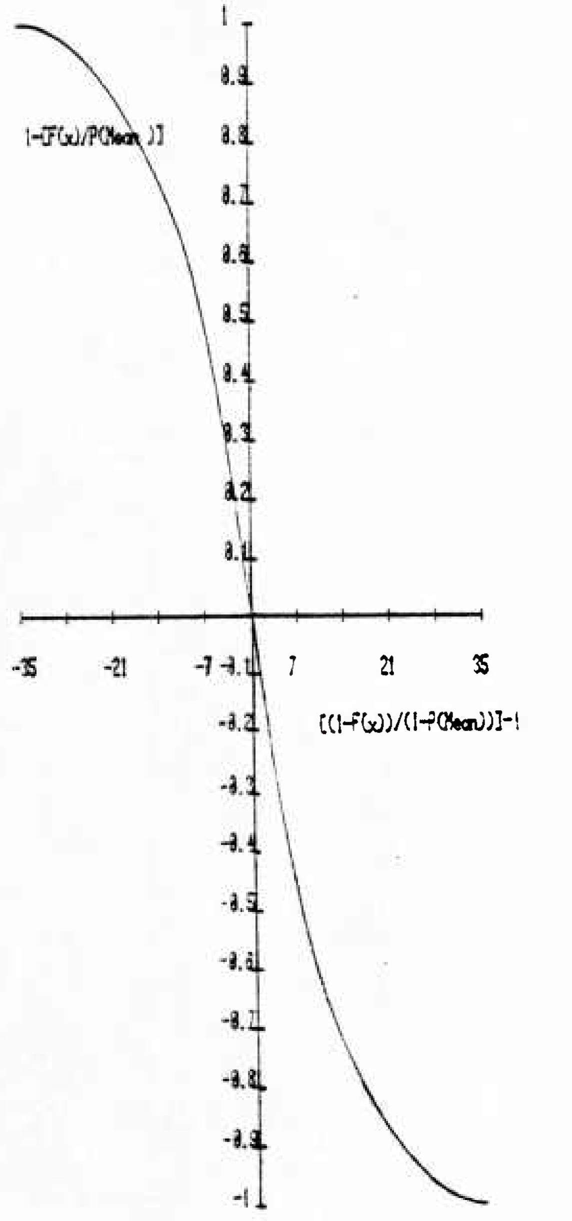

FIGURE 7. SHARE FUNCTION (1st Example)

to the inherent difficulty in achieving a value lower than the mean.

When this technique is used as an award fee with underlying learning curves, the available award fee for the program is divided among the number of units being produced. The award fee for each unit is multiplied by the function value corresponding to the actual cost to obtain the incentive for each unit. The incentive is positive below the mean and negative above the mean. The negative incentive should equal the positive incentive so that the contractor will be rewarded for sustained improved management and the associated reduced program costs. Figure 8 shows how this incentive works. Assume that the contractor delivers the first two units, as shown in Figure 8. The first unit takes 14 hours less than predicted by the underlying learning curve and the second unit takes 7 hours more. Assume a fee per unit of $10,000. The contractor would have a positive $7400 reflected for the first unit and a negative $5000 dollars for the second unit for a net award fee of $2400 at the end of two units. The resulting positive and negative awards for successive units are summed until the end of the contract. At that time final disposition is made of the award fee.

An incentive sharing arrangement is based upon the philosophy that the organization responsible for manufacturing the product should share in the savings or costs in direct proportion to the difficulty in achieving the actual cost. The target cost is the baseline from which the amount to be shared is measured. This method recognizes that both the lowest possible cost and highest possible cost are equally unlikely if management is attempting to achieve an actual cost which is at or below the target cost. This difficulty of achieving any cost is shown by the Probability density function for the cost. Thus, it follows that a transform of the probability density function could be used to proide a fair and reasonable measurement of the difficulty in achieving an actual cost which is different from the target cost. The transform should provide the seller 100% of the savings at the lowest possible cost and require that the seller pay in 100% of the added cost at the highest possible cost. The sellers share should be 0% at the target cost. The buyers share of the savings should be 100% at the target cost and 0% at both the highest and lowest possible costs. If the total cost is equal to the cost plus a profit plua the incentive, and the sharing arrangement shown in Figure 9 is used (based upon the example shown in Figures 1, 2, and 3), the profit versus cost

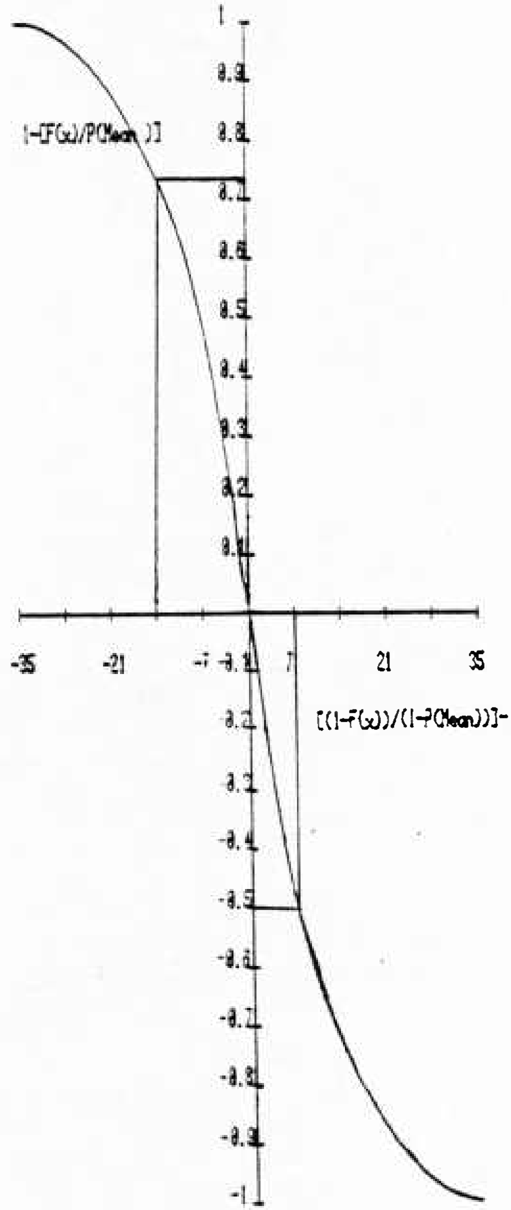

FIGURE 8. EXAMPLE OF USING THE NEW SHARE FUNCTION (1st Example)

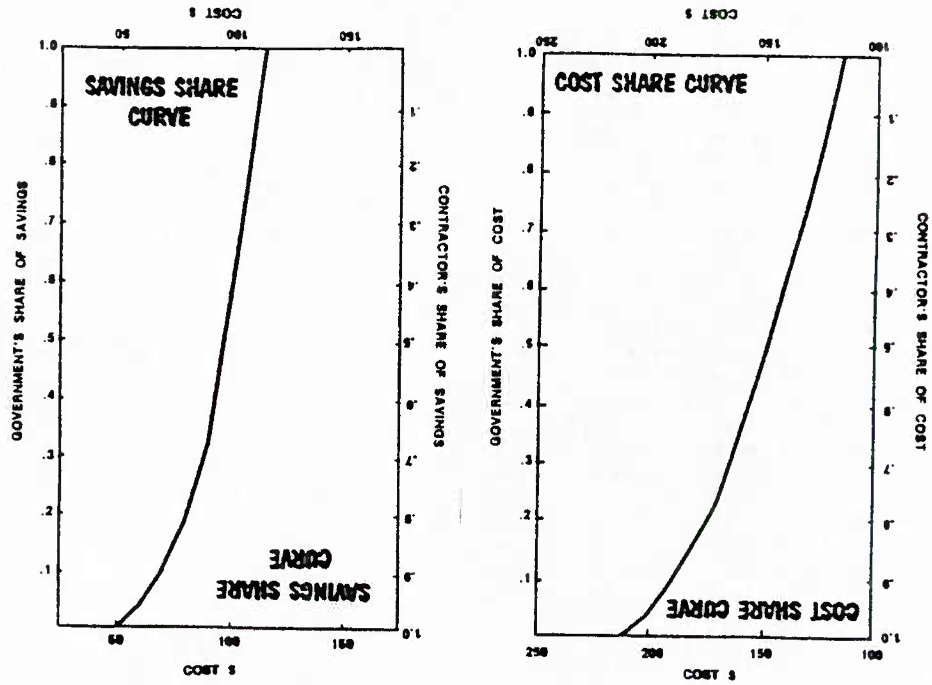

FIGURE 9. SHARE FUNCTION SHOWN USING ALTERNATE FORMAT- 2nd EXAMPLE
(Cost Shown in Thousands of Dollars)

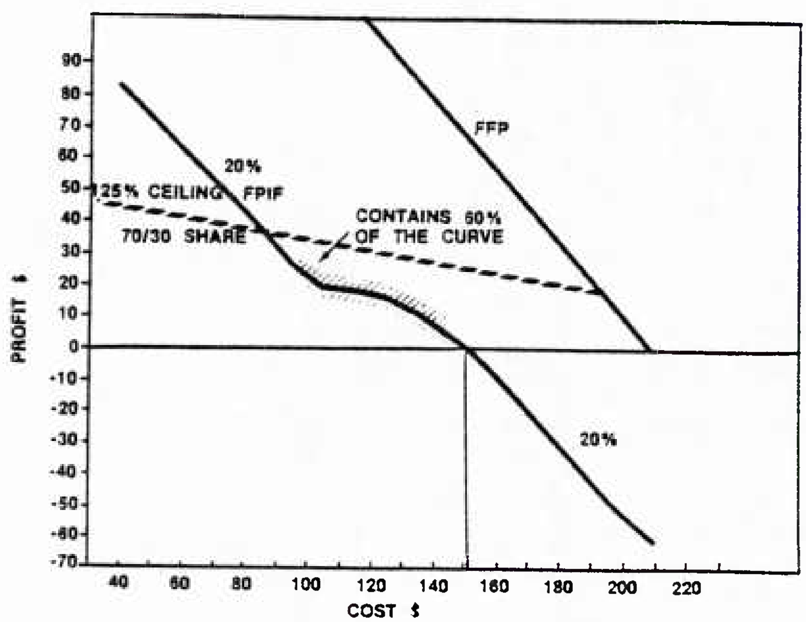

FIGURE 10. PROFIT VERSUS COST CURVES- 2nd EXAMPLE
(Profit & Cost Shown in Thousands of Dollars)

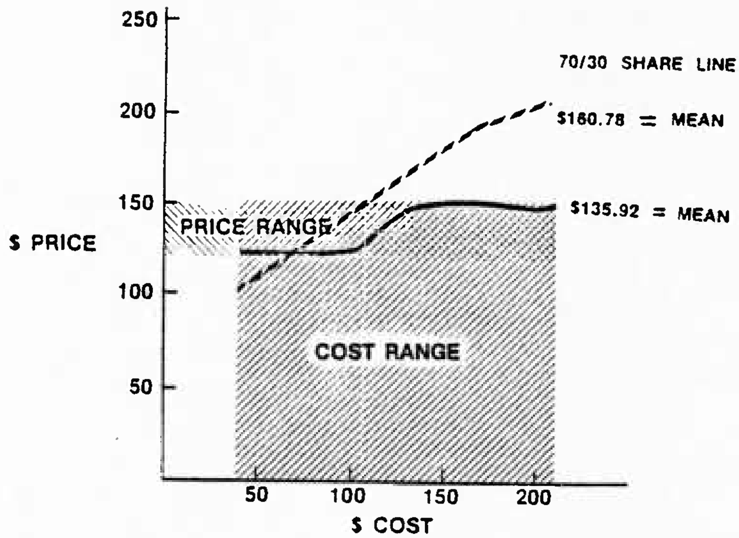

FIGURE 11. PRICE VERSUS COST CURVES- 2nd EXAMPLE
(Price & Cost Shown in Thousands of Dollars)

curve for a 13.5% fee is shown in Figure 10. Note how this compares to the Firm Fixed Price contractual arrangement discussed earlier and to a typical Fixed Price Incentive Firm Contractual Arrangement where the ceiling is 125% of the point of total assumption. It is important to note that while the average cost of this new arrangement is lower. For the buyer, the profit potential for the seller is greater. Note that the new arrangement is bounded by two Firm Fixed Price Lines. A price versus cost curve shows this more clearly (Figure 11). The mean for the FFP contract is $210,000, the mean for the FPIF contract is $160,780, and the mean for the new arrangement is $135,920. This new arrangement gives the seller the incentive to lower costs so that higher profits can be achieved. For the buyer, it provides a method of reducing the average price and reducing the range of the price given a wide range in cost. It also provides an analytical basis for determining a fair and reasonable basis for a firm fixed price contract. When the cost of contract administration for an FPIF or sharing arrangement contract is greater than the range in price, then a firm fixed price contract which is based upon the upper bound of the price range should be used.

SUMMARY

Probability functions and their transforms can be used to quantify risk in the acquisition process. Defining the risk quantitatively also results in the opportunity to define an incentive plan which is related mathematically to the risk. This relationship is defined through transforms and the choice of the values required for the transforms is related to the cumulative probability of the mean.

The use of the probability density function for defining acquisition risk through the use of transformations provides a continuous sharing arrangement. This technique can result in sharing arrangements which vary continuously between two firm-fixed price lines when viewed on a profit versus cost curve. An analysis of a price versus cost curve shows that the technique can help in both budgeting and determining when an acquisition should be handled as a firm-fixed price contract.

CONCURRENCY: THE PROGRAM MANAGER'S DILEMMA

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ABSTRACT

With the growth in acquisition time, cost, and technological complexity of new weapon systems, concurrency has been proposed as a specific method for shortening the acquisition cycle and reducing the problem of cost growth as well. This paper describes the problem of concurrency, attempts to define the term operationally, and reports on some new research in the area.

In evaluating concurrency as a method for reducing acquisition time, the Program Manager (PM) has, in the past, been constrained by not having a formalized approach for evaluating the short- and long-term program impacts of his decisions. Frequently circumstances arise which force concurrent scheduling of activities late in the program, when activity dependence is the greatest.

PURPOSE

Management Consulting & Research, Inc. (MCR) under contract to the Office of Naval Research (ONR), is developing an approach to assist the PM in making trade-off decisions concerning concurrent scheduling of program activities, specifically addressing the associated cost and schedule risks. This paper presents the preliminary findings of this research. The following topics will be addressed.

- a background discussion of the problem,
- the various interpretations of concurrency,
- risk analysis,
- concurrency considerations,
- the needs of the Program Manager in relation to concurrency,
- a brief overview of the descriptive model, and
- a summary of conclusions.

BACKGROUND

The first major weapon system procurement in the U.S. occurred on March 27, 1794 when Congress authorized the building of six large frigates by the U.S. War Department. Some seventeen months later, six keels were laid. Due to schedule slippage and cost overruns, the program was cut back to three frigates.[1] Now, almost two hundred years later, the problem of schedule and cost is being rediscovered as a "new" problem. The difference now is that the concept of "concurrency" is being suggested as a potential solution.

General Bernard Schriever is credited with coining the term "concurrency" in early 1958 while describing the Air Force Ballistic Missile (AFBM) program. A 1958 report[2] described this program and the Navy's Polaris program as successful examples of the "concept of concurrency." Throughout the 60's several programs including several which were cancelled such as MBT-79, F-111B, Condor, and Cheyenne, allowed production efforts to begin prior to completion of full-scale development. However, enough problems had occured that were attributed to concurrent scheduling that by the Spring of 1969, then Deputy Secretary of Defense David Packard promulgated the philosophy of "fly-before-buy." Several studies also echoed similar concerns

Acknowledgement: This work is being supported by the Navy Acquisition Research Program under Office of Naval Research contract #N00014-81-C-0764. The views, opinions, and findings contained in this paper are those of the authors and should not be construed as an official Department of the Navy position, policy, or decision unless so designated by other official documentation.

and advocated producing only after the system development had been completed.[3] The formal guidance came in the 1971 version of DoD Directive 5000.1 which noted that one should not propose ". . . unnecessary overlapping or concurrency."[4]

By 1977, however, the concept of concurrency was beginning to be re-established. Dr. Richard DeLauer, then of TRW, Inc. and currently Under Secretary of Defense for Research and Engineering, chaired a Defense Science Board (DSB) Summer Study to examine the problem of the lengthening acquistion cycle.[5] The report noted that it often takes 12-13 years to complete the acquisition cycle from Program Initiation through Deployment. In fact the average time to DSARC II grew from two years in 1950 to five years as of 1977 according to the report. Of more importance was the report's observation that programs are not cancelled for reasons of concurrency, but rather for reasons of a technical or political nature, or changes in requirements.

Two recent articles describe the advantages of concurrency.[6] In addition, DoD Instruction 5000.2 now notes that:

> . . . consideration (should be given) to minimizing acquisition cycle time by planned concurrency. This may include increasing funding, overlapping, combining or omitting the phases of the acquisition process, or overlapping or combining developmental T & E with operational T & E. The amount or degree of such concurrency should be based on the extent of the potential savings in acquisition time balanced against technical, cost and supportability risks and national urgency in each acquisition program.[7]

This paper describes preliminary concepts and considerations necessary in the development of a theory of concurrency. More importantly it establishes the framework for development of tools which can specifically assist a Program Manager in evaluating the opportunities for concurrently scheduling program activities and the associated risks.

INTERPRETATIONS OF CONCURRENCY

The 1977 DSB study restricted its definition of concurrency to:

> The conduct of the steps leading to production for inventory before the end of the full-scale development time span.

In examining the literature, however, one finds the most frequent interpretations of the term concurrency to include:

- parallel (back-up) technological development,
- concurrent, but independent subsystem development and testing,
- co-production, and
- overlap of dependent, normally sequential activities.

In addition, in examining alternatives to reduce the acquisition cycle time, it is clearly not sufficient to concentrate solely on the development/production overlap.

Thus MCR's initial research concluded the following:

- There is no universally accepted definition of concurrency;
- Few studies have been conducted which specifically address the effects of concurrency on program acquisition;
- People have historically perceived concurrency to be a contributor to serious acquisition deficiencies;
- Virtually no formal direction is provided to the Program Manager concerning techniques for developing or evaluating alternative program schedules.

Concurrency should be examined in light of two alternative planning concepts:

- schedule protection: recognizes that the need to extensively revise the program schedule may occur in the future. The PM can attempt to avoid a crisis later on by identifying concurrency options and potential alternatives before a crisis occurs.

- schedule compression: frequently, despite the best planning, a schedule must be revised due to conditions such as earlier schedule slippage resulting in less time available for the remaining activities; the moving earlier in time of a deadline; the avoidance of cost increases due to a longer acquisition cycle, etc. Any or all of these occurances can result in the need to limit an already existing or imminent crisis.

RISK ANALYSIS

In considering the use of concurrency as a scheduling option, it is important to analyze the potential risks associated with the decision. A body of knowledge already exists to allow analysis of some of the risks associated with concurrently scheduling program activities. Typically "risk analysis" is used to assess the degree to which a proposed system is likely to achieve its predicted performance within cost and schedule goals. In conducting a risk analysis it is essential to consider these three aspects:[8]

- Risk Assessment: the identification of the degree of risk with respect to the realism, soundness, and credibility of the programs cost and schedule, and the system's performance.
- Risk Management: The development of a plan for managing all types of risk (risk minimization plan) as a function of time (i.e., Acquisition Milestone I, II, and III). Methods for minimizing risk, such as quality assurance, and other hedges against new technology failure are considered here.
- Risk Demonstration: The formulation of a test and evaluation demonstration plan will allow early identification of risks. Specifically, the steps required to reduce high risk program elements to acceptable levels as well as the cost of doing so are demonstrated.

A risk assessment includes not only an evaluation of the likelihood of success, but also must include assessment of the consequences of failure in measureable terms, usually dollars. Hence the concept of a "cost-risk analysis" becomes of interest. The analysis of concurrency, as part of the overall development of acquisition strategies, is part of the risk assessment process. It does not obviate the need for continued risk management or risk demonstration. Several models are currently available to assist in the analysis of acquistion activities. These are typically network analysis or critical path techniques. Some of the best known include:

- Gantt Charting
- Critical Path Method (CPM)
- Program Evaluation and Review Technique (PERT)
- Program Evaluation and Review Technique/Cost (PERT/-COST)
- Graphical Evaluation and Review Technique (GERT)
- Venture Evaluation and Review Technique (VERT)
- Simplified Network Analysis Portrayal for Planning and Control (SNAP)
- Risk Information for Schedule and Cost Analysis (RISCA)

Many more techniques are currently in use. The Services have not attempted to standardize or institutionalize one specific technique for a Program Manager's use. Although there has been a move to advocate the use of the Total Risk Assessing Cost Estimate (TRACE) methodology, or a similar method, by all services, this model only looks at cost uncertainty, not schedule uncertainty.

Conceptually the cost/schedule risk problem can be described as shown in Figure I. A baseline program schedule (presumably "optimal" in some sense) has a period of performance and level of funding associated with it. It also has implicitly (at a point in time) a chance of requiring additional time or cost. If a PM is willing to accept a non-zero chance of exceeding his funding level or time estimate, then he can begin to trade-off cost/schedule/risk. For example, suppose a 50 month program, funded at $52 million has a 10% chance of exceeding those values. Then the schedule can be shortened by additional funding, while maintaining that same 10% risk level. Alternatively, the funding level can be maintained or even reduced as the schedule is compressed simply by accepting an increased risk of exceeding those values. This is the risk assessment process. By using a proper risk management plan, however, the initially higher risk level can be monitored and minimized over time. Risk demonstration through well designed test procedures can potentially result in a program lower in cost and shorter in time than the initial "optimal" baseline schedule.

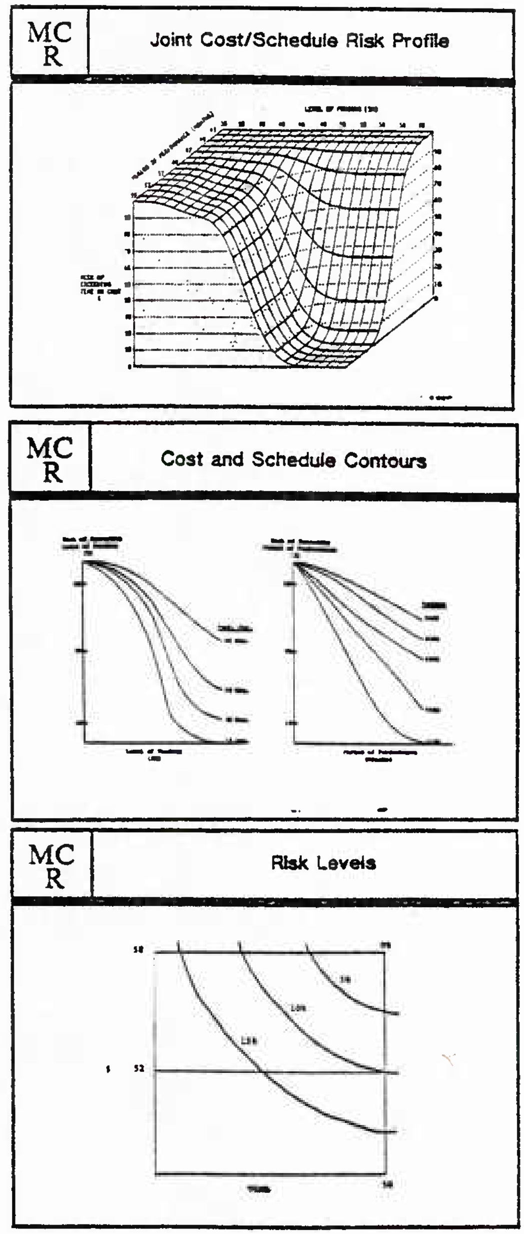

Figure I. Cost/Schedule Risk Problem

CONCURRENCY CONSIDERATIONS

In attempting to understand what concurrency involves, specific factors and criteria must be developed for considering program activities and decisions required of the Project Manager. The basic components in creating program schedules must be identified. Then program activities and events can be considered in light of the components.

Specifically, it is necessary to consider:

- Phases: acquisition phases such as Concept Exploration, Demonstration and Validation, Full Scale Development, and Production.
- Functions: major categories of work performed in, or under the direction of, the

Program Management Office such as Technical Management, Logistics Management, Business Management, etc.

- Task Areas: subtasks of functional work such as hardware design, software design, test and evaluation, etc. under Technical Management.
- Events: end points such as document delivery, design review meetings, milestones, and initiation of development of documents.
- Activities: efforts involved in preparing for a particular event, or following a starting event (e.g. preparation of a baseline, review of a procurement plan).
- System Type: generic type of weapon system related to the program schedule (i.e., ship, aircraft, missile).
- Subsystems: level 3 work breakdown structure elements of hardware which may be on different developmental schedules, but which collectively constitute a viable weapon system.

Figure II illustrates representative acquisition activities.

In examining the degree of desirable concurrency for a particular program many factors must be considered. The following considerations are briefly summarized here:

- factors influencing the applicability of concurrency,
- acquisition cycle-related problems,
- previously suggested alternatives,
- pros and cons of increased concurrency, and
- factors for changing program concurrency.

It is not clear that concurrency is applicable to all system acquisitions. Development factors such as design status/familiarity of technology, environmental characteristics, program personnel experience, contractor availability/experience, etc., and production factors such as production resource availability/manufacturing capability, sources, and level of previous program involvement are all important. But so, too, is the discipline required (risk management) of scheduling far in advance of actual requirement (i.e., consider production and logistics problems very early in the cycle). Risks of technological advancement or lack of maturity of design balanced against high development cost or high cost

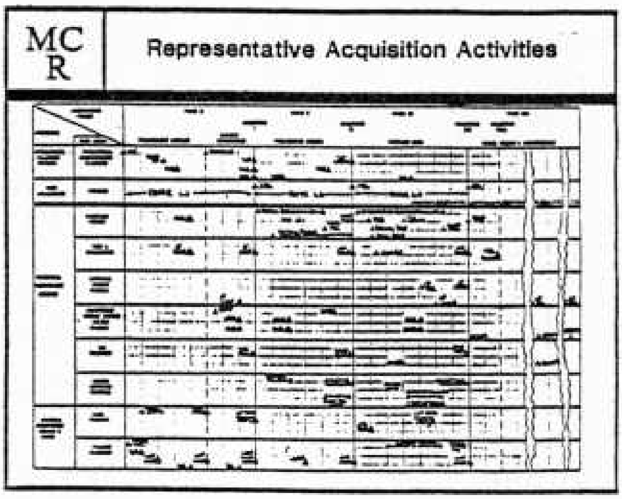

Figure II. Acquisitions Activities (Ships) uncertainty can doom a program and require higher costs of maintaining low risk alternatives. There is a complex hierarchy of responsibility and review that also contributes to the problem rather than to the solution.

Various prior studies have suggested alternative ways to shorten the acquisition cycle. These include:

- reduction of in-service review,
- reorganization of the DSARC process and reassignment of hierarchical responsibilities,
- explicit emphasis on developing techniques for shortening the acquisition cycle,
- increased emphasis on front-end analysis and development of design philosophies,
- committment to freezing designs, development of scheduled Top Level Requirements/ Top Level Specifications (TLR/TLS), and the application of Pre-Planned Product Improvement (P^3I),
- increased coordination of DSARC and PPBS, and
- development of techniques for quantitatively analyzing impacts/risks of program schedule changes.

Many of these alternatives have been specifically addressed by the DoD Acquisition Improvement Program promulgated by Deputy Secretary of Defense Carlucci.

The basic arguments for and against use of concurrency can be summarized as follows:

- Potential Advantages: concurrency potentially allows the attainment of an earlier IOC, increased likelihood of meeting intermediate goals and thresholds, lower overhead costs, work force continuity, and increased worker motivation.
- Potential Disadvantages: concurrency may lead to premature committment to high cost program elements, excessive and higher cost changes in design after production has commenced, unreliable equipment in service, and degradation of training because of multiple configurations and faulty systems.

The problem with any discussion of concurrency, however, is that of over-generalization. A given program can easily be affected by threat induced changes in IOC, initial overly ambitious schedules, redefinition of the need and changing technologies to meet that need resulting in program restructuring, as well as the need to compensate for other program delays. One of the overriding conclusions of MCR's initial research, however is that continuous risk analysis is required, as well as careful planning of funding support and program stability. The Carlucci initiatives collectively solve many of the problems previously preceived as overriding disadvantages.

PROGRAM MANAGER NEEDS

Based on the conclusions noted above, we believe the Program Manager has four specific needs. He must:

- Define the amount or degree of concurrency deemed desireable for his particular program:
- Determine the set of program activities which can be concurrently scheduled considering:
  - the amount of dependence on activities in the previous phase,
  - whether there are high costs associated with the particular activity,
  - whether failure to meet the schedule/cost objectives of the activity will produce long-term increases in the program costs, and
  - whether failure to meet the schedule/cost objectives of the activity will produce long-term increases in the program schedule;
- Evaluate the cost-risk impact on program goals, thresholds and requirements; and
- Justify these decisions to the Service hierarchy and OSD.

In addition to these needs the program schedule must also be analyzed in terms of its sensitivity to external forces such as political/budgetary decisions.

DESCRIPTIVE MODEL

Figure III shows the descriptive model MCR is developing. This model is composed of seven basic steps to be performed by, or under the direction of, the Program Manager. The first step involves the development of the initial program schedule which forms the basis for concurrency and cost/schedule risk analyses. It also includes the formulation of the rules and criteria for performing the analyses, and the identification of an initial set of concurrency options.

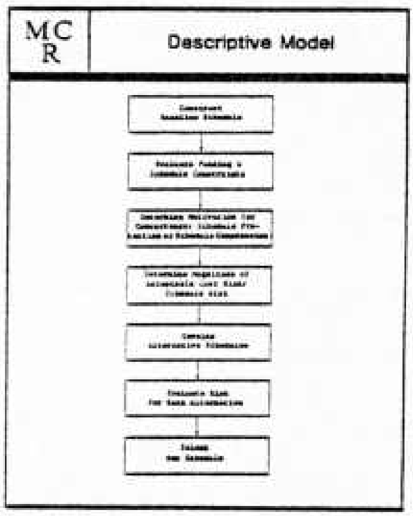

Figure III. Descriptive Model

Having set up the problem, the second step concerns the considerations of the constraints that the PM must respond to in the schedule. These constraints may be pre-existing or newly imposed, endogenous or exogenous to the program. This step is closely related to step three, determining the reason for considering concurrency. In evaluating the constraints the PM must determine the desirable scope of the concurrency, i.e., the phases, functions, task areas, and activities affected by the implementation of concurrency. In recognizing the motivation, the PM is also considering the ultimate purpose to be achieved by using concurrency as a scheduling mechanism, as well as the circumstances driving the decision, i.e., earlier schedule slippage, protection of the remaining schedule, incorporation of changing direction, etc.

In the fourth step the PM determines the magnitude of acceptable risk to be considered in developing and selecting alternatives. This narrows down the set of possible alternative schedules which could fulfill the requirements. It is at this point that decisions are made about acceptable degrees of concurrency. Based on the analysis performed in the previous steps it is possible that there may be more than one set of concurrent activities in an alternative, each of which will have to be decided upon.

The fifth step involves the development of alternative schedules which are within the scope of the preceeding constraints and risks. A variety of alternatives addressing one or more of the previous selected sets of concurrency options may be developed.

The companion to this step is the analysis of the risks associated with each alternative, performed in the sixth step. The evaluation of the alternatives is performed using checklists tailored to the particular characteristics of the system type, the stage in the development of the system, and the particular task areas and activities involved. Development of these structured checklists is begun with the selection of the concurrency options in step one and is continued through each step, incorporating the refined direction that is being developed in this process. They are tailored to respond to the PM's information needs necessary to make an actual decision.

Having evaluated and scored the alternative scheduling options, the final step is the selection of the alternative which most adequately satisfies the requirements at the time of the decision. Using the basic criteria developed in the first step, and refined for the actual decision, the PM trades-off the options presented in the alternatives among cost, schedule, risk and the program environment. The ultimate selection is the revised schedule. Although a single alternative may be selected in this process, it is often the case that other potentially viable alternatives have been developed and should be monitored in the process of subsequent schedule reviews.

Initially several assumptions are made:

- the Program Manager is assumed to have a Baseline Schedule,
- funding and schedule constraints can be defined,
- resource estimates (time cost) can be made for each schedule component,
- analysis will be made for alternative schedules representing relatively fixed performance, and
- concurrency can be meaningfully considered in terms of potential savings in time versus cost-risk.

The Top Level Hypothesis (TLH) are simply that:

- program schedules can be quantitatively and qualitatively evaluated,
- quantitative or qualitative risk analysis measures can be developed and applied to evaluate degrees of program concurrency,
- the Program Manager can himself make meaningful decisions regarding shortening the program acquisition cycle using a structured checklist methodology.

Given the TLH, the PM must be able to intelligently apply available analytical techniques to his program in order to make concurrency decisions. Some of the alternatives he needs to consider are:

- funding of parallel activities, in order to increase the probability that one of the alternatives will successfully meet the goals of the program;
- funding repetition of activities, when a critical activity has not been previously successful;
- scheduling activity "slack time," to allow for the unforeseen extension of the duration of an activity; and
- lowering performance objectives of a high-risk activity and compensating by increasing the performance requirement for a lower risk activity.

CONCLUSIONS

Several major conclusions result from the research conducted on concurency to date:

- To be effective, concurrency must be specifically planned for in the program.
- Techniques such as network analysis models and cost risk analysis models, useful in assessing impacts of concurrency are already available, but have not been coordinated in a consistent methodology useful to a Program Manager.
- In order to evaluate concurrency, the relationship between program events and activities must be defined and specific "checklists" developed so that techniques already available can be tailored to specific PM needs.

The Program Manager's Dilemma is that he must (1) determine the magnitude of acceptable risk, and (2) apply a methodology to quantify risk in order to effectively make cost/schedule/risk trade-offs.

FOOTNOTES

1/ Decision-Making for Defense, Charles J. Hitch, 1965, (University of California Press, Los Angeles, CA)

2/ "The United State Guided Missile Program" prepared by the Legislative Reference Service of the Library of Congress for the Senate Armed Services Committee, referenced in the Congressional Record, January 27, 1959.

3/ Examples are the, RAND Report, "System Acquisition Strategies," by Robert Perry in June 1971 and the Blue Ribbon Defense Panel Report of July 1970.

4/ DoDD 5000.1, "Acquisition of Major Defense Systems," 13 July 1971.

5/ "Acquisition Cycle Task Force Report," DSB Summer Study, March 15, 1978.

6/ "Concurrency, " Robert Gibson, Defense Systems Management Review, Autumn 1979; "Concurrency Today in Management," Thomas Harvey, Defense Systems Management Review, Winter

7/ DoDI 5000.2, "Major Systems Acquisition Procedures", 19 March 1980 (currently being revised though these words remain in the draft).

8/ "Cost-Risk Procedures for Weapon System Risk Analysis," Gerald McNichols, Proceedings Annual Reliability & Maintainability Symposium, January 1981.

METHODS TO PREDICT COST OVERRUNS IN THE ACQUISITION PROCESS

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April 3, 1982

INTRODUCTION

There have been numerous instances where acquisitions in both military and civilian projects have had costs exceed the original estimates. With increasing levels of system complexities, limited resources, concurrent development and production, constant changes in scope, continuous advance in technology and urgency in achieving operational status, the probability of cost growth is a critical aspect of the acquisition process.

ACQUISITION UNCERTAINTY

Uncertainty or variability are recognized as inherent aspects of the acquisition process. Because "as contracted costs," are, in effect, single point estimates, they do not represent a meaningful basis for controlling cost. The objective of this paper is to describe an approach for predicting cost uncertainty, which recognizes that variability cannot be eliminated but rather that there are trade-offs that are available to decision makers. These tradeoffs are based on cause and effect models which can be used to improve the acquisition process. Inherent in the approach presented here is the dynamics, interdependencies, variability, and uncertainty in the acquisition process. These include: concurrency, learning, curve effects, design changes, technological advances and program management, which contribute to the cost effects observed.

THE ACQUISITION PROCESS

Any description of the acquisition process is, at best, only a static representation of an extremely complex set of interdependent activities. For our purpose, we will use two basic diagrams to aid in understanding the process. The first, shown in Figure 1 describes the kinds of uncertainty associated with acquisitions (28).

The matrix shown in Figure 1 is used as a basis for understanding causality. Thus, internal control assumes all things are known and controllable with estimates based on past data, procedures, designs, etc. The other three categories, ' however, represent the reality in major acquisition. It is this uncertainty that has significant impact on cost and is the principal emphasis of this paper.

An approach which will be used to describe the acquisition process and the inherent cost overruns is represented in Figure 2. Illustrated are the factors, the interdependencies, and the processes involved in acquisition management. Because the acquisition process is as extremely complex network of activities a static model is unsatisfactory. A computer simulation model is proposed which can be used to predict cost overruns.

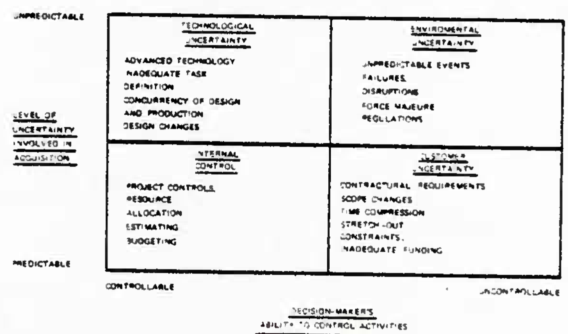

FIGURE 1 ACQUISITION UNCERTAINTY

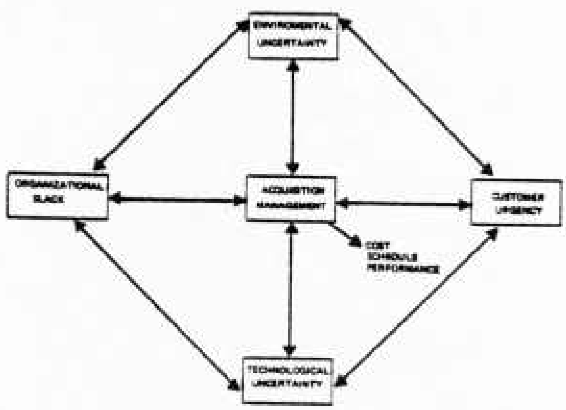

FIGURE 2 FACTORS AFFECTING ACQUISITION MANAGEMENT

Although Figure 2 does not reflect the dynamics and interactions that occur in an on-going organization, it does illustrate a number of key concepts that will be developed. The linkages between the four basic uncertainty variables and acquisition management help to define the processes, activities or variables that contribute to the uncertainty of acquisition management. The four basic uncertainty variables are:

1. Organizational Slack: A measure of the organization's ability to perform the task requirements.

2. Customer Urgency: The time compression, concurrency, or degree of overlap betwen phase of development, and changes in scope.

3. Technological Uncertainty: A measure of the state-of-the-art and the degree of interdependency among system components.

4. Environmental Uncertainty The factors that cause disruption, delays, shortages, failures, etc., that are not under the control of management in the acquisition process.

The exterior linkages identify secondary effects and relate the four uncertainty variables. The variables and linkages define a network of interdependencies which ultimately contribute to the uncertainty and the consequent cost problems in the acquisition process.

A CAUSAL BASIS FOR DEFINING UNCERTAINTY

Although uncertainty is defined as lack of knowledge about specific effects, it can be examined in terms of the factors that contribute to disruption and in turn attempt to understand the causal relations that lead to cost increase. The premise is that control of the variables contributing to uncertainty is an effective means for controlling cost. This is analogous to queuing theory where a knowledge of queue behavior and sequencing rules permits servicing the maximum demand with available resources. Delays are not eliminated; rather, they are reduced by adding capacity or are modified by changing priority rules. Disruption in the acquisition process can be considered similar to queuing delays in limited capacity servers. By understanding which factors cause disruption, management can alter the expected cost growth by controlling those factors. Typical factors leading to disruption are shown in Table 1.

1. Delay: gaps in carring out a program
2. Interruption: short term delay
3. Stretch-out: slow down of program
4. Interference: delay by other projects
5. Redesign: change in scope or rework
6. Work stoppage: interruption of work
7. Interdependencies: indirect delays caused by external factors
8. Shortages or errors: delays due to lack of material or components
9. Concurrency: interference and delay resulting from overlap
10. Redirection of effort: disruptive effect of reorganization

TABLE 1 FACTORS IN DISRUPTION

Two key factors that contribute to disruption in the acquisition process are concurrency and technological uncertainty. Concurrency is most often a result of customer urgency in attempting to meet tight deadlines. Delivery urgency enforced by competitive conditions exerts strong pressure on suppliers to commit to delivery dates which are inherently optimistic or based on the assumption that no serious problems will develop. The plan becomes critical when combined with technological uncertainty.

TECHNOLOGICAL UNCERTAINTY

As used here, technological uncertainty refers to two conditions. One is the highly abstruse demands at the very forefront of scientific knowledge or state-of-the-art. It also refers to a major gap between an organization's area of expertise and what is required to perform effectively. Rapid technological change can have a major financial impact on an organization which can be catastrophic and can be termed a "technical disruption."

Uncertainty occurs where conditions of rapid technological change exist. Managers must rely on the recommendations of technical personnel and yet, they must be able to detect errors and inconsistencies based on incomplete knowledge.

In order to examine technological advance, factors are needed to determine the state-of-the-art. Ones shown in Table 2 provide a starting point:

1. Size - number of inter-related components, physical volume
2. Complexity - difficulty in meeting performance requirement
3. Experimental nature of technology - has it been proven.
4. Degree of newness - percent of components of proven technology
5. Company's experience in the field - work on similar programs
6. Interdependency of subsystems - number of linkages
7. Degree of precision - quality requirements
8. Unique resources - testing, or tooling requirements
9. Definitive specifications - clarity in meeting requirements
10. Design flexibility - tolerance level, substitutes available
11. Required theoretical analysis - need to support proposed design
12. Degree difference from existing technology - life cycle of technology
13. Infra-structure support required - degree of dependency on vendors

TABLE 2 FACTORS WHICH CAN BE USED TO DETERMINE THE STATE-OF-THE-ART

The factors shown in Table 2 include the newness as well as the design requirements for determining the state-of-the-art. Thus, state-of-the-art for a given organization can be construed as the "ability" to produce a given design, in addition to the newness of the technology involved.

An approach to determining technological advance was developed at the RAND Corporation (26) is shown in Figure 3. The range is from 0 to 20, where the newness of the design determines the advance in state-of--the-art. Examples of a number of military and commercial aircraft, as well as a number of different missiles are shown on the chart.

Uncertainty often arises from the overlap or "concurrence" of development and production. The perceived necessity to initiate the ponderous and involved processes of production before there is certainty as to the stability of the product design, places programs at the mercy of changes which occur in the design. Such delays or changes are more likely to occur as the degree of concurrency increases.

Concurrency can be costly because of the effort and cost needed to establish production momentum. It might seem obvious that the solution is to avoid concurrency, however, alternative courses of action offer options which can avoid real failure. Rapid technological change produces pressure to implement new ideas. However, doing so entails greater risk than under conditions of technological stability. Technological disruption can be characterized as follows:

--Programs are promised in an unreasonable or unrealistic time period.

--The product is not fully designed, but is considered within the current state-of-the-art.

--Unanticipated technological problems arise which require extensive time to resolve and result in substantial changes to the original product and to production.

-- The changes increase costs substantially.

-- Intensive effort is required to minimize deviation from the original delivery schedule and product specifications.

Much interaction occurs among the various stages and events of each situation, and the end result is often a cost overrun of significant proportion .

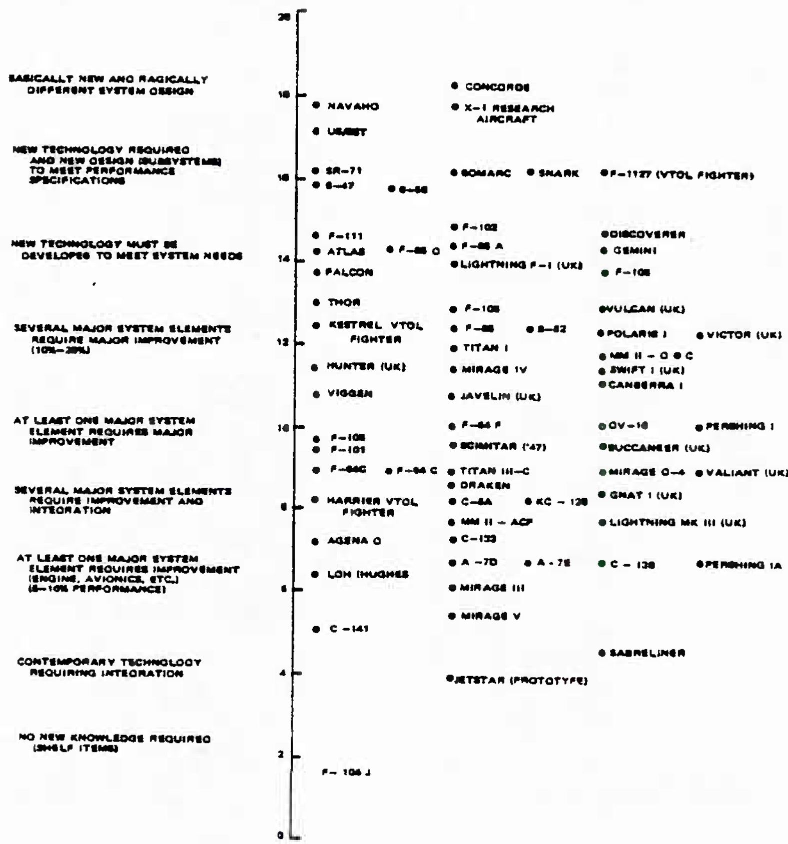

FIGURE 3 TECHNOLOGICAL ADVANCE RATINGS
(SOURCE: RAND R-733/PR/ARPA JUNE 1971)

INTERDEPENDENCY

If the degree of state-of-the-art is a driver of technological uncertainty, then interrelatendness is a major multiplier on cost of development and production. Interrelatedness of design relates a change in one component or subsystem to many others. Interrelatedness can also affect production and vendor activities, since a change in oroduction methods or delivery cycle in one area or component may affect production of other components or work in other areas. A product in an advanced area of technology will be subject to higher levels of interrelatedness. Interrelatedness can be described in a matrix form as shown in Figure 4.

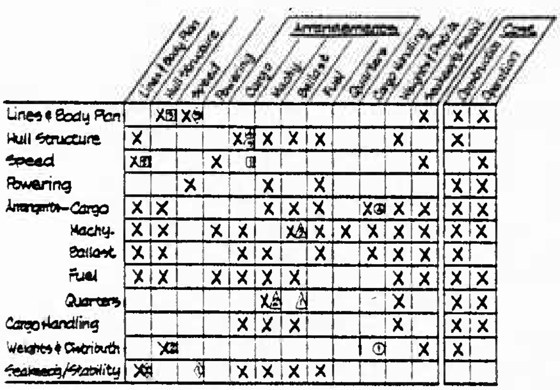

FIGURE 4 SHIP DESIGN INTERRELATEDNESS

ORGANIZATIONAL SLACK

Two additional factors compound the disruptive effect of concurrency. First, the level of resources available to the oroject, and second, the degree of external control over events. The level of resources comprises all tvpes of resources technical, managerial, facilities, financial, etc. Adequacy of resources is measured by the variable "organizational slack".

This factor is based on the organization's experience using the basic technology involved. It provides a fund of knowledge on how to handle the inevitable unexpected oroblems which arise. A second problem is the degree to which the frame of the project, which may leave inadequate reserves for use on unexoected problems. This inadequacy can be a critical flaw, given the intense time compression inherent in concurrent design and production.

Organizational slack, thus, defines the level or degree of unknowns that are internal to the system rather than the external exigencies. Factors related to internal uncertainty could be measured using dimensions such as:

1. The organization's ability to respond to new or unforeseen requirements.
2. The slack or flexibility that has been built into the organization.
3. Prior experience with the given technology.
4. Number of linkages of subsystem dependencies or interaction with other projects.
5. Percent of the oroject's subsystems being developed that are at the state-of-the-art of the technology.
6. The amount of time compression or tightness of schedules (concurrency).
7. Availability of, or access to, resources.
8. Maturity in the planning and control of operations, including computer systems and organization structure.
9. Amount of overlap of development, design, and implementation.
10. Number of contractors or organizations involved in the project.

These factors contribute to management's ability to cope with uncertainty. In turn, the delay, disruption, or slippage that can be anticipated would be measured by the relationship of this capacity to customer demand as shown in Figure 5.

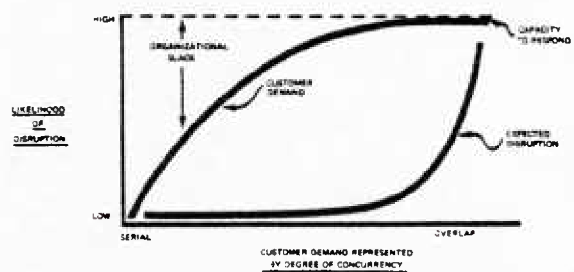

FIGURE 5 IMPACT OF CONCURRENCY ON OIRUPTION ON DIRUPTION AND RESPONSE CAPACITY

Expected disruption is an exponentially increasing function which is dependent on the organizational response capacity, which in turn depends on the level of concurrency. Thus, when the level of concurrency approaches the response capacity, the delay increases. This formulation does not deal with uncertainty per-se, but whether the organization is able to cope with problems as they arise, or is able to anticipate problems. In turn, the amount of slack or flexibility in the organization determines the ability to respond to uncertain requirements. If management is operating with minimum slack, then any disruption can cause a large delay.

Another perspective of management practices is shown in Table 3 for four government agencies based on a RAND (27) study of R&D management. An examination of the findings reveals the considerable latitude given program managers in dealing with creative individuals needed in R&D programs. Given this kind of organizational environment, the accuracy of estimates is highly questionable. At best, the estimate is a target that permits a level of effort to be applied in attempting to achieve what are often elusive objectives or requirements.

Perry, in a study of acquisition strategies, recommended that acquisition management use an incremental approach (25). This support was based on an analysis of 36 major DoD programs which revealed that high cost growth was due to:

1. Willingness to pay the price for having high technology with compressed schedules.
2. Over-optimism regarding the cost of coping with long term technology.
3. Little evidence that the programs had extreme urgency.
4. Little improvement in cost based on:
    a) contractual approaches
    b) complex management reforms
    c) improved estimating
    d) early identification and correction of cost growth.

Despite these four factors, a number of programs had surprisingly good outcomes and were able to predict cost performance and schedule. Using their findings, the authors

Agency	Program			
	Planning	Development	Evaluation	Utilization
National Aeronautics and Space Administration: Goddard Space Flight Center	Highly directed with specific objectives	Reliance on internal staff for project selection Close monitoring	Regularly and frequently evaluated	Plan for utilization included in projects
National Science Foundation: Research Applied to National Needs (RANN)	General objectives and priorities	Project ideas generated externally Consultation with research community on project selection Partial monitoring	Regularly evaluated, but infrequently	Plan for utilization included in projects
Engineering, Mathematics, Physics Divisions	By disciplines or fields of inquiry	Support of individual scientists External mail review with feedback to reviewers Little monitoring	Program manager defends his project selection decisions	Little direct attention
Biological and Social Sciences	By disciplines (within these, by lines of inquiry)	Support of individual scientists External panel review of borderline decisions Little monitoring	Evaluation implicit in considering renewal or continued support	Little direct attention
National Institutes of Health	By disciplines, collections of similar subjects	Support of individual scientists Unsolicited proposals Dual panel review (greatest attention to evaluating proposals) Little monitoring	Evaluation implicit in considering renewal or continued support	Little direct attention
Office of Naval Research	By disciplines and directed at attracting most capable researchers	Seek new researchers No formal review of project ideas Monitor activities (once or twice a year)	Evaluation implicit in considering renewal or continued support	A part of the program manager's mandate

TABLE 3 EXAMPLES OF PROGRAM MANAGEMENT
(SOURCE: RAND - R-1375, APRIL 1975)

suggested that an incremental strategy and control in the early phases of development would have the most effect on avoiding cost growth.

The incremental strategy recommended the following steps:

1. Resolve uncertainty early in the program.
2. Avoid concurrency of development and production.
3. Separate performance from reliability and maintainability.
4. Require periodic reassessment, redefinition, and readjustment regarding proposed changes.
5. Conduct tradeoff studies to resolve restructuring.

The benefits from an incremental approach to management would lie in greater predictability based on prototype demonstration and in uncovering difficulties early in program life. It would also encourage competition and transfer of technology as the need required.

Another consideration relating to organizational slack is presented in the study by Moeller (23) of the DSARC management review process to determine its effect on the length of major system acquisitions. He found that although DSARC demands considerable time and generates a sizeable workload for the program office, there was no excessive delay in 11 of the 13 programs examined. His conclusion, therefore, was that regardless of how cumbersome the review process might be, it had no significant effect on the length of the acquisition cycle because the review was concurrent with the production activities. Rather, the primary contributer to lengthening the development process was lack of adequate funding or instability which caused stretchouts. Another significant factor in lengthening the cycle was the lack of agreement on configuration and performance parameters. This lead to indecision or inconsistency in meeting technical requirements. There were a number of delays resulting from testing requirements. Two significant recommendations were the judicious use of concurrency, such as for logistics and more flexibility in the approach to acquisition.

ORGANIZATIONAL PERFORMANCE

Another aspect of organizational slack relates to expected performance. Cochran (8) has identified key factors which contribute to disruption and which management can review in order to achieve more effective control:

1. CONTRIBUTORS TO TASK VARIABILITY
   - a) Inadequate definition of product specification.
   - b) Underestimating the "state-of-the-art" (SOA).
   - c) Poor cost engineering or organization planning.
   - d) No allowance for uncertainty in meeting plans.
   - e) No "backup" activities in the event that the design approach fails.
2. MEANS FOR DETERMINING DISRUPTION
   - a) Review the degree of rigidity in the delivery date.
   - b) Analysis of the SOA tradeoffs.
   - c) Examine areas where tasks could not be anticipated.
   - d) Define the degree of SOA advancement required, and the cost involved by area.
   - e) Determine the risk elements involved and their effects.
   - f) Define specific cost increase relationships.
   - g) Develop modeling techniques to conduct appropriate analysis.

Considering that industry is often confronted with untenable contractual procedures, including perpetual specification change and rigid contracting requirements, as well as, unanticipated price changes, inflation, changes in the number of systems, and the impact of new technology, it is small wonder that acquisition managers do not have effective means for handling uncertainty.

Cochran (8) also described the S-Curve patterns of labor hours as a cause of disruption leading to substantial cost overruns when development of a major new design is concurrent with production and under severe delivery pressure. Labor cost reflects the impact of design delays, growth, and changes in the production function. The disruption caused by the S-Curve effect generally continues well beyond the first units produced, because of the way in which production operates. The procedures, tools, and methods established during the start-up period inevitably carry forward to subsequent periods. Costs follow accordingly and managers generally acknowledge that it is harder to revise engrained organization practices than it is to start from scratch. Further, design growth and changes cause revisions to production methods and sequencing, and in facilities usage. If a change is introduced after production has been established, considerable time is required to fully implement the program. If design changes occur after the affected components have been completed, this requires rework and reinstallation, which involves extra cost. The cost of such work is dependent on the degree to which it is different from the position or sequence normally assigned to the original task. Such work also creates extensive interference with other on-going tasks, which can involve correspondingly greater cost penalties.

Another cause of disruption carryover is the "queuing effect". For example, work still in process must be held up because of design delays, design changes, or the need to perform a sizable amount of rework. Inventory control demands frequent rearranging to locate items currently required from the shop, and other double handling affects units in process. In turn, the clogging up of valuable staging areas and even workspace may cause direct interference with follow-on units.

The repeated delays imposed on the production organization in the early stages of a new product cause deceleration of previous activities and rework with their many cost penalties. But beyond that, the relentless need to deliver "on-time" causes a corresponding acceleration later, with its own cost penalties. The repeated cycles of decelerationacceleration generate a pulsation which sweeps across every phase of production, gaining momentum and leaving confusion and wasted effort in its wake. The effects on production procedures, facilities utilization and personnel deployment and morale are profound, and account for much of the cost overruns and schedule slippages encountered in production.

DETERMINING A PATTERN OF DISRUPTION

The ability to define causal relations among variables in disruption and uncertainty is a first step in predicting cost overruns and in determining which actions a program manager should take to avoid cost growth. For example, Augustine (3) proposed using additional planning funds based on an assessment of risk. He contends that even the most capable program manager is not able to forecast all the problems that will be encountered in a development program spanning anywhere up to ten years. However, it is quite possible to forecast the "probability" that additional funds will be required. He recommended the use of TRACE (Total Risk Assessing Cost Estimate) as the basis for justifying the additional funding.

One of the early attempts to deal with uncertainty was proposed by Marshak, Glennon and Summers (18). They indicated that where "component" interrelatedness is defined, one can predict the effects that are likely to occur. Under conditions of uncertainty, low slack heightens interrelatedness and substantially increases the risk of redesign. Furthermore, the risk of redesign is sensitive to the degree that design reaches beyond past state-of-the-art and where there are requirements to use existing components which can strain the designer and lead to suboptimization. Based on three conditions describing component interrelatedness, one is in a position to predict potential disruption. When there is a high degree of close coupling or interrelatedness, the likelihood of design change is substantial. Where there is loose coupling and engineering slack, when components are redesigned the deviation does not influence the other components, and there is less propensity to redesign. It is argued that the tightness of component interrelatedness can be traded off against uncertainty, and thus achieve more effective control.

Another measure of uncertainty is system complexity which contributes to determining the entropy in a system. Table 4 illustrates the impact of complexity on maintainability and availability. Complexity is indicative of the uncertainty related to potential disorder and resultant cost overruns.

	Degree of Complexity	Not mission capable	Mean Flight Hours between failure	Maintenance man-hours per sortie
Air Force				
A-10	low	32.6%	1.2	18.4
A-70	medium	38.6	0.9	23.8
F-4E	medium	34.1	0.4	38.0
F-15	high	44.3	0.5	33.6
F-111F	high	36.9	0.3	74.7
F-111D	high	65.6	0.2	98.4
Navy/Marine Corps				
A-4M	low	27.7%	0.7	28.5
AV-8A	low	39.7	0.4	43.5
A-7E	medium	36.7	0.4	53.0
F-4J	medium	34.2	0.3	82.7
A-6E	high	39.3	0.3	71.3
F-14A	high	47.1	0.3	97.8

TABLE 4 COMPLEXITY, MISSION CAPABILITY, AND MAINTAINABILITY OF VARIOUS WEAPON SYSTEMS.

(Source: Armed Forces Journal International, May 1980)

RISK MODELS

Many causal relations currently applied utilize risk, rather than uncertainty to predict possible outcomes. Figure 6 shows the relationship between risk and uncertainty as related to causality. Models of known phenomena provide a more certain basis for prediction than random events which are used for estimating probabilities. Uncertainty, on the other hand, covers those areas that are illdefined or where there is a lack of knowledge of effects.

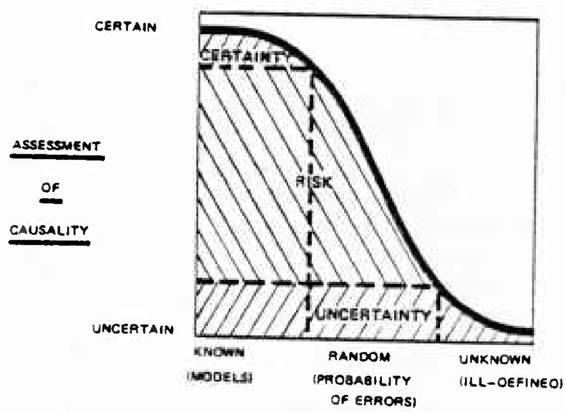

FIGURE 6 TAXONOMY OF CAUSALITY AND UNCERTAINTY

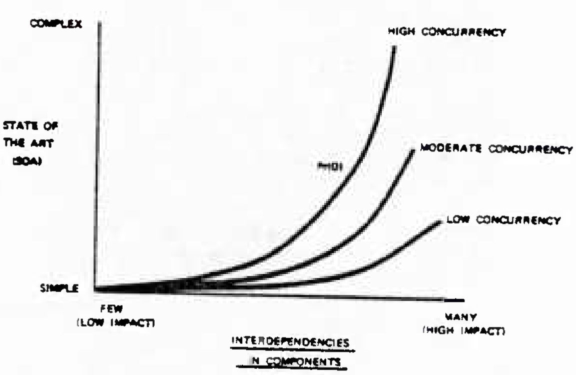

FIGURE 7 RELATION OF STATE-OF-THE-ART TO CONCURRENCY

Figure 7 attempts to relate state-of-the-art to interdependency and level of concurrency. The likelihood of disruption is shown as a function of varying levels of concurrency. The more complex the program, and the higher the interdependencies the greater the likelihood of disruption. Thus, the likelihood of disruption increases with increasing concurrency.

In regard to technological uncertainty, Duvivier (9) recommends the use of technological forecasting to assess the risk in meeting the demand for increasingly advanced technology. He postulates that advances are extrapolations of current knowledge and that breakthroughs are rare. Even when occur, such as the laser, it takes 8 to 12 years to incorporate them in new systems. He shows examples of engine weight, lift and fuel consumption all following smooth curves. Thus, the cost and benefit of new technologies can be based on an extrapolation of technology growth curves.

Because technological uncertainty impacts projects with advanced state-of-the-art, reduction in development time is possible by maintaining a strong research and development (R&D) posture. New technologies can be tested and evaluated prior to incorporation in major systems and thus "avoid" some of the uncertainty. Considering that new technology is limited to a small percent of components, advanced or anticipatory development can contribute significantly to the reduction of technological uncertainty, reduced need for concurrency and ultimately reduced disruption. Thus, "demonstrated" technical capability could supplement "fly before buy" as an approach to the management of risk and uncertainty in major acquisitions.

This latter position is consistent with DOD 5000.3, dated April 1978 which states, "Test and evaluation shall be commenced as early as possible and con ducted throughout the system acquisition process as necessary to assess and reduce the acquisition risk". It also concurs with OMB circular A-109 which states, "When risks can be accommodated and progress indicates that a proof of concept demonstration is in order, the alternative system design concepts selected for consideration for competitive demonstration are to be submitted to the agency head for approval, along with other alternatives which were identified and evaluated." Although early prototyping offers a number of advantages, the maintenance of a basic technological capability consistent with emerging needs can effectively collapse the time span taken for major developments. In the commercial field IBM and Bell Labs are examples of maintaining continuous, high technology, R&D capability which has payoff in terms of capability in developing new technology.

CURRENT APPROACHES TO ACQUISITION MODELING

This portion of the paper will examine representative models that are currently being applied to the acquisition of major systems. For our purposes the types of models will be grouped into two major categories - probabilistic/stochastic models and general models. Within this framework several aspects of each of the models will be explored - namely, the basic approach of the model, how it is used, results of its use (postmortem analysis will be included where available), the requirements for its use, and, the problems or limitations. The selection of the models chosen for analysis is not intended to be exhaustive, but rather indicative of the type of models currently being used or proposed for use in the acquisition process.

The extension of the two groups of models leads to a proposed approach - the Causal-Integrative Model (CIM) - which is suggested as a means to deal with factors beyond those used by many of the current models.

Stochastic/Probabilistic Models

Within this category, two models will be discussed. These are - VERT, and a Risk Analysis Model presented by Admiral Freeman at the 1979 Symposium on Risk and Uncertainty.

VERT - Venture Evaluation and Review Technique

VERT was developed in 1973 by Gerald Moeller (5) and has been used almost exclusively by U.S. Army program managers to determine the "best" balance among the three program parameters: cost, schedule, and performance. The model evolved from earlier methodological approaches such as GERT (Graphical Evaluation and Review technique), CPM (Critical Path Method), PERT (Program Evaluation and Review Technique), MATHNET (Mathematical Network Analyzer), and RISCA (Risk Information System and Cost Analysis). The short comings of these earlier models when compared with VERT was their failure to include the performance variables along with the cost and schedule variables in th total risk-analysis methodology. The VERT model corrects this problem.

The VERT approach is a general networking method that determines program risk analysis through two basic steps: construction of the graphically representative network and analysis of the network using the VERT software. The first step entails development of the ordered series of activities or subtasks that lead to a specific task. This network includes all aspects including decision points - required to complete the event. If the problem is quite large and complex, lower level networks or subnetworks of the major subsystems are developed.

Once the network (or networks) is developed, the program is converted into the VERT software compatible terminology. The software allows for a variety of input capabilities that make it possible for decision events and activities occurring within the network to be described. Numerical values for a task's time, cost, and performance are assigned along with probabilities or decision rules based on a specified relationship. The process involves a Monte Carlo simulation in which the design of the network flow across the entire network or subnetworks from the start to an appropriate decision point leads to a trial solution of the problem being modeled.

The process is iterated as many times as the need warrants in order to create a large sample of possible outcomes concerning: slack time, completion time, cost, and performance. Frequency distributions, scatter diagrams, and probabilities of exceeding given values are also generated. Finally, pictorial histograms are generated for desired events, giving the program manager an integrated risk analysis for a particular point of interest in the program. Mann (17) reported in Defense Management Journal that "some minor problems have arisen with VERT, but none are considered major obstacles to its effective use." The problems center about the probability distributions. Most data sets in VERT are triangular indicating pessimistic, optimistic, and most likely values. This factor reduces the flexibility of the model and the accuracy of the simulations. Another problem, according to Mann, is the inability to obtain expert estimates of the time and cost requirements. The experience is that most of the values obtained have been overly optimistic - which affects the usefulness of this approach.

Risk Analysis Model

RADM Freeman's risk analysis model allows various alternatives or systems to be objectively compared through aggregate risk analysis. The process begins with a segmentation of the various program functions into categories reflecting the schedule, cost, and performance variables. Risk distributions, represented by utility functions, are used to determine utility values versus a change in one of the variables. For example, the question of "how much additional risk is presented by a change in performance variable A ?" is answered. The next step consists of developing a Risk Matrix where the options (or alternative systems) are presented versus the criteria for choice. The summary risk or probability for each system/alternative can then be compared on a quantitative basis. The term risk factor is presented in the form of an equation:

$$R_f = 1 - P_s(1 - C_f)$$

Where: R_f = Risk Factor

P_s = Probability of Success

C_f = Consequences of Failure

With: $0 \le P_s \le 1$

$0 \le C_f \le 1$

If C_f, the consequence of failure, is interpreted to represent a utility function, then the risk factor curve will be defined as a utility function. The shape of this function will be in the form of a negative Pareto curve. If the system criteria and associated risks developed from the Risk Matrix earlier in the sequence were plotted in rank-ordered fashion, it too would be representative of a negative Pareto function.

General Models

Within this category, two types of models will be discussed - parametric cost estimation and dynamic modeling.

Parametric Cost Estimation

Parametric Cost Estimation is the primary costing methodology for DoD weapon system acquisition. This approach evolved from research by RAND Corporation in the late 1950's. The basic idea was to make accurate estimates of weapon system costs at the early stages of system design. This approach uses performance variables such as speed, weight, range, power, etc. to predict costs since estimates of these parameters are usually known early in the design phase.

These estimates are based on historical data of previous or similar systems and utilize statistical relationships between cost and the performance parameters of these past or similar systems. These statistical relationships, called cost estimating relationships (CER), take the form of an equation using cost as a function the performance variables and constant coefficients. McNichols (20) describes the relations in simplified format by:

$$C = f(X) = f(X_1, X_2, \ldots\ldots X_n)$$

where X_1 denotes, a performance parameter. The total cost would then depend on each of the values of X_1 based on data from historical or similar systems. McNichols criteria for selection of the variables is given by:

- The logical or theoretical relation of a variable to cost (thus implying that a real dependence between cost and the value of the particular variable or set of variables exists, subject to some random disturbance or uncertainty.)
- The statistical significance of the variable's contribution to the explanation of cost (thus implying that relevant cost experience exists to test and calibrate the postulated cost dependence - subject to measurement uncertainty.)
- The dependence pattern of the contribution made by a variable to the explanation of cost (thus the analyst must have sufficient confidence in the relationship that he is willing to extend it to estimate a new item - and different analysts will have different degrees of confidence).

There are several adavantages to the parametric cost estimation approach. First, since the method consists of a series of CER's and requires aggregation, it is easly adapted to a computer. Output and turnaround for new estimates can be obtained quickly when compared with the detailed engineering approach. Second, sensitivity analysis is easily performed using this method. For any change in a given parameter, the corresponding change in cost is easily determined. Third, cost/benefit analysis or trade-offs are also easy to perform. Fourth, each time a later generation system is estimated, the historical data base already developed can be updated and used.

The approach is not without its disadvantages. First, the cost of computer resources could be significant. Collection of the data is time-consuming as well as subjective. Second, keeping the database relevant is a major problem. Haese (14) states that the tremendous technological advances of weapon system state-of-the-art have tended to outdate cost data even before it is reported. Thus, cost data collected on the latest weapon system may not represent the cost of <u>current</u> technology. With changes from discrete components to integrated circuits, from compound metals to composite materials, etc., what, if any, historical technology is similar enough to any proposed weapon system to allow valid design and credible cost comparisons? Third, the relevance of the cost data base is equally influenced by differences in weapon system acquisition management philosophies, contractual approaches, contract types, and resources available. Fourth, the comparability of the cost data among contractor generated cost reports produces serious problems. Often, it is difficult to understand what the collected cost data represents.

Dynamic Modeling

Computer-based dynamic modeling was proposed by J.W. Forrester in the 1950's as an approach to help solve problems of complex, continous systems. Forrester states that a dynamic model of a system should have the following characteristics:

- A statement of cause-effect relationship.
- Simple mathematical relationships.
- Be extendable to large numbers of variables without exeeding the computer limitations.
- Be able to handle "continous" interactions in the sense that any artificial discontinuities introduced by solution-time intervals will not affect the results. It should, however, be able to generate discontinous changes in decisions when these are needed.

A dynamic model is based on four factors that have improved understanding of complex systems:

- The theory of information-feedback systems.
- A knowledge of decision-making processes.
- The experimental approach to analysis of complex systems.
- The digital computer as a means to simulate realistic mathematical models.

Dynamic models should be based on the following premises:

- Management decisions can be shown as information-feedback systems.
- Model experimentation can show the way system components interact to produce unexpected over-all system effects.
- Systems are internally constructed in a way that creates many of the effects that are attributed to external causes.
- Policy and structure changes can be made that will produce substantial change in system performance.

Dynamic system models contain four essential features:

- Levels within the systems; e.g. - number of employees, work in process.
- Flows rates that represent changes in contents from one level to another.
- Decision functions that are used to control the rates of flow between levels.
- Information channels that connect the decision function to the levels.

Expansion of the concepts presented by Forrester into an acquisition model could contribute to a better understanding of the likelihood of cost overrun and disruptions. The main advantage of dynamic simulation is that it forces managers to clearly define their decisionmaking. This approach leads to greater insights into the acquisition process.

However, dynamic modeling is not without disadvantages. Among these are:

- In simulation, all relevant variables and phenomena must be quantified. The reduction of all descriptive knowledge to quantitative measures is not always valid.
- Dynamic simulation is found to be most useful in price-quantity problems, less useful in organizational design, and least-useful in external product-market strategy.
- Dynamic simulation is not easy to apply. It is a complex technique that needs considerable data and knowledgeable people.

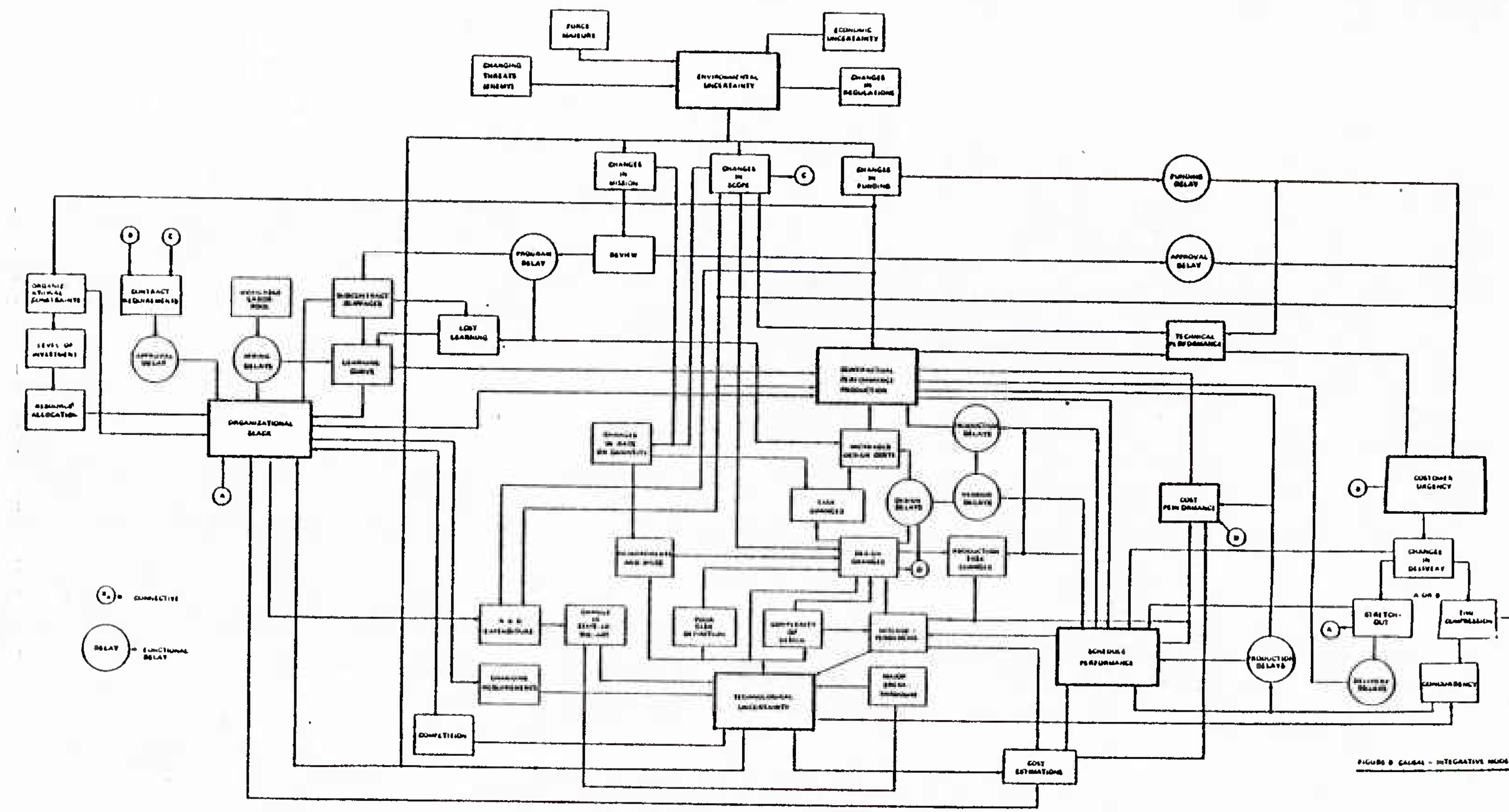

FIGURE 8. CAUSAL-INTEGRATIVE MODEL

- There are problems in acceptance of the approach because it is often considered a research tool.

Causal Integrative Model (CIM)

An extension of the dynamic modeling approach is described as a causal integrative model. The modle shown in Figure 8 describes the processes, flows, variables, feedback loops, delays, exogenous variables and key decisions as they are related to the four basic variables in the acquisition process shown in Figure 2. As noted earlier, acquisition models currently being used do not address all of these variables, thus, each of there models lacks some degree of completeness.

Referring to Figure 8, the Causal-Integrative Model can be used, for example, to determined how a change in economic uncertainty affects the level of environmental uncertainty which, in turn, affects mission, scope, and funding. These changes perturbate the system to effect changes in organizational slack, technological uncertainty, and customer urgency. Thus, a change in one variable can be shown to cause changes in the others through the pervasive network of interdependencies. These changes in a key variable impact the acquisition cycle in ways that are not intuitively obvious without the aid of a dynamic model to point out the causal relationships.

Representative Module of the CIM

A modular approach was used to develop the Causal-Integrative Model. This method entails developing one module at a time in a dynamic mode and interfacing it with the rest of the model being kept in a static mode. After the first module is developed and the interfaces are valid, a second module is then developed and integrated into the total model. The interfaces of the two modules are then tested for proper operation with the same approach used for the single module. This process is repeated until all the modules are completely integrated into one model with many submodels on modules. Data from projects can then be used to test the model for variations in actual versus predicted values.

The aggregate variable Organization Slack (OS) will be used to briefly demonstrate this modular process for the single module. From Figure 8, the subvariables for Organizational Slack are those shown in Table 5. Added to this Table are some criteria measures that can be used to quantify these subvariables.

Organizational Capacity (ORCA) - people, experience levels

Organizational Demand (ORDE) - hours required for task

Subcontract Slippages (SUSL) - percent delay, time

Change in Scope (CHSC) - variation from contract, percent change

Level of Resources Allocated (REAL) - people, budget levels

Learning Curve (LECU) - rate of learning effects

Key Personnel Turnover (KPTO) - percent change

Key Equipment Delays (DEKE) - percent time

Subcontractor/GFE Delays (DESE) - percent time

Changes in Technological Uncertainty (CHTU) - state-of-the-art advances, complexity, # of components

Changes in Rate/Quantity (CHRQ) - production required concurrency

Level of Competition (LECO) - price levels in real percentages

TABLE 5 SUBVARIABLES FOR ORGANICATIONAL SLACK

As an initial step, the development of the OS Module would start with a system dynamics representation of the events and processes that make up this aggregate variable. Once this step, and the programming effort is completed, test data for the subvariables can then be used to check the module operation. Data inputs from outside of the module can be of either table "look-up" type or of functional relationships (curves). Thus, when the module "needs" external values, they are developed from computations utilizing the functional relationships or from a data matrix.

With programmatic test data in the module and empirical data used in the rest of the CIM, the output variables can then be observed as functions of changes in the Organizational Slack module. For example, output curves of Cost Performance can be generated by varying the Level of Resource Allocated (REAL). Sensitivity studies could be made regarding Cost Performance and the impact of variation of the Organizational Slack subvariables on this output peformance mesure.

The direction in acquisition management prompted by this approach requires the following:

- development of a complete computer-based model,
- testing of the model with a completed program,
- validation of the model using current programs,
- implementing the model for policy level decisions in acquisition management.

CONCLUSION

The material presented here has attempted to highlight important advances that have been made in improving the acquisition process. Because of the pervasiveness of the subject, of necessity, not all relevent research or applications could be included. Rather, what has been presented here can be considered as indicative of the current state-of-the-art in acquisition management and a baseline approach for future developments.

At the outset, the report emphasized the need for a causal basis for under standing the factors that affect cost overruns. A number of illustrations were presented that clearly identify that cost growth is a phenomena that is related to the acquisition of complex projects, both civilian and military. Further more, that four primary variables contribute to cost growth. These include environmental uncertainty, technological uncertainty, customer urgency and organizational slack. The discussion pointed out that program control as currently practiced, is not appropriate to avoid cost overruns. A number of research reports were cited which showed reasons for cost overruns. Among the key contributors to incurring higher than budgeted costs are the four primary variables in the acquisition process described.

Having established a basis for understanding why cost overruns occur, the next consideration was to examine risk and uncertainty aspects of the problem. This material provided a foundation for the section on a causal basis for defining uncertainty. A number of studies were presented to help understand what causes uncertainty and how to approach it in the acquisition process.

For example, it was pointed out that uncertainty and disruption cannot be eliminated, but rather can be controlled if there are causal models such as relating cost to advance in state-of-the-art.

Given the foundation presented to this point, a set of causal relations among variables in disruption and uncertainty were examined in order to establish a "pattern of disruption". This was followed by the section on current approaches to acquisition modeling, including ones used for risk analysis.

The final section presented a "Causal-Integrative Model", which illustrates the complex relationships that exist among the variables that affect the acquisition process. Although this is a preliminary model, it provides a basis for integrating the approaches to date to managing the acquisition process. It includes many causal sub-models, such as concurrency, learning curve, dis ruption, etc. It also covers the dynamic interdependencies that exist and the treatment of risk and uncertainty as integral parts of the model.

Acquisition managers who use more sophisticated tools can improve the potential of cost control. Obviously, no set of tools or techniques is a substitute for the management process; however, the well informed program manager can increase the likelihood of decisions in "managing" cost. The causal integrative model approach described offers the potential for achieving this goal.

BIBLIOGRAPHY

1. Allen, Wayne H., Should Cost/Will Cost/Must Cost: A Theory on Cause of Cost Growth . U.S. Army Safeguard Office, Arlington, VA June, 1972.

2. Arvis, Paul F. Business/Procurement Strategy , US Army Procurement Research Office, Ft. Lee, VA. Jul 1980(est.) LD-41596.

3. Augustine, Norman R. "Augustine's Laws and Major System Development". Defense Systems Management Review , Spring, 1979, p.50-76.

4. Cheslow, Richard T. and Dever, James R. "Acquisition Costing in the Federal Government." Defense Systems Management Review. Autumn, 1979. Vol.2 No.4 p.7-16.

5. Cockerham and Associates, Inc.; U.S. Army Total Risk Assessing Cost Estimate (TRACE) Guidelines . Hopewell, VA, Dec. 1976. AD/A036-327.

6. Davis, Guy W. The Dilemma of Uncertainties Associated with Cost Estimating in the Project Management Office , Defense Systems Management College, Ft. Belvoir, VA. May, 1976. LD-36420A.

7. Cochran, Edward B., and Rowe, Alan J. "The Sources of Disruption to Project Cost and Delivery Performance", Proceedings of Eighth DoD Symposium on Acquisition Research. West Point, NY 1978.

8. Cochran, EB. "Measuring and Predicting Production Disruption Costs Due to Design Uncertainty and Delivery Urgency "Proceedings of Ninth Annual DoD/FAI Acquisition Research Symposium June, 1980.

9. Duvivier, G.F. "Technological Advances and Program Risks." Technological Forecasting and Social Change, Vol 2, No. 3-4, 1971. p.277-287.

10. Forrester, Jay W., Industrial Dynamics , MIT Press, Cambridge, MA., 1961.

11. Freeman, Rowland G., III. "Major Systems Developed: Lessons Learned." Program Manager's Newsletter, Jan/Feb, 1979, p.1-7.

12. Harvey, Thomas E. "Concurrency Today in Acquisition Management" Defense Systems Management Review Winter, 1980. Vol.3 No.1 p.14-18.

13. International Maritime Associates, Inc., A Study of Ship Acquisition Cost Estimating in the Naval Sea Systems Command, Executive Summary, Washington, D.C., Oct, 1977, AD/A046-976.

14. Haese, Edward J. "How Useful Are Historical Costs?" The Air Force Comptroller . July, 1977 p.34-36.

15. Lincoln, James B. Managing Total Acquisition Time: A New Priority for Major Weapon Systems . Defense Systems Management College, Ft Belvoir, VA. May, 1977.

16. Lochry, Robert R. et al, Final Report of the USAF Academy Risk Analysis Study Team , US Air Force Academy, CO. Aug. 1971. AD/729-223.

17. Mann, Greg A. "VERT: A Risk Analysis Tool for Program Management" Defense Management Journal . May-June 1979. p. 32-36

18. Marschak, Thomas, et al, Strategy for R&D: Studies in the Microeconomics of Development . RAND Corporation, Santa Monica, CA. 1967.

19. Martin, Martin D., Lenz, Joseph D. and Glover, William L., "Uncertainty Analysis for Program Management," Project Management Quarterly , Vol. VI, No.3 (1975), pp. 15-18.

20. McNicols, G.R. On the Treatment of Uncertainty in Parametric Costing . Unpublished PhD dissertation, George Washington University, Washington, D.C. 1976.

21. Merrifield, D. Bruce, Strategic Analysis, Selection, and Management of R and D Projects. AMACOM, New York, N.Y. 1977.

22. Merrow, Edward W. A Review of Cost Estimation in New Technologies: Implications for Energy Process Plants . R-2481DOE. RAND Corporation, Santa Monica, CA. July, 1979.

23. Moeller, William G. et al. Accelerating the Decision Process in Major System Acquisition, Washington: Logistics Management Institute, 1979.

24. Peck, Merton J., and Frederic M. Scherer. The Weapons Acquisition Process: An Economic Analysis. Boston: Division of Research, Graduate School of Business Administration, Harvard University, 1962.

25. Perry, Robert L. et al, System Acquisition Experience RM-6072-PR, RAND Corp., Santa Monica, CA. Nov., 1969.

26. Perry, Robert et al. Systems Acquisition Strategies, R-733-PR/ARPA, RAND Corporation, Santa Monica, CA. June, 1971. AD/730-921.

27. Press, S. James, et al Methodology for Subjective Assessment of Technological Asessment. R-1375 RAND Corporation, Santa Monica, CA. Apr., 1975.

28. Rowe, A.J. and Somers, I.A. "Methods to Measure, Predict, and Evaluate Cost Overruns." Conference on Risk and Uncertainty, U.S. Air Force Academy, February, 1981.

29. Spencer, David T. Alternatives For Shortening the Systems Acquisition Cycle: Milestone 0 to DSARC II. Unpublished research paper. Air Command and Staff College, Air University, Maxwell AFB, AL, 1979.

30. System Development Corporation. Risk Assessment Methodology. Rept-SDC-TM-WD-7999/001/003 McLean, VA. July, 1979. AD/A072-249.

31. Thomas, Thomas N., VERT- A Risk Analysis Technique for Program Managers. Defense Systems Management College. Ft. Belvoir, VA. May, 1977. LD-40483A.

32. U.S. Congress. Congressional Budget Office. Shaping the General Navy of the Eighties: Issues for Fiscal Years 1981-1985. U.S. Govt. Print. Off. Washington, D.C.

33. U.S. Congress. House. Committee on Government Operations. Inaccuracy of Department of Defense Weapons Acquisition Cost Estimates. Hearings before a subcommittee, 96th Cong., 1st sess. June 25 and 26, 1979. Washington: U.S. Govt. Print. Off., 1979.

34. U.S. General Accounting Office. Impediments to Reducing the Costs of Weapons Systems, PSAD-80-6. Washington, D.C. November 8, 1979.

35. U.S. General Accounting Office. Issues Identified in 21 Recently Published Major Weapon System Reports. PSAD-80-43. Washington, D.C. June 12, 1980.

36. U.S. Government, Department of Defense Directive Number 5000.1, Major Systems Acquisition. Washington, D.C. Jan 18, 1977.

37. U.S. Government, Department of Defense Directive Number 5000.2, Major Systems Acquisition Process, Washington, D.C. Jan 18, 1977.

38. U.S. Government, Office Management and Budget, OMB Circular A-109, Major System Acquisitions. Washington, D.C. April 5, 1976.

DETERMINING COST UNCERTAINTY IN BOTTOMS-UP ESTIMATING

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ABSTRACT

This study addresses the problem of determining the uncertainty associated with a conventional Work Breakdown Structure (WBS) estimate. It treats both the independent and completely dependent relationships among WBS elements to establish a probability region of cost risk.

Approximation methodologies are shown that are adequate for many (if not most) applications, and may be performed on a hand held calculator.

INTRODUCTION

This paper describes procedures for estimating the total cost uncertainty in a Bottoms-Up estimate by using the uncertainties in the individual task estimates. As long as the tasks may be considered independent a straight forward analytic procedure may be employed. However, dependency usually exists; for example, if some part of a project runs into trouble, other parts are almost always affected. Then a more complex approach must be employed.

Traditionally, attempts to improve a Bottoms-Up (Grass Roots) cost estimate have concentrated on improving the accuracy of the point estimate. Lately there has been growing interest in determining the amount of uncertainty in the estimate itself. This information can be used to identify estimating errors or can be considered a measure of the risk associated with the particular task.

The latter purpose was recognized in Revision 2 of DoD 5000.2 which stated that "Although there is considerable uncertainty early in the acquisition process, every effort must be made to use the best available data and techniques in developing estimates. Bands of uncertainty shall be identified for point estimates." This position has been spelled out in more detail in the recent DoD recommendation on New Management Initiatives (ASD R&D memo April 30, 1981) which has ordered the services to develop procedures to calculate this risk estimate and include it as an integral part of the budgetary process.

A Grass Root estimate consists in dividing the completed project into identifiable activities which taken together include all required tasks--a Work Breakdown Structure (WBS). The cost to complete each activity is separately estimated, usually based on a mixture of experience and analogy with previously completed similar tasks. These WBS element estimates are then added to become a total cost estimate. Usually man-hours are estimated and dollars are found by applying the rates applicable to each skill code. Also various additional factors are also included, such as indirect allocations, G&A and fee. These factors add some computing complication but do not change the basic approach, so they will be ignored here.

An uncertainty analysis covers the same ground. It uses the same WBS. However, the cost estimates of the individual WBS elements are expressed as probability distributions rather than point estimates. Then it adds the distributions to obtain a total probability function. This resulitng function expresses the range of possible costs in terms of their probabilities of being achieved.

INPUT DENSITY FUNCTIONS

Since we have stated that our estimates are to be expressed as probability distributions rather than point estimates, it is necessary to determine what form our input probability density function should take. If we assume that the project is technically feasible, then for each element:

- There is a greatest lower bound for the resources required for the task to be accomplished with a probability of zero.
- There is a least upper bound for the resources required for the task to be accomplished with a probability of one.

The actual shape of the density function is, in reality, unknown, and probably unknowable. We can, however, assign characteristics to it that would be logical.

1. It should have fixed, positive upper and lower bounds
2. It should not be necessarily symmetric
3. It should be unimodal
4. It should be computationally simple.

Many density functions meet all or most of these criteria. Perhaps the most widely used is the Beta distribution suggested by the pioneering work of Dieneman (3), and used by Klein (5, 6) and many others. McNichols (8) uses a Weibul distribution, which does not require the strict feasibility assumption since it is open ended at the top. In this paper, we will use the triangular distribution. It is completely characterized by three points, low (l) with an associated probability of zero, mode (m) the most likely, or modal value, and high (h) with an associated probability of one. We usually assign the modal value to the nominal or point estimate. This distribution meets the criteria mentioned above, and a very useful characteristic is that its inverse transform is closed form and quite simple, making it very convenient for Monte Carlo or other simulations.

The requirement, then, is for three estimates for each element, l, m, and h. In some cases the analyst may feel uncomfortable with trying to estimate the zero and one probability points. In this case, we ask for a low estimate (l') and an associated probability of underrun (s), the mode (m) and a high estimate (h') and a probability of overrun (p). The l and h values are calculated easily as shown in Appendix A-1.

In some instances it may only be possible to assign bounds to the estimate. In that case, we use the uniform distribution. The characteristics of the triangular and uniform distributions are described in detail in references (9) and (10).

INDEPENDENT ELEMENTS

If it can be assumed that these estimates, or WBS elements are independent, then our normal approach is to use the method of moments. This approach follows the general approach of McNichols (7) and is described in detail in references (9), (10), and (11). For this reason, only a brief summary is included.

If X is a random variable with mean μ (first origin moment) and using the nomenclature $\mu^{(i)}$ to signify its i^{th} central moment, then its additive moments Ai are as follows:

$$A_1 = \mu$$

$$A_2 = \mu^{(2)}$$

$$A_3 = \mu^{(3)}$$

$$A_4 = \mu^{(4)} - 3\,(\mu^{(2)})^2$$

The useful property of these A moments is that for all independent x_i, the A moments of the sum of the x_i's is the sum of the A moments of the individual x_i's.

To perform the analysis, we determine the four A moments of the input distribution and add them to determine the output distribution's A moments. We then fit a Beta distribution to these four moments (reference (1)) and assume that it represents the output density function. We have developed a library of fortran subroutines to determine these for triangular and uniform distributions and for the Beta fit.

A main program is written to input the data, call out the required subroutines, and supply required formatting. These programs are also written in BASIC for the HP 9830, and are being translated into BASIC for the HP 9845.

Use of the four additive moments enables us to shape the output density function, since a function of A_4 and A_2 defines the kurtosis, or peakedness, and a function at A_3 and A_2 defines the skewness. The output Cumulative Distribution Function (CDF) is easily found by a simple numerical integration, and the output probability statements obtained from this.

By examining the element results, useful insights may be obtained into the risk elements of the project. The risk drivers are those elements with the greatest variance, while the cost drivers are those with the greatest means. They are not necessarily the same.

DEPENDENT ELEMENTS

We have used three approaches to perform a cost risk analysis where the independence assumption cannot be made. (it is our intuitive opinion that the independence assumption is usually invalid)

1. Simulation
2. Moment Function
3. "Quick" and Dirty" Triangle

1. Simulation

For the simulation of dependent elements, the "slice" technique was used. This technique is described in detail in reference (2). Briefly, the same input is made to the inverse transform during a single pass through the elements as used by Haise (4), except that we do not use a random input. By using this "slice" technique, good results are obtainable in as low as 100 iterations, although we prefer a much larger number. In the example that follows, "TEST PROGRAM" used 10,000 iterations. This was done on a HP 9845 and took about 40 minutes running time.

2. Moment Function

For the moment function approach we use the fact that for the sum of dependent random variables (i.e. correlation coefficient = 1 for each pair) the standard deviation of the sum is the sum of the standard deviations as shown in Apprndix A-2. The mean of the sum is the sum of the means for any set of random varibales (independent or not). For each of our elements, we calculate mean and standard deviation, and sum to characterize the resulting output mean and standard deviation. It must be recognized that the skewness and peakedness characteristics of the output cannot be defined since we use only two moments. Strictly speaking, the most conservative approach would be to use two moment Tchebycheff-Markoff inequalities to define the probability bounds, but for convenience, and supported by much emperical deta, we characterize the output density function as normal, with mean and standard deviation as described above. With these caveats in mind, we feel that the moment function approach is suitable for many, if not most circumstances.

3. "Quick and Dirty Triangle"

The "Quick and Dirty Triangle" (QD) is not on as firm an analytical foundation, but seems to be a good approximation, as we will show in our example, and supported by emperical data. We sum lows, modes, and highs and say that for the dependent case, the output density function may be approximated by a triangular distribution whose low, mode, and high values are the sums of the element lows, modes, and highs. Note that we maintain a skewness function. Generally, the QD triangle will be more peaked than the results obtained by simulation (which we assume are close to the real result), and the modal value is open to some question.

With the output density function thus characterized, the CDF and other probability statements are found, as shown in Appendix A-3

CALCULATIONS

To facilitate calculations and to provide a tool that an analyst can use without resort to a computer, the moments function approach for the dependent case, method of moments (first two only) for the independence case, and the QD triangle have been programmed for use on a hand held TI 59 calculator. The calculations in the worksheets for the two examples which follow were prepared using the TI 59. Frankly, at the beginning of this study, we had no idea of simplifying the procedures to the extent that a simple hand held calculator could perform the required computations. It seemed to develop itself as we progressed. We feel that it is one of the most valuable results of our efforts.

Documentation and a users manual are not complete at this time.

EXAMPLE 1 "TEST PROGRAM"

As shown on the INPUT DATA section of the Risk Analysis Worksheet (Figure 1), this analysis consists of four triangular and two uniform inputs. The low, mode, and high for each input

TITLE TEST PROGRAM ANALYST J. WILDER DATE 3-30-82

INPUT DATA					ELEMENT RESULTS	
	ELEMENT	LOW	MODE	HIGH	MEAN	STD DEV
1	TRIANGLE 1	3	4	9	5.33	1.31
2	TRIANGLE 2	5	8	15	9.33	2.09
3	TRIANGLE 3	6	8	13	9.00	1.47
4	TRIANGLE 4	5	9	13	9.00	1.63
5	UNIFORM 1	4	–	10	7.00	1.73
6	UNIFORM 2	8	–	16	12.00	2.31
	Σ	31	48	76	51.67	10.55
					$\Sigma\sigma^2$	19.28

NOMINAL 48 EXPECTED 51.67

CUM PROBABILITY POINT			
%	IND(0)	DEP(1)	QD
95	58.89	69.03	68.06
90	57.30	65.20	64.78
80	55.36	60.55	60.13
60	52.78	54.34	53.55
50	51.67	51.67	52.42
40	50.56	49.00	48.50
20	47.97	42.78	43.37
10	46.04	38.14	39.75
05	44.44	34.31	37.18

Z VALUES	
%	Z
95-05	1.645
90-10	1.282
80-20	0.842
60-40	0.253

Figure 1 Risk Analysis Worksheet

are entered and the mean and standard deviation recorded on the worksheet. The summaries, as indicated, are provided by the calculator program.

As explained before, for the Independent and Dependent cases, we assume normality with means as indicated and standard deviations of $\sqrt{\Sigma\sigma_i^2}$ and $\Sigma\sigma_i$ respectively. To calculate our Cumulative Percentage Points (CPP), (i.e. for any arbitrary value at cost, the CPP is the probability that the cost will be the arbitrary value or less) we use the appropriate z value from a table of standard normal deviates. The worksheet lists some values of z for this purpose.

Examination of the worksheet can point to mean and uncertainty drivers, and provides the required probability statements.

We ran the independent case by our standard method of moments, and the dependent case by a 10,000 iteration "slice" simulation. We plotted the dependent density function derived from the "slice" simulation and the QD triangle (Figure 2). As expected, due to the two rather powerful uniform inputs, the simulation density function is fatter than the QD triangle and has a lower modal value. An all triangular example would show closer correspondence.

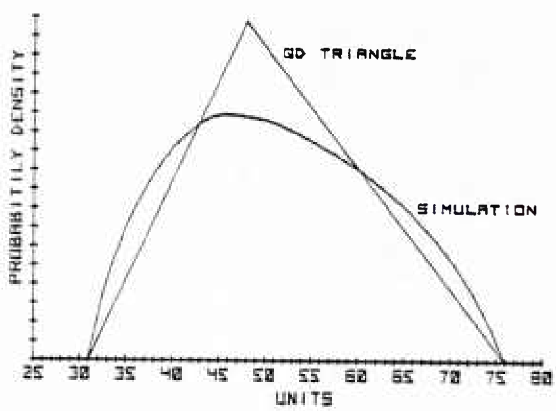


Figure 2 Test Program Density Functions (Dependent Case)

Figure 3 shows the CDFs for the independent case determined analytically by the method of moments, and for the dependent case determined by the simulation. Points calculated with the TI-59 calculator for dependent, independent, and QD triangle are shown. The correspondence between the various methods is remarkably close when it is considered that uniform distributions were part of the input.

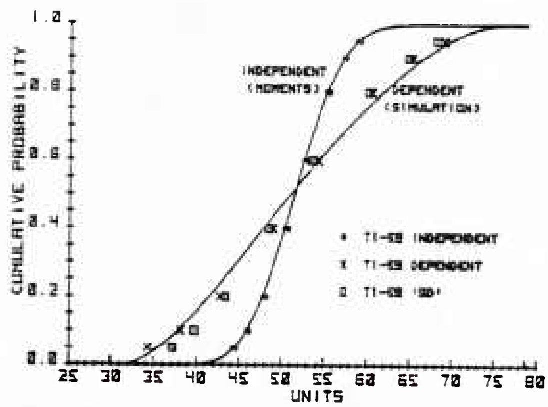


Figure 3 Test Program Cumulative Distribution Functions

EXAMPLE 2 PROJECT "M"

This example was done at level 4 of a project WBS. This level consists of 63 elements, as shown on the worksheet (Figure 4). As mentioned before, mean and variance drivers are easily identified and may be singled out for management attention. The reason for choosing this example was to show that in spite of rather large spread in most of the inputs, the leveling effect of the independence assumption gives the impression, as seen in Figure 5, that the project has a very low level of uncertainty, when, in fact, it was felt to be quite risky.

It is also interesting to note that using the independent assumption, the probability of achieving the nominal estimate (sum of the modes) was substantially zero, while the QD triangle approach calculates a probability of .27 (the r value).

In Figure 5, the curve of independent case was determined by the standard method of moments, and Beta fit technique. The hand calculator results for dependent and independent assumptions are shown. The dependent CDF was generated by the "QD".

CONCLUSIONS

Calculating the probability distributions for a WBS based cost risk analysis using both the independence assumption and the completely dependent assumption provides bounds for the analysis. The specific location between these bounds will depend upon the estimated degree of dependency.

Useful approximations to these bounds, which should be adequate for most analyses may be made with the use of a simple hand held calculator such as the TI-59.

TITLE PROJECT M ANALYST J. WILDER DATE 3-18-82

	INPUT DATA				ELEMENT RESULTS	
	ELEMENT	LOW	MODE	HIGH	MEAN	STD DEV
1	347.04	500	642	1000	714	105
2	349.04	15000	15525	22000	17508	1592
3	351.04	3000	3588	4500	3696	309
4	352.04	400	508	600	503	41
5	353.04	1000	1141	1300	1147	61
[illegible]		600	778	1250	875	137
			333	440	358	30
				2000	1720	104
				[illegible]	11488	
55	677.04					
56	678.04	321				
57	679.04	0				
58	680.04	5603	5914	6000		85
59	710.04	400	418	550	456	33
60	720.04	350	445	500	448	41
61	730.04	100	190	220	170	25
62	932.04	300	320	350	390	57
63	902.04	0	0	0	0	0
	Σ	88923	97923	122745	103197	7267
					$\Sigma\sigma^2$	4182054

NOMINAL 97923 EXPECTED 103197

CUM PROBABILITY POINT			
%	IND(0)	DEP(1)	QD
95	106551	115152	116266
90	105819	112514	113582
80	104919	109316	109787
60	103714	105036	104420
50	103197	103197	102437
40	102680	101358	100301
20	100575	97078	96726
10	100575	93880	94440
05	99833	91242	92824

Z VALUES	
%	Z
95-05	1.645
90-10	1.282
80-20	0.842
60-40	0.253

Figure 4 Risk Analysis Worksheet

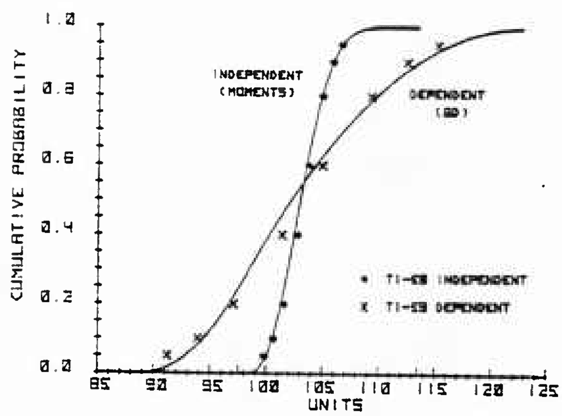


Figure 5 Project "M" Cumulative Distribution Functions

REFERENCES

(1) Black, R.; Fitting a Beta Distribution from Moments; Grumman Aerospace Corporation, PDM-OP-79-115, 12 June 1979.

(2) Black, R.L. and Wilder, J.J.; Probabilistic Cost Approximation When Inputs Are Dependent; Grumman Aerospace Corporation, PDR-OP-1382-01 Presented at the 1982 ISPA Conference.

(3) Dienemann, P.F.; Estimating Cost Uncertainty Using Monte Carlo Techniques; The Rand Corporation, RM-4854PR, January 1966.

(4) Haese, Edward J.; Cost Uncertainty/Risk Analysis; USAF System Command, March 1976

(5) Klein, Michael R.; Treating Uncertainty In Cost Analysis; The Beta Distribution; U.S. Navy CNO Resources Analysis Group March 1973.

(6) Klein, Michael R. and Jordan, Harley R.; An Application Of Subjective Probabilities To The Problem Of Uncertainty In Cost Analysis; U.S. Navy CNO Resources Group, November 1975.

(7) McNichols, G.; On The Treatment Of Uncertainty In Parametric Costing; PhD Dissertation The George Washington University Program In Logistics, 2 February 1976.

(8) McNichols, G.R.; Treatment Of Uncertainty In Life Cycle Costing; Proceedings 1979 Annual Reliability and Maintainability, Symposium, IEEE.

(9) Wilder, J.J.; An Analytical Method For Cost Risk Analysis; Grumman Aerospace Corporation, PDR-OP-T79-12, 27 June 1977.

(10) Wilder, J.J.; A Simplified Approach To Monte Carlo Cost Risk Evaluation; Grumman Aerospace Corporation; PDR-OP-T73-27, 11 July 1973.

(11) Wilder, J.J. and R. Black; Using Moments In Cost Risk Analysis Proceedings of "Management Of Risk and Uncertainty In The Acquisition Of Major Programs", U.S. Air Force Academy, February 1981.

APPENDICES

1. Determination of triangular distribution characteristics when low and high estimates are not at probability 0 and 1.

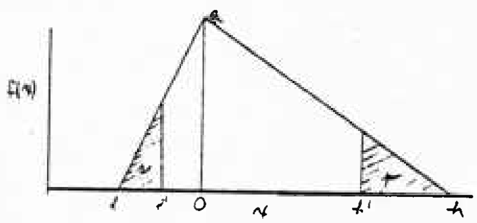
2. Second Moments for Dependent Case

3. "Quick and Dirty" Cost Risk Analysis

Determination of l, m, h when estimates of l and h are not at probability 0 and 1.*

Given X, Δ (l*, m*, h*)
and h'* is the high estimate with p, the probability of overrun
l'* is the low estimate and 1-s is the probability of overrun.

Without loss of generality, we subtract m* from each of these quantities, and show the density function as follows:



Since this is a density function, area = 1 hence

$$\frac{a(h-l)}{2} = 1$$

① $(h-l) - 2/a = 0$

Consider the Δ a, o, h

$a'/a = (h-h')/h, \; a' = (h-h')/h$

$p = (h-h')\, a'/2 = a\,(h-h')^2/2h$

Solving for h

② $h = h' + p/a + \sqrt{(2\,h'p)/a + p^2/a^2}$

In the same way using Δ a, o, l

③ $l = l' - s/a - \sqrt{s^2/a^2 - (2\,l's)/a}$

Substituting 2 and 3 into 1 and multiplying through by a

$f(a) = (h'-l')a + (p+s+2) + \sqrt{2h'pa+p^2} + \sqrt{s^2 - 2l'sa} = 0$

$f'(a) = (h'-l') + h'p/\sqrt{2h'pa + p^2} + l's/\sqrt{s^2 - 2\,l'sa}$

Using the Newton Raphson solution

$$a_{n+1} = a_n - f(a_n)/f'\,(a_n)$$

Using $a_o = 1.8/(h'-l')$ a converges very rapidly.
and h and l are found by using this value of
a in ② and ③

Example:

L',.Xx= 10 0.1
MODE = 18
H',.XX= 25 0.05

LOW = 4.196744201

MODE = 18

HIGH = 28.5951748

---

*Unpublished memo R. Dowd to J. Wilder March 1982

Second Moments for Dependent Case

Let $Z = X + Y$

then $\sigma_Z^2 = E(Z^2) - E(Z)^2$

$$= E((X + Y)^2) - E(X) + E(Y))^2$$

expanding and taking expectations, we have

$$\sigma_Z^2 = E(X^2) - E(X)^2 + E(Y^2) - E(Y)^2 + 2(E(XY) - E(X)E(Y))$$

① $$\sigma_Z^2 = \sigma_X^2 + \sigma_Y^2 + 2(E(XY) - E(X)E(Y))$$

Correlation coefficient ρ is defined

$$\rho = (E(XY) - E(X)E(Y))/\sqrt{V(X)V(Y)}$$

if $\rho = 1$, then

$$E(XY) - E(X)E(Y) = \sqrt{V(X)V(Y)}$$
$$= \sigma_x \sigma_y$$

Substituting in ①

$$\sigma_Z^2 = \sigma_X^2 + 2\sigma_X\sigma_Y + \sigma_Y^2$$

$$Z^2 = (\sigma_X + \sigma_Y)^2$$

$$\sigma_Z = \sigma_X + \sigma_Y$$

By induction it can be shown that

if $Z = \Sigma Xi$

$\sigma_Z = \Sigma\sigma X_i$, if $\rho = 1$ for all X_i pairs

APPENDIX 3

"QUICK AND DIRTY" COST RISK ANALYSIS

This approximates the dependent case for a sum of triangular distributions (a few uniform distributions won't make too much difference, use $m = (h + l)/2$).

1. Estimate low(l_i), mode(m_i), high(h_i) for each element i
2. Calculate $L = \Sigma l_i$, $M = \Sigma m_i$, $H = \Sigma h_i$
3. Calculate $r = (M-L)/(H-L)$

Let P(.xx) be the Cumulative Percentage Point (CPP), i.e., for any arbitrary value, P is the probability that the cost will be that value or less.

4. For $P > r$, $p = 1-P$

   $CPP = H - \quad p(H-L)\ (H-M)$

   For $P < r$, $p = P$

   $CPP = L + \quad p(H-L)\ (M-L)$

Example:

Let $L = 10$, $M = 17$, $H = 30$

$r = (17-10)/(30-10) = .35$

90% CPP $P = .90 > .35$, $p = 1-P = .1$

CPP (90%) $= 30 - \quad .1\ (30-10)\ (30-17) =$ 24.90

30% CPP $P = .30 < .35$ $p = P = .30$

CPP (30%) $= 10 + \quad .3\ (30-10)\ (17-10) =$ 16.48

APPLIED RISK ANALYSIS WITH
DEPENDENCE AMONG COST COMPONENTS

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ABSTRACT

The assessment of uncertainties in component costs, a method of combining these uncertainties for determining the total cost uncertainty, and a method of presentation for risk analysis results are discussed in this paper. An extension of the method of statistical risk analysis which uses the Weibul distribution and the method of moments is developed for incorporating covariance between component costs.

I. INTRODUCTION

When estimates and objectives are being established for contract negotiations, numerous sources of information are available and must be sensitized by the persons responsible for preparing a pre-negotiation briefing. Within ASD these persons are assigned to the Directorate of Pricing and are referred to as price analysts. The price analyst has the responsibility of determining and negotiating a fair and reasonable price for a contract.

The information available to the price analyst is generally point estimates of components which directly affect the total cost (e.g., material cost, overheads, labor hours, etc.). These point estimates for components are generally derived by engineering, cost, or price analysis. By combining these point estimates for components, one can derive a point estimate for the total cost of the contract.

Seldom are the component costs known with certainty unless there are firm purchase orders, negotiated overhead rates, fixed wage rates, etc. The components which are not fixed at the time of negotiations are the components for which a point estimate is not sufficient unless one has a crystal ball. The components not fixed will be referred to as uncertain components.[1] Risk analysis is a procedure for taking information about the uncertain components and reflecting how much uncertainty exists in the total cost. An uncertain component such as the manufacturing labor hours is often referred to as random. This is not to say that management cannot control labor hours, but simply implies that under good management the specific amount of manufacturing labor hours required cannot be determined specifically; therefore, there is still some uncertainty or randomness.

Risk analysis is basically a three-phased procedure. First, the contract must be analyzed to determine where uncertainties exist and to determine the magnitude of the uncertainty for each component. Second, the component uncertainties must be combined to reflect the uncertainty in the total cost. Third, the resulting total cost uncertainty must be used and presented in a way that aids in the decision-making and understanding of the contract under consideration.

The second phase of the risk analysis is the link between component uncertainty and total cost uncertainty. This phase is often considered to be the risk analysis; however, the first and third phases are the most important in implementation. The second phase has been approached many different ways making different assumptions and using different methodologies [1, 2, 3, 6, 7, 10]. Section II contains the assumptions made, the information concerning components required, and the results provided by the second phase of the risk analysis. Section III contains an explanation of how the resulting total cost uncertainty can be used and how it can be presented in order to provide the decision-maker with valuable information. Section IV contains a description of how the price analyst can assess the uncertainty in the components. Section V provides an example of the use of a computer program designed to perform the calculations to combine the component uncertainties into the total cost uncertainty. In Section VI, several recommendations are made concerning improving the usefulness of risk analysis.

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[1]Technically many authors differentiate between risk and uncertainty, but the two terms will be used interchangeably in this paper.

II. STATISTICAL RISK ANALYSIS

In order to discuss the component uncertainty and total cost uncertainty, we use probability distributions. The area under a probability distribution represents a probability of an uncertain quantity having a value between two points. For instance, in Figure 1, the probability (p(c)) of the uncertain component cost being between $1,000 and $2,000 is given by the amount of area shaded.

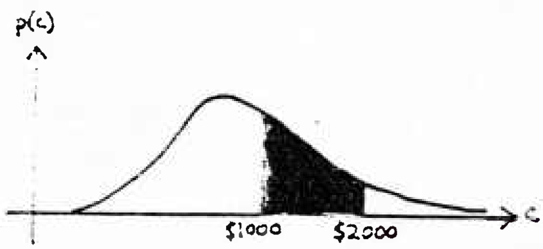

Figure 1

In order to describe component uncertainty and total cost uncertainty, the Weibul distribution has been chosen. The term "Weibul distribution" is used to describe characteristics of the probability distributions. For instance, the Weibul distribution can have many different shapes. (See Figure 2). There is a lower limit on component costs but no upper limit. By no upper limit we mean that the curve is asymptotic to the axis. The probability of extremely large over-runs is, however, approximately zero. The skewness of the Weibul distribution is a desirable characteristic for describing cost.

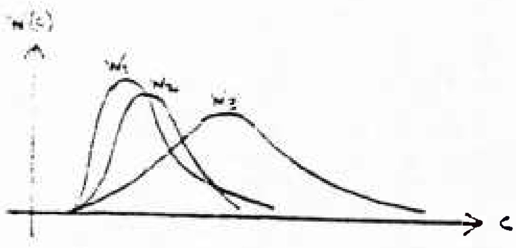

Figure 2

The price analyst must supply the information necessary to choose the appropriate Weibul distribution. The information required is three estimates of the component. First, the price analyst must estimate the component's most likely value. This is the value which has the highest probability of occurring. Second, the analyst must estimate for the component a value for which there is only a one percent chance of being less than that value. In other words, under the best circumstances, what would the component cost actually be? The third estimate is the high value for the component, one which has a one percent chance of being exceeded. In other words, under the worst circumstances what would the component cost actually be? The three points are denoted ML, L, and H respectively. The three points and a resulting Weibul distribution are shown in Figure 3.

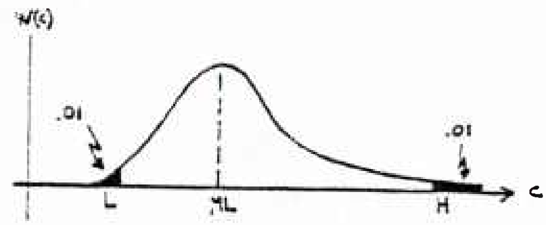

Figure 3

Naturally, a different L, ML, and H would give a different shape to the distribution for the component cost.

The components for which the analyst must supply the L, ML, and H are basically the same as those used in the DD Form 633. They are:

- Material Cost
- Material Overhead (not based on Material Cost)
- Material Overhead Rate
- Interdivisional Transfer Cost
- Engineering Hours
- Engineering Wage Rate
- Engineering Overhead (not based on Engineering Cost)
- Engineering Overhead Rate
- Manufacturing Hours
- Manufacturing Wage Rate
- Manufacturing Overhead (not based on Manufacturing Cost)
- Manufacturing Overhead Rate
- Other Cost
- General and Administrative (G&A) Expenses
- Other Cost with no G&A Expenses

If a component is known with certainty, then L = ML = H. Section 4 contains information which should be useful to the price analyst in determining the L, ML, and H for each component.

By putting the three estimates for each component into the computer model described later, the distribution for the total cost uncertainty is determined. That is, the probability of exceeding different values is printed. These probability statements are made using a Weibul distribution for the total cost. The computer program takes the information supplied by the analyst for the components and determines the best Weibul distribution for the total cost uncertainty.

The preceding estimates are used when the analyst is asked to assess each component independently. But quite often when one assesses the uncertainty for different components (e.g., the amount of material and the amount of manufacturing labor), there is a common underlying reason for this uncertainty. This is called a covariance between the components. The model being used allows the component uncertainty to be broken into two parts. The first part of the uncertainty for a component is independent of events which affect other components. The second part of the uncertainty in each component is dependent on a common set of events. For instance, part of the uncertainty concerning the amount of material and manufacturing labor hours may be dependent on the amount of rework. Therefore, material cost and labor hours would not be independent. To provide this information to the model requires the price analyst to assess the portion of the uncertainty in each component between the Low and High which is attributable to the same influences.

If one of the components is independent, then the portion of the uncertainty attributable to common factors should be zero. If the effects are in different directions (one positive and the other negative) this can be reflected by using a negative proportion. Again, assistance in assessing the amount of covariance is presented in Section IV.

The price analyst is asked to assess the amount of dependence between the set of components listed below:

- Material Cost
- Material Overhead (not based on Material Cost)
- Interdivisional Transfer Cost
- Engineering Hours
- Engineering Overhead (not based on Engineering Cost)
- Manufacturing Hours
- Manufacturing Overhead (not based on Manufacturing Cost)
- Other Cost
- Other Cost with no G&A Expenses

It should be observed that the covariance between the components is a function of one set of common factors or events. This single set of factors is assumed to cause the specific proportion of variation.

In summary, the assumptions made in the statistical risk analysis are:

1. Component uncertainty can be represented using a Weibul distribution. This assumption is based on what most analysts feel is a reasonable expression for the behavior of cost uncertainties.

2. Total cost uncertainty can be represented using a Weibul distribution. This assumption is based on the same reasoning as above plus the fact that the Weibul chosen to represent the total cost will have the correct first three moments (i.e., mean, variance, and skewness).

3. The dependence between components' uncertainties is related to a common set of influences or factors.

Naturally, the results of the risk analysis are only as good as the information supplied by the analyst. It is the opinion of the author that these assumptions are intuitively reasonable and represent the current state of the art.

III. RESULTS, USES, AND PRESENTATION

As with any mathematical or statistical technique, the purpose of risk analysis is to supply information to a decision maker. The forms of this information and the interpretation are critical in risk analysis. Its use must be considered as only one input into development of a negotiation objective. The overall business strategy considers many factors. The risk analysis should be performed in an impartial, objective manner without regard to gaming, political climate, etc. Analysts should prepare and/or present analyses based on their best judgment of the uncertainties involved in the contract.

Quite often the amount of uncertainty in the total cost is considered unacceptable by a decision maker. This would indicate that more analysis is needed on some of the components. The specific component or components causing the large amount of uncertainty in the total cost can be determined through sensitivity analysis. An unacceptable total cost uncertainty may be the result of viewing the results with a knowledge of the political climate. Care should be taken not to "fix" the risk analysis results. This is one piece of information for decision making and not the decision.

When the information concerning the amount of uncertainty is presented, the primary drivers should identified. Effectively, one says how much uncertainty exists and why. Actions may be desired on the reasons for uncertainty. Ways of presenting the total cost uncertainty will now be discussed.

At the time of negotiations the future actual cost, since unknown, must be estimated. Risk analysis does not estimate the cost but rather estimates its distribution. A distribution is a pictorial representation of the probabilities of different final actual costs. The probability density function, Figure 4, is one way of presenting the probabilities of different final actual costs. This figure relates <u>area to probability</u>.

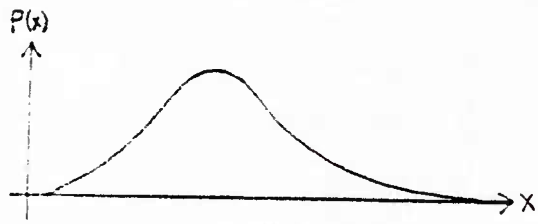

Figure 4

An easier way of presenting this same information is to use the cumulative distribution shown in Figure 5. From this figure one can determine the probability of exceeding a given total cost by reading the Y axis. For example, from Figure 5 we can see that the probability of exceeding $3,000 is .3. This would mean that there is a .7 probability of being less than $3,000.

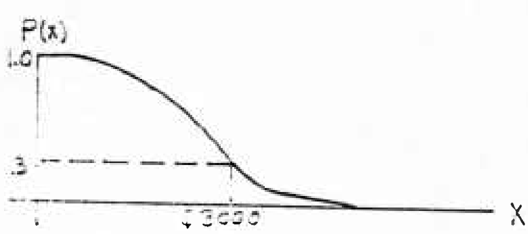

Figure 5

Usually from a risk analysis, two other pieces of information are available. These are the mean and the mode. The mean reflects the average total cost if the contract was executed many times. Of course, the contract is executed only once and, therefore, the mean may not be the best point estimate. The mode, on the other hand, is a good point estimate since it represents the most probable total cost. Contrary to intuition, the most probable total cost is <u>not</u> the sum of the most probable component costs. This can best be illustrated by using a simple example. Suppose we have two loaded dice, where the "one" is twice as likely to occur as the 2, 3, 4, 5, or 6. The analogy is that the dice represent the uncertain components, each having a most likely value of 1 since each is loaded. Intuition may tell us that the most likely total of the two dice would be 2. This is not the case however. The probability of a 2 with these two dice is 4/49, whereas, the probability of a 7 with these two dice is 8/49. The total of 7 is twice as likely. The same is true for the most likely total cost. That is, the resulting total cost by summing the most likely values for each component is not the most likely total cost.

The presentation of the risk analysis results to convey the most information might best be accomplished using a display that gives the distribution of total cost, the important drivers, and the negotiation positions.

The rest of this section is devoted to discussing the use of risk analysis in structuring contract types. These results should not be considered rules, but rather suggestions which may be helpful. If the total cost uncertainty[2] is small (e.g., 4 percent), then a Firm Fixed Price (FFP) type contract would be appropriate. The price would be the most likely total cost plus profit as determined by the Weighted Guidelines (WG).

Although incentive contracts were designed to provide incentives to the contractor to keep the cost down, they can also be structured to distribute the risk in a contract. For instance, if the uncertainty in total costs is between 4 and 16% and the share ratio is 60/40 (government/contractor), then the contractor is only accepting 40% of the risk or between 1.6 and 6.4% reduction in profit, or, given the share ratio remains the same, an increase in profit if there is a cost underrun. One might thus consider

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[2]When a single number is used to represent the uncertainty, it is usually the percent that the 99 percentile total cost exceeds the most likely total cost.

structuring a Fixed Price Incentive Firm (FPIF) contract by using the following rules of thumb:

Target Cost = Most Likely Total Cost
Target Profit = WG (including risk)

Ceiling Price =
99 percentile Total Cost Plus
WG (excluding risk)

$$\text{Share} = \frac{\text{WG (including risk)} - \text{WG (excluding risk)}}{\text{99 percentile} - \text{Most Likely Cost}} \times 100$$

See the example in Section V for structuring an incentive contract.

Of course, these are only guidelines and may be totally unacceptable for a particular contract. For instance, if the decision has been made to use a FFP type contract or specific share ratios or ceilings, then these guidelines need not be applied. If a contractor has the same uncertainties as the government (say 16%), then the contractor will most likely not consider a FFP Contract with a price equal to the most likely cost plus WG profit. The contractor would naturally try to negotiate a price which would cover a majority of the risk. It is important to note that the uncertainty in total cost might be totally different from the contractor's point of view as opposed to the government's point of view.

In summary, the total cost uncertainty is a result of the uncertainty assessed at the component level. The accurate reoresentation of the total cost uncertainty and the reasons for this uncertainty constitute one input into the decision making. This information reflects the uncertainties involved in a contract and should be only one part of sound business decisions. Its use in decisions on contract type, again is only one of many factors to be considered. It can, however, show the effect of different contract types when uncertainties exist.

IV. ASSESSING UNCERTAINTY

The assessment of uncertainty is by far the most difficult task in a risk analysis. It is important to have the proper perspective of the problem when one is attempting to develop the estimates for the low, most likely, high and the dependence for the components of the total cost. This perspective includes:

1. Estimates are for the actual future cost and not the cost which can be negotiated. Actual future cost should be estimated when determining a fair and reasonable price.

2. Risk is associated with uncontrollable factors without regard to controllable factors such as gaming, political climate, etc.

3. Risk analysis is only one input into development of a negotiation objective.

4. Results of the risk analysis will reflect the inputs; nothing more, nothing less.

It is sometimes difficult for a decision maker on one side of a contract to relate to a risk analysis which is useful for determining a fair and reasonable price (the one mentioned above). Therefore, another analysis viewing the risk from the Air Force point of view might be useful. This analysis would not attempt to estimate the future actual total cost, but rather attempt to estimate the price which the contractor would accept. The two analyses differ considerably because of the point of view. There are really two questions. First, what is the distribution of actual total cost? Second, what is the distribution of the resulting negotiated cost at the end of negotiations? In the strictest sense, the second question is not generally addressed by a risk analysis, but can be answered by estimating for each component the cost acceptable to the contractor. Even though the bottom line is the result of the negotiations, acceptable levels of each component can be estimated. The discussion in this section will address the estimation of component costs when the distribution of actual total cost is desired.

Table 1 contains a list of drivers for the uncertainty involved in a contract. This list is presented here as a thought provoker and is not meant to be all inclusive.

The analyst must use all of the resources available in order to estimate the uncertainty in each component. These resources include:

- historical records
- experience
- support groups (engineering, etc.)
- contractor's track record
- similar contracts

The resulting estimates may be either subjective or a combination of subjective and standardized factors.

Subjective estimates are difficult to make and to evaluate; therefore, there is often differing opinions of the correct values. When subjective estimates are used, try both a conservative and a liberal set of estimates. This requires running the model twice. Many times you will find that the results are approximately the same. A risk analysis model is very useful in assessing the "What If" questions. Don't be afraid to try different inputs to determine the effect on the total cost distribution.

Table 1

Cost Uncertainty Drivers

Material Elements

- Extent of firm POs
- Extent of established vendors
- Projected inflation
- Reliability of estimated allowance factors
- Design maturity
- Critical items

Labor Elements

- Design maturity/deficiencies
- Reliability of estimating methodology (L/C/ratios/estimates/LOE)
- Impact of schedule slippages
- Relatable historical experience
- Employment population
- Production capacity

Labor and Overhead Rates

- Status of union agreements
- Status of FPRA
- Projected inflation
- Period of performance
- Variance of direct cost elements
- Variance of plant volume

Other Costs

- Reliability in estimating methodology
- Impact from direct cost variances
- Reliability of factors

Assessing the dependence between component costs involves listing the common cost drivers inherent to all cost elements, e.g., design maturity, manufacturing methods, etc.; then estimating the proportion of uncertainty between the low and high which is due to these cost drivers. For instance, if the low material = 3000 and the high material = 7000, and the common cost drivers cause a total fluctuation in materials of 1000, then the dependence for material is 25% (i.e., 1000/(7000-3000)). Each cost dependence is assessed using the same set of drivers. See the list in Section II for the cost elements for which dependence is allowed.

A preliminary set of standardized factors have been developed at ASD Pricing. These factors are listed in Table 2.

Table 2

Draft of Standardized Factors for Risk Analysis

1. Material: This cost element is broken into several distinct sub-elements due to their peculiar nature.

a. Raw Material:

L%	H%	Score
-5	+7	1 - 90% firm purchase orders (POs), established sources - 2% or less critical material (titanium, chromium, etc.)
-5	+9	2 - 80% firm POs; 5% critical material
-5	+12	3 - 70% firm POs; 10% critical material
-8	+20	4 - 60% firm POs; 15% or more critical material

b. Purchased Parts (Supplier designed items):

L%	H%	Score
-5	+7	1 - 90% POs
-5	+9	2 - 75% POs; 25% current quotes
-5	+12	3 - 50% POs; 25% current quotes, 25% history
-8	+20	4 - Less than 50% POs greater than 25% history

c. Subcontracts (Prime designed items):

L%	H%	Score
-5	+7	1 - 90% POs and current quotes
-5	+9	2 - 75% POs and quotes; 25% engineering estimates
-5	+12	3 - Less than 75% POs and quotes; more than 25% engineering estimates
-10	+25	4 - Inhouse engineering estimates + 50%

d. Special Material Factors (Scrap, rework, freight, receiving inspections, attribution):

L%	H%	Score
-5	+5	1 - Historical factors well supported.
-5	+9	2 - Design in minor state of flux
-6	+12	3 - Design not set; factors not reliable
-9	+18	4 - New program with little relevant history

Table 2 (continued)

L%	H%	Score
2. Engineering Labor:		
-5	+5	1 - Firm design sustaining type effort
-5	+9	2 - 50/50 mix of changes and sustaining effort
-8	+15	3 - Design set but many changes; 1st production phase
-10	+25	4 - New program; design not determined; little historical basis to estimates
3. Manufacturing Labor:		
-2	+4	1 - Firm standards, well documented learning curves
-5	+7	2 - 80% firm standards less reliable variance data due to limited history
-5	+10	3 - 1st production limited standards & variance data extensive tooling effort
-7	+15	4 - Model shop operation or RSED. Tool design not yet determined.
4. Labor and Overhead Rates:		
a. Status of Union Agreement:		
-2	+5	1 - Firm 2-3 yrs before renegotiation
-5	10	2 - No agreement through 1 yr before expiration
b. Status of FPRA:		
-3	+7	1 - FPRA negotiated
-2	+8	2 - Recommended rates within 5% of proposed
-5	+5	3 - Recommended rates at more than 5%
c. Projected Inflation:		
-2	+2	1 - Contract includes EPA clause
-2	-15	2 - No EPA - inflation less than/equal to field rec.
-2	+10	3 - No EPA - inflation more than field rec.
d. Period of Performance:		
-5	+5	1 - 1 year
-2	+10	2 - 2-3 years
-0	+15	3 - 4-5 years
-0	+20	4 - More than 5 years
5. Considerations That Are Equally Inherent to All Cost Elements:		
a. Design:		
-2	+5	1 - Firm design, mature program
-5	+7	2 - 2nd/3rd production lot changes predictable
-5	+10	3 - 1st production/pre-production
-8	+15	4 - Design/development phase

Table 2 (continued)

L%	H%	Score
b. Manufacturing Methods:		
-2	+5	1 - Standard defined, hard tooling
-5	+7	2 - 50% standards, production rate building
-5	+10	3 - First production hard tooling being developed
-8	+15	4 - Model shop, FSED

This list is a first draft and should be modified and added to as needed. Once an acceptable set of factors is developed, it will only be necessary for the analyst to supply point estimates and identify the characteristics of the contract as in Table 2. The computer could then apply the L% and the H% to the component estimates and perform the risk analysis. The decision maker would then know specifically the drivers, the amount of uncertainty introduced by each, and the resulting distribution of total cost.

The advantages of using standardized factors are:

1. Uncertainty is based on objective characteristics of the contract.

2. Uncertainty becomes less dependent on the analyst performing the analysis.

3. The amount of uncertainty due to characteristics of the contract can incorporate different view points of analysts and management, and

4. Uncertainty assessment is consistent between contracts.

An effort should be made to modify and revise the standardized factors to encompass additional reasons for uncertainty.

The next section demonstrates the use of a computer program useful for determining the total cost distribution from three point estimates of the components' costs.

V. EXAMPLE USE OF COMPUTER PROGRAM

Before presenting an example of the usage of this program, several input peculiarities need to be explained. A brief explanation is given below.

1. Overhead rates and dependency are entered as whole numbers (e.g., 50% is entered as 50).

2. The distance between the low and the most likely value should be less than 65% of the distance between the low and high. (i.e., (ML-L)/(H/L) $\leq$ .65)

3. If the computer responds with a question mark, additional input is needed.

4. If labor is entered as cost rather than hours, the L, ML, and H for wage rate should be 1, 1, 1.

5. Independence of component costs is given when D% is 0.

6. Conversion to 1,000 or 1,000,000 of dollars and hours may be desirable.

7. When dependence is considered, D% for material must be other than zero.

The user should always check the reasonableness of the results. If a problem is perceived, the inputs should be checked.

The program is available through the COPPER IMPACT computer system. It is executed by typing RUN RISKA$. An input form has been completed for a specific contract and is shown in Form I. The program takes the cost component input data supplied by the analyst and provides probabilities of exceeding various total costs.

The results of this analysis indicate that the most likely total cost is $19,708 and that there is only a 1% chance of the total cost exceeding $21,011.

Contract #________________
Date ____________________
Analyst__________________

FORM I

INPUTS FOR RISK ANALYSIS

Elements	Minimum	Most Likely	Maximum	Dependence	Comment
Material Cost	8,400	8,900	10,000	0	
Independent O.H.	--	--	--	--	
Rate for Mat. O.H.	5	5.2	6	xxx	
Interdivisional Transfer	1,700	1,850	2,200	0	
Engineering Labor Direct	35	45	65	0	
Wage rate	11.57	11.57	11.57	xxx	
Independent O.H.	--	--	--	--	
Rate for Eng. Lab. O.H.	102	102	102	xxx	
MFG Labor Direct	200	205	215	0	
Wage rate	11.04	11.5	12	xxx	
Independent O.H.	--	--	--	--	
Rate for MFG Lab. O.H.	150	150	150	xxx	
Other Cost with G&A	400	450	500	--	
G&A Rate applied to Subtotal	4.92	4.92	4.92	xxx	
Other Cost with no G&A	--	--	--	--	

In this example the 99 percentile is 6% larger than the most likely total cost. This example would be a case in which either an FFP or an FPIF type contract might be used. The price would be the target cost plus the weighted guidelines profit for an FFP contract, where the target cost is set by analyzing the results of the risk analysis. There is no way to state a hard and fast rule for determining the target cost; however, the following list of possibilities should be considered.

1. Target Cost = $19,708
   Target set at most likely total cost.

2. Target Cost = $19,774
   Target set so there is a 50% chance of over and under run.

3. Target Cost = $21,011
   Target set where the government absorbs 99% of the cost risk.

4. Target Cost = $18,900
   Target set where the contractor absorbs 99% of the cost risk.

The setting of a specific target would consider factors not included in the risk analysis but can be evaluated by the total cost distribution. For instance, if a target cost of $20,000 is chosen, there is approximately a 33% chance that the total cost will exceed $20,000.

For an FPIF contract, the procedure given in Section III might be used. For example, suppose that the weighted guideline was (including risk) 16% or (excluding risk) 12%, then the following would structure an incentive contract so that the most probable profit for the contractor would be 16% and there would be only a 1% chance of his having less than 12% profit. This is achieved by setting

Target Cost = $19,708
WG (excluding risk) = 19,708 · .12 = $2,365
WG (including risk) = 19,708 · .16 = $3,153
Point of total assumption = $21,011
Target Profit = $3,153
Ceiling Price = 21,011 + 2,365 = $23,376 (119% of target)
Share = (3,153 - 2,365)/(21,011 - 19,708) = .60 or 60%

Note that quite often this procedure will come up with unacceptable results. Always apply sound business judgment when analyzing the results of these calculations.

VI. RECOMMENDATIONS

Risk analysis can provide valuable information to decision makers if it is developed carefully and presented in a meaningful manner. Several suggestions are made here to facilitate its usefulness.

1. Uncertainty information should be requested from engineering and other support groups.

2. Several computer runs would be useful to answer the "what if" questions and to analyze the contract from different points of view.

3. Continued development of standardized factors would help to make the risk analyses consistent and, therefore, more meaningful.

4. Good business judgment should be used when using the results of the risk analysis.

References

1. Dienemann, P. F. "Estimating Cost Uncertainty Using Monte Carlo Techniques," RM-4854-PR, The Rand Corporation, January, 1966.

2. Fisher, G. H. Cost Considerations in Systems Analysis, American Elsenier Publishing Company, New York.

3. Klein, Michael R., Treating Uncertainty in Cost Analysis: The Beta Distribution, U.S. Navy CNO Resource Analysis Group.

4. McNichols, G. R., "Treatment of Uncertainty in Life Cycle Costing," Proceeding of the Reliability and Maintainability Symposium, 1979.

5. McNichols, G. R. and Moyer, R., "The Navy's Use of Analytic Procedures for Treating Cost Uncertainty in Parametric Costing," Proceedings of the 13th Annual Meeting of the Southeastern Chapter, The Institute of Management Science, 1977.

6. McNichols, G. R., On the Treatment of Uncertainty in Parametric Costing, Ph.D. Dissertation. The George Washington University Program in Logistics, February 1976.

7. Schaefer, D. F., Husic F. J. and Gutowski, M. F., "A Monte Carlo Simulation Approach to Cost-Uncertainty Analysis," March 1969.

8. Wilder, J. J. and Black, R., "Using Moments in Cost Risk Analysis," Proceedings of the Risk and Uncertainty Workshop, U.S. Air Force Academy, Colorado, 1981.

9. Worm, George H., "Structuring Incentive Contracts Using Risk Analysis," Proceedings of the Risk and Uncertainty Workshop, U.S. Air Force Academy, Colorado, 1981.

10. Worm, George H., "Application of Risk Analysis in the Acquisition of Major Weapon Systems," Air Force Office of Scientific Research and Air Force Business Research Management Center, 1980.

PANEL B

ACQUISITION INFORMATION MANAGEMENT

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DECISION SUPPORT SYSTEMS, DISTRIBUTED DATA PROCESSING, AND MANAGING THE SYSTEMS ACQUISITION PROCESS

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ABSTRACT

This paper explores how management of the systems acquisition process might be improved through the application of computer based Decision Support Systems (DSS) concepts. This approach calls for a meshing of individual decision styles, processes, and customized information requirements with significant supportive, personal computing power at the disposal of a program manager.

The combination of DSS and DDP concepts can result in an integrated decision/information network linking personal micro-computers and personal data bases with the central program data base and other program managers. In the paper Dr. Gardiner defines the DSS conceptual framework; Colonel Williams, USMC, provides a case study from the Marine Corps acquisitions experience; and Dr. de Balogh discusses the current state of DSS in acquisitions management and what needs to be done to develop such a capability.

INTRODUCING THE DSS CONCEPT

To start out I would like to set a continuum of Decision Support for the Acquisitions area which I'm not sure I believe in. But, at least it will give you an idea of where we are focusing this paper. If you can think of a computer-based information system that grinds out big stacks of paper, that's on one end for decision making. On the other hand, think of the TV series Star Trek, and recall what Mr. Spock used to do when something unusual came up. He'd run over and talk to the computer and ask for it's advice. Well, the millenium is not here yet, so we're nowhere near the Star Trek end but I think that decision support systems are designed to whittle away towards that direction.

The thrust of our paper is in the program management area. There is sort of a new environment afoot with the Carlucci-Weinberger initiatives now in place. You, the program manager, have more responsibility, authority, accountability and all that good stuff but still you are responsible for program cost, schedule and performance. The question is "How can Decision Support Systems Help?" First, in defining DSS we can say that it is designed to help knowledge workers in using data and models improve their performance by interactive computer based components to solve problems. What are these components? They are systems of hardware and software which amplify a manager's judgement. (See Figures 1-3) They don't replace him. There is a technical thing called a DSS generator. There are special languages involved. It is interactive so you can actually sit down and "chat" with it. It will adapt to changes in the program environment you can't anticipate when you originally built the thing. It is user friendly so you don't have to be exposed to a lot of "computerese" to use it. The user sits down at a terminal and there is a big thing in the back there called the DSS. It contains a data base which is managed and a model base with models "running around" waiting for use. The user talks with the DSS via a software system that allows him to translate what he wants to do in something fairly close to English or by choosing from a menu. Then the DSS goes to "talk" with its data base management system and its model base management system so the user can get the help he desires. There is an interface between the user, the models and the data.

Conceptually, the DSS provides the support for semi-structured and non-structured decisionmaking. What this means is that you can't cover all the contingencies. Things are bound to come that you can't preprogram for. DSS helps integrate decisions across decisionmaking boundaries, across organizational lines, and within groups and among individuals. It can help you make decisions, help you ask questions, and it can do this in an independent, personalized way.

This is quite different from most current Management Information Systems (MIS) that you are familiar with. MIS in many places is focused on middle managers. But, this is not necessarily true everywhere. MIS is primarily oriented around structured information flows and quite often integrates EDP jobs by function such as personnel and finance reports. There is a capability of inquiry and report generation, usually with a database.

However, DSS is designed specifically to support decision making at any and all levels. It crosses functional organizational boundries. Whatever you need to make your decision is theoretically provided by DSS. It is flexible, adaptable and quick. It is user-initiated and controlled. It does what you want to do when you want it to. DSS supports varied personal decision styles. This is very important because if you foist something that is not reflective of a decision maker's style, it may not get used.

Just a word about distributed data processing. This concept is designed to decentralize computer power to the users, through a network which links users together. When you put DSS and DDP together there is a very conceptual framework. DSS helps program managers in decisionmaking, in asking questions, or figuring out what questions to ask. DDP brings the power of the computer to the program manager. You put them together and it begins to allow the program manager to link his key people, provide computing power to his staff and also allows him to amplify his own judgement and look at how his program is progressing.

DSS AND THE MARINE CORPS: A CASE STUDY IN PROGRAM REQUIREMENTS ANALYSIS

THE USMC SYSTEM ACQUISITION PROCESS

To begin with I would like to describe a very simple model that might orient all of us exactly with the systems acquisition process. (See Figure 4) Most of that capability you need is relative to the weapons system. If the homework's been done, that weapons system and the ensuing combat capability is relative to the mission of the service. In turn, that is relative to who the enemy is and what his capabilities are.

The thing that most of us tend to forget when we start to lay out the first stages of the systems acquisition business is that it's just not a weapons system by itself. But, it is a weapons systems composed of the way you intend to use it, the organization that you use it in, the way you train with it and the way you support it. And I would propose to you that this is an iterative process that lasts throughout the life of the weapon system not just in the beginning but always. I liken it to a potter's wheel that has to be kept smooth throughout the life of the system because things always change. It is this change, I think that is best handled through a DSS in order to keep up with the dynamics of the system. So the system I have to talk about today, the mobile protected weapons system, I'd like to represent in a way with a view of the total process in mind and looking at the capability we try to acquire again in the terms of the iterative systems acquisition wheel that we try to look at. (See Figure 5)

DEVELOPING SYSTEM REQUIREMENTS FOR A MOBILE PROTECTED WEAPONS SYSTEM

One of the key components of the acquisition process is the big "R" -REQUIREMENTS- which always gives a person big problems: 1) trying to figure out precisely what our requirements are; 2) successfully communicating those requirements both to those who have the resources and to industry so you can get back what you had in mind; 3) industry's reaction to those requirements through their response in the sense of a proposal; and 4) our evaluation of that response.

In general terms, any requirements determination is certainly based on the analysis of the threat and it's capability. This calls for some anticipation of future of the world and what our environment might be like. There is the usual problem of making decisions in a realm of uncertainty. The operational experience of those who might be using the system and determining what qualities it should have must be incorporated. Accomodating technical reality in getting something that would really be there in the time frame that you wanted it and, an acquisitions strategy on how to get there all play a role. My case study is called "Mobile Protected Weapons Systems". Mobile in the sense that it is on wheels or tracks. It is a vehicular system. Protected in the sense that it has some armor protection. And, a weapons system in the sense that it has some kind of cannon on it. So, you are looking at this system as being a wheeled or tracked vehicle with a gun.

AN INTUITIVE MILITARY NEED

In this particular case, the requirements determination process had an intuitive need. (See Figure 6) The intuitive need goes back to the 1970's when several curious things were happening in both the Army and the Marine Corps. Some of the conventional weapons systems like the bazooka - the things that you typically shoot at bunkers and targets with - were eliminated from inventory in favor of more specialized weapons that were optimized for anti-tank roles. The anti-tank guided missile like the Dragon is an example. So, as the conventional munitions left and the missiles arrived in the inventory, we lost the kind of thing that you want to shoot at bunkers with. You don't shoot missiles at those kinds of things for practical reasons. Consequently, we experienced an intuitive need for something that you would shoot with at conventional targets. But, in view of our study of the Israeli war, it should have some degree of protection and some degree of mobility. We asked ourselves, what kind of enemy are we coming against? Are we going to be facing a T-64 or T-72 tank? If so, should we have the kind of systems that will always have the capability of wiping it out? Our interesting computerized analysis here indicated that whether we were fighting the Warsaw Pact or some other enemy some place in the world that the probability of facing what type tank was not a certainty. So, certainly one should keep in mind the true representation of the threat that is there. Most often there is the tendency to over-speculate the need, to over optimize it, and thus drive up the cost of the weapons system.

We tried to look at the systems we aspired to in terms of accurate use. There is a hierarchy that can be used to describe The Multiple Protected Weapons System in terms of effectiveness, protectiveness and cost in terms of whether it was assaulting or defending in blocking position; or whether it was involved in subsequent operations (sometimes attack and sometimes defense). This was further broken down in all kinds of attributes such as helicopter transport, survivability, mobility, firepower, etc. (See Figure 7)

The idea then was to take a system that we could field from an operational standpoint and evaluate it from the several kinds of tactical scenarios that we could imagine. It looked like to us there were two ways to field such a system. You could look at existing systems somewhere in the world. Some vendor might sell it to you. Or, something that existed that could be improved (we chose to call it a hybrid) could be used. Or, you could design it from scratch (we called it a conception). Each approach hinged on our being able to successfully convey to industry and to ourselves exactly what it was we really wanted. So the next logical step is to send out a RFP or something by a similar name with a statement of work, or a systems description. But, in our case we used an unusual approach.

The approach that we used in the Mobile Protected Weapons System case was unprecidented, and it harks back to the Decision Support System of the time and basic requirements. What was so new about it was that we took the challenge to industry. We didn't attempt to do anything ourselves. We assumed that the people that made the machines like this would be the people best able to integrate it and so consequently when we articulated our requirements to industry there were only six absolutely necessary requirements in the systems which we called non-variables. The point that applies here is that there were only six. Everything else was a variable. That is, there was a tradeoff. You could put various aspects of the system together in many different ways and hopefully come up with a system that was operable. We described our requirements again in terms of effectiveness, cost and other considerations under three scenarios. Each of those - under assault, under blocking and under subsequent operations - described the system in terms of the desired attributes. And under each of these, firepower, mobility and so forth are broken down into components. At this point, in order to describe to the manufacturer what our real sense of importance was we adopted what we called utility curve processes.

REQUIREMENTS DEFINED WITH UTILITY MODELS

Now let me show you what a utility curve is. (See Figure 8) This is what we are looking for in case of a material target. What it essentially says in terms of the basic load, the amount of ammunition on board the vehicle, and in terms of the utility curve here, and some parameter of an attribute I have here. I am very happy with using it as long as it takes no more than 1% to 3% of my basic load to knock out a target. But, if it takes more than that, I get unhappy in a hurry. Certainly, if it takes more than 20% of my basic load I'm not interested in the system that would be proposed. That is conveying to the manufacturer what I think of my operational experience. If you look at Figure 9 (accuracy) against me being stationary and the target being moving, I say I have to have a probability of at least .3, I would like to have the probability of a hit of 1. Further on the curve, I am about half satisfied of a probability of a hit of .8 and, Mr. Manufacturer, I'm much more interested in improving your proposal in this area because the curve is steeper than back in the lower area. That is what is being conveyed by the curve. Now, take all the curves and put them across the various scenarios. Take the attributes and put them in the same scenarios. (See Figure 10) Here, the specific numbers are important. What it does convey to the manufacturer is that in those three scenarios, firepower is more important in assault than it is in the other things. In these scenarios, mobility is very important in your attack. But, mobility is even more important in the subsequent operations. And, finally, we might say that helicopter transferability is important in any kind of assault. After all, I in my business have to get on the beach, maybe in my helicopter. It's doubly important if I have to put a helicopter in any sort of force that has a defensive mission. It is routinely important in routine operations. Now, the manufacturer has everything that I think is important described in the best way I can describe it to him both through scenarios, utility curves and attributes. That is exactly how the RFP was written when it went out to ten manufacturers calling for a nine-month concept design period.

CREATIVE INDUSTRY REACTION

The manufacturers reacted in somewhat a typical way. They put together appropriate management teams and evaluated our requirements on the basis of business and engineering considerations. They sought to optimize efficiency and effectiveness and control costs all within the bounds of the systems requirements. In doing this the manufacturers also took our utility curves and put them all into their computers. They also determined those things that were most sensitive from their point of view. Those attributes which would give them the most return on their design considerations. We found in talking with the manufacturers that this technique for communicating requirements was very useful. They knew exactly what the Marines wanted and they produced exactly what was desired. We have said any source selection process includes cost and effectiveness. It is a formal process as everybody knows. In the case here, I would just like to illustrate a couple of techniques that we anticipate using in the future.

DSS AND THE FUTURE

Obviously it may not happen exactly this way. But, within the DSS system that we put together, we can do some interesting things. First of all, we go back to the same kind of hierarchy that we had before. Except, in this case, we put weights on everything for storing procedures so that by assigning weights relative to our important criteria you can sum it all up and draw a conclusion. So, having weighted the same decision you looked at before and by loading it into the computer we're able to obtain a printout with all kinds of attributes to compare five manufacturers. (See Figure 11) (A-F) The numbers on this printout give you some idea of the relative value of these attributes and the whole order of things as compared to the lower numbers which obviously are of a lesser value to us. Between the bottom rung of numbers and the top rung you find a vast number in the middle. All these are totaled to indicate the true character of the proposal. The last example relates to what we hope the the model will do and that is to ask: "How come B is better than A?" (See Figure 12) In this case, one of the rungs lets us compare two of the alternatives, A to B, on a variety of attributes. Clearly, B has higher scores than A in this example. This model verifies that B is better than A in the top attributes. But, at the bottom where all the numbers turn negative, it shows that A is superior to B. We found this to be a very handy tool when trying to evaluate specific differences between manufacturers based upon varied scenarios. The Marine

Corps were able to use the DSS Approach in actually several different models with several different data bases. Hopefully, in the future these will be integrated into a single interactive DSS which will have even greater utility.

WHERE ARE WE AND WHERE DO WE GO FROM HERE?

I would like to touch on two areas in Decision Support Systems: 1) how you go about determining what you need; and 2) what exists out there that you could acquire or emulate. Dr. Gardiner set the conceptual DSS framework, Col. Williams has given us an illustration of the application of data and modelling in a Decision Support environment. The capability we are trying to achieve on behalf of program managers, whether they are in the services or are contracters, consists of three major components: 1) the program data base; 2) a library models (to include personal decision models) that the project needs; as well as, 3) a dialogue system for the decisionmaker. (See Figure 13) These must be integrated through a command language or set of menus. The achievement of this kind of balanced, integrated DSS is a rather difficult task.

DETERMINING YOUR DSS REQUIREMENTS

Determining what your needs are in terms of DSS for your area is approached a little differently from standard data processing. In other words, in most standard data processing applications, you do a lot of flow charting. You go down to a very precise level of detail. When we talk about decision support needs we want to be able to aid a group of managers or a class of decisionmakers. So, we're looking at a general needs for particular modeling, statistics, graphics, database management, and other capabilities. The requirements definition is hierarchic in nature. We identify the general DSS capabilities we want and then define them more precisely in 3 major areas - dialogue, data base, and modelling. Then we come up with a list of specific capabilities for each area. (See Figures 14-15) The acronym given to this approach is ROMC. You identify the representations that your managers utilize such as the kinds of output forms that they're interested in; the input forms that they are comfortable with; the graphics that they may be looking for; report generation characteristics, and so forth. In addition, you find out the kind of analytical modelling or operations that the program office wants to do. In terms of memory aids, we are talking about data files, database management, a "help" function for the user, the ability to store your own models, and a variety of other things. This has to be integrated and controlled interactively so you have a user friendly DSS support environment. Coming up with a program DSS that does all this is something that hasn't been achieved in very many places.

WAYS TO SATISFY YOUR DSS NEEDS

In this connection I would like to address the questions of "What is out there?" and "Who's got DSS stuff?" Basically there are bits and pieces out there in terms of Decision Support Systems. We really don't know of any good systems in the acquisitions area. We have plenty of vendors who want to sell us bits and pieces. For instance, if you want to start out in this area there are vendors like IBM with its PMS-4, SYSTONETICS and its VISION system; you could probably list a dozen others that could offer you something along those lines primarily in the cost, schedule and the performance areas. But all of those systems have certain strengths and weaknesses. Most of them are very inflexible. For example, adding the utility model that Colonel Williams talked about to a fancy system like VISION would be difficult. IBM's system is even more inflexible. We don't find any balanced DSS out there at this stage. You can turn to companies such as TYMSHARE that specializes in building DSS to your specifications. This can be very costly. The bits and pieces that are out there now do not meet the conceptual DSS framework that we have described.

Another approach is to say, "OK, I'm going to buy all of the basic DSS elements that I think are necessary for our particular program and I'm going to integrate (link) them." This is a very tough undertaking. You can acquire a database management system, graphics and statitistical software, etc. individually and try to construct a DSS. Some aerospace firms have tried this with only limited success. In our opinion, a great deal of research remains to be done with regard to the DSS concept in the acquisitions area. At the University of Southern California, we've established a Decision Support Systems Laboratory. We're looking into the adaptability of this concept not just in the acquisitions area but to other fields as well.

By way of summary, let me leave you with a couple of thoughts. We're all aware of the mushrooming of computer technology in our society. I'm sure that in many of your offices you're finding the phenomenon of the "office of the future" coming in with word processing and so forth. In many instances you may find that your secretary will have more personal computing power available to do her job than you do. A number of you may have also bought your own personal computing systems which you have at home helping you out. Again, it may very well be that what you possess as a private individual has a lot more power than what your company or service has provided you personally to do your job. The ultimate is when you think about the fact that when you buy an Atari or whatever for your children for educational and recreational purposes they're playing around with probably more computing power at their disposal than you have personally to do the serious job that you've got. What all this says is that DSS is clearly needed if major improvements in acquisitions program management are to be realized.

SELECTED BIBLIOGRAPHY

1. Sprague, Ralph H. and Carlson, Eric D. Building Effective Decision Support Systems. Englewood Cliffs, N.J.: Prentice-Hall, 1982.

2. University of Southern California. Institute of Safety and Systems Management and the U.S.A.F. Business Research Management Center Proceedings of Management of Risk and Uncertainty in the Acquisition of Major Programs, USAF Academy, Colorado Springs, Colorado, Feb. 9-11, 1981.

3. USAF Systems Command. Command Management Information System (CMIS). SMART-D USERS DIRECTORY (7 August 1979).

4. Rudesill, Steve, et al, SAM/DSS: System Acquisition Model Decision Support System. (University of Southern California, ISSM Paper, 1982).

5. Col. Larry Williams, USMC. "U.S. Marine Corps: Getting Technology Onto the Battlefield". Presentation to the AIAA Conference. Los Angeles and San Francisco, California. (22 and 26 October, 1981).

6. Alter, Steven L. Decision Support Systems: Current Practices and Continuing Challenges. Reading, Mass.: Addison-Wesley, 1978.

7. Keen, Peter G. and Morton, M.S. Scott. Decision Support Systems: An Organizational Perspective. Reading, Mass.: Addison, Wesley, 1978.

8. Captain Harold C. Bain, USAF, et al, A C/SCSC Decision Support System for the Ballistic Missile Office. (University of Southern California, ISSM paper, 1982)

9. Andriole, Stephen J. "Another Side to C3" Defense Management Journal (1979)

10. Neumann, Seev and Hadass, Michael. "DSS and Strategic Decisions." California Management Review (Vol. 22, No. 2, Spring 1980, pp. 77-84)

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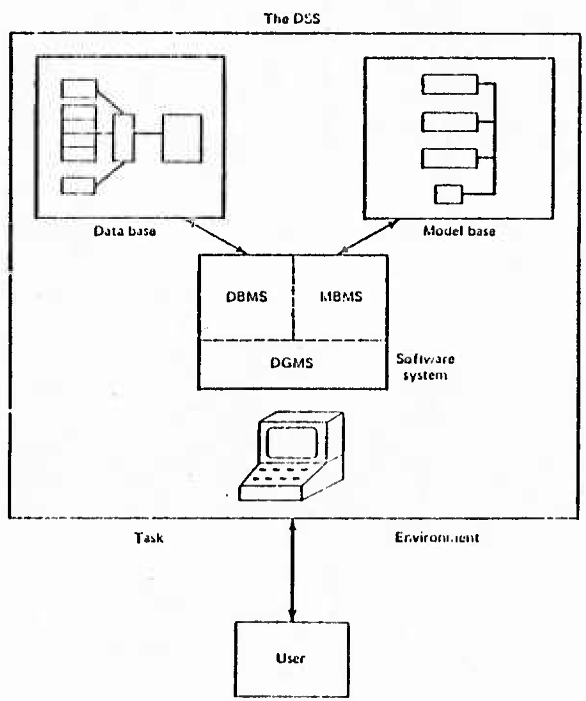
Los Angeles, California 90089

(213) 743-5119/4048

FIGURE 1

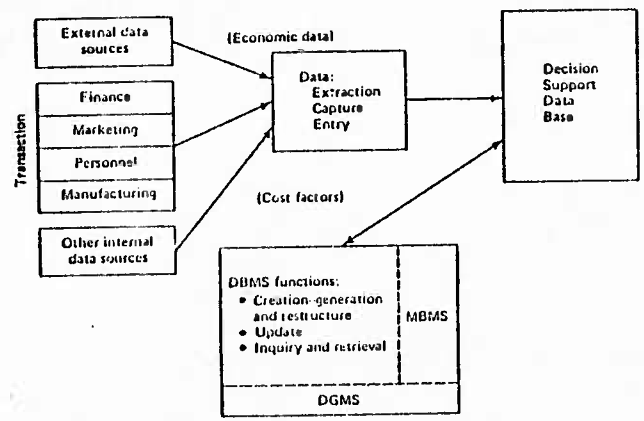
MAJOR DSS COMPONENTS



Source: Sprague, Ralph and Carlson E. Building Effective Decision Support Systems. Prentice Hall 1982.

FIGURE 2

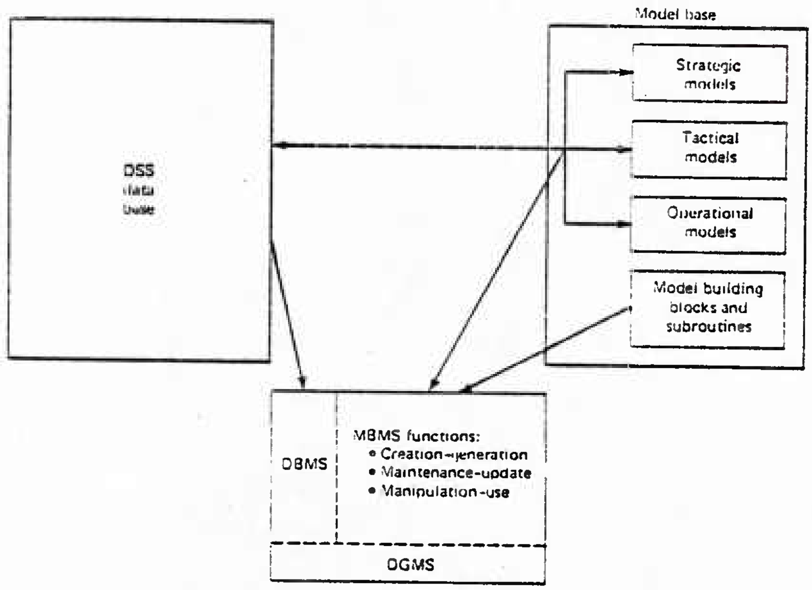
DSS DATA BASE COMPONENT



Source: Sprague, Ralph and Carlson E. Building Effective Decision Support Systems. Prentice-Hall 1982.

FIGURE 3

DSS MODELLING COMPONENT



Source: Sprague, Ralph and Carlson E. Building Effective Decision Support Systems. Prentice-Hall 1982.

FIGURE 4

UNITED STATES MARINE CORPS
MARINE CORPS SYSTEMS ACQUISITION

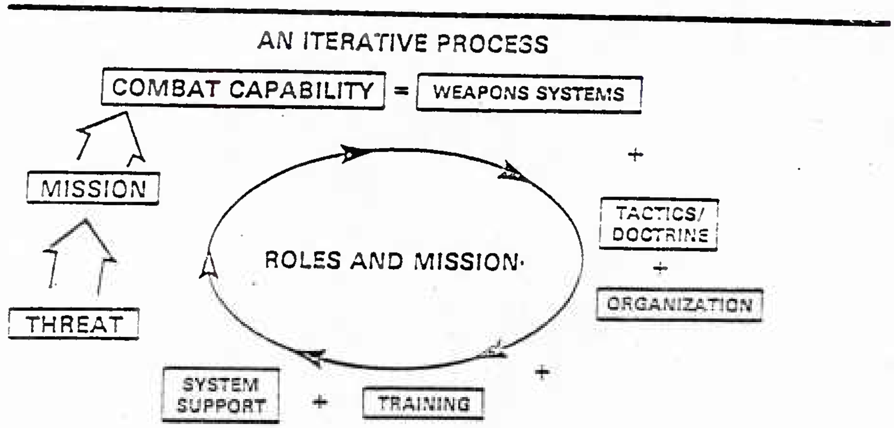


FIGURE 5

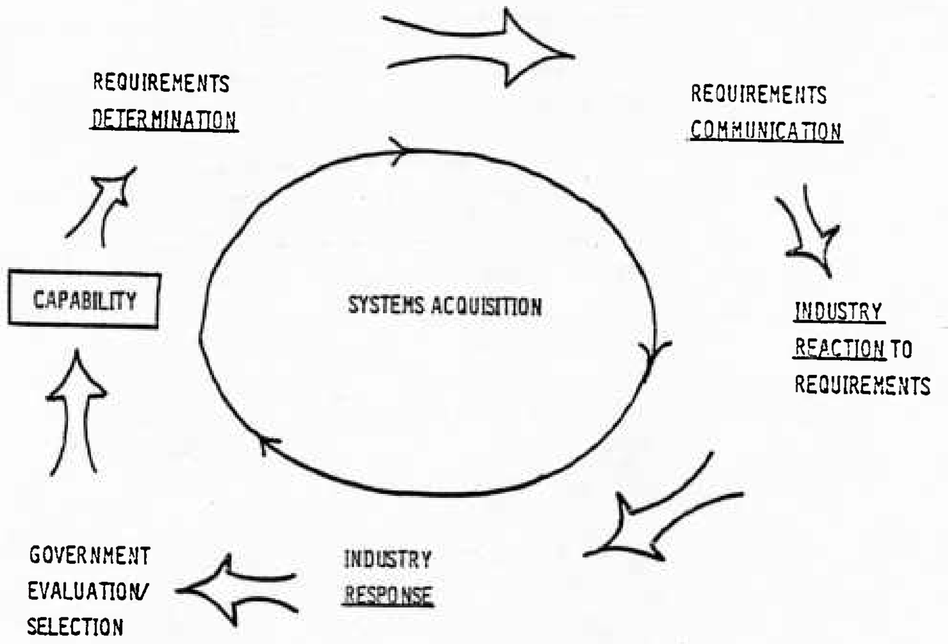


FIGURE 6

MPWS Requirements Background

Intuitive Need (Early 1970's)

- **Diminishing Naval Gunfire Support**
- **Increasing Enemy Air Capability**
- **Eroding Assault Gun Assets**
  - *ONTOS/Recoilless Rifle/ 3.5 in Rocket Launcher Deleted From Inventory*
- **Requirement for Increased**
  - *Armor Protection*
  - *Firepower*
  - *Maneuverability*

Reinforcement

- **1972-1973, MPWS Study**
- **1976 DARPA/USMC/USA ACVT Program**
- **1978 MPWS RCC**
- **1978-$5M Congressional Add-On**
- **1979-$5M Congressional Add-On**
- **1979 IOC of 1988 Approved**
- **1979 Acquisition Strategy Defined**

Substantiation

- **1973-1980, MPWS Concepts Study (SRI)**
- **1979-1980 ARMVAL**
- **1979-1980 Threat Definition**
- **1979-1980 Mission Area Analysis**
- **Mission Element Needs Statement**
- **1979-1980 Field Analysis Concept Test**
- **1979-1980 Foreign Vehicle Evaluation Study**
- **July 1980 Milestone — 0**

FIGURE 7

VARIABLE PERFORMANCE PARAMETERS OF MPWS

(EXAMPLE)

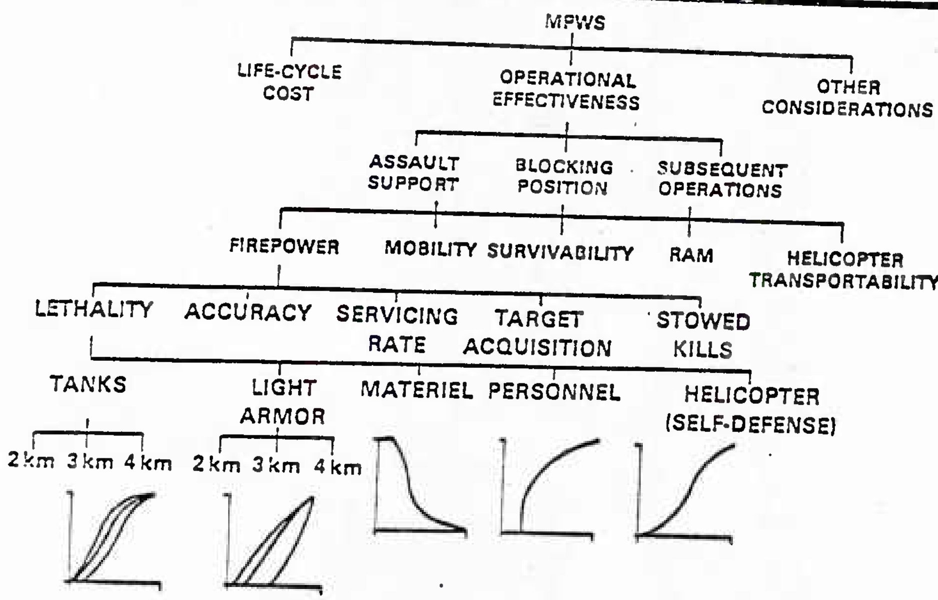
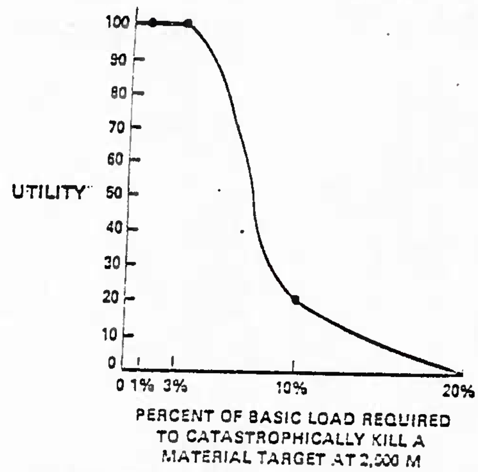


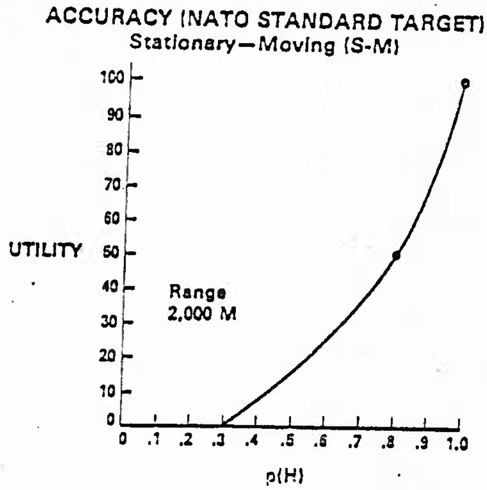
FIGURE 8

MATERIEL TARGET



- INCLUDES REINFORCEO CONCRETE, OTHER TYPE BUNKERS
- IMPORTANT WHERE TANKS CANNOT TRAFFIC (MOBA)
- MEASURED AS % OF BASIC LOAO NEEOEO FOR CATASTROPHIC KILL
- IF % OF LOAO IS HIGH, RESUPPLY IS TOO FREQUENT

FIGURE 9



- MEASURE IS PROBABILITY OF HIT, p(H)
- ASSUMES NATO STANDARD TARGET, RANGE 2000 METERS
- CROSSING SPEED OF 20 KM/HR
- EVALUATES MAIN GUN, SIGHT, AND FIRE CONTROL

FIGURE 10

—An Example—

RELATIVE IMPORTANCE:
OPERATIONAL EFFECTIVENESS

Operational Effectiveness	Assault Support	Blocking Position	Subsequent Operations	Range
FIREPOWER	34	29	29	29-34%
MOBILITY	20	17	24	17-24%
SURVIVABILITY	19	20	24	19-24%
RAM	10	13	17	10-17%
HELO TRANSPORTABILITY	17	20	6	6-20%

FIGURE 11

EVALUATION CRITERIA BY CUM WEIGHT

	(WT)	A	B	C	D	E	CUMWT	SUM
PENETRATION	(65)	49	100	0	27	55	8.17	8.17
FIRE DETECT	(65)	93	94	100	69	0	6.53	14.70
TRANSPORTABILITY	(75)	90	25	0	81	45	4.73	19.44
ACCURACY	(40)	0	0	100	0	0	3.30	22.74
ROAD SPEED	(55)	95	90	95	95	95	3.10	25.84
SAFETY	(21)	27	100	32	0	16	2.60	28.44
	←	200	ITEMS	→				
DUST SIGNATURE	(6)	0	0	0	0	0	.03	99.93
RANGE	(10)	36	28	52	41	28	.02	99.95
DESIGN	(50)	75	0	50	100	1	.02	99.97
TURRET	(50)	55	90	71	81	81	.02	99.99
AGILITY	(10)	0	0	0	0	0	.01	100.00

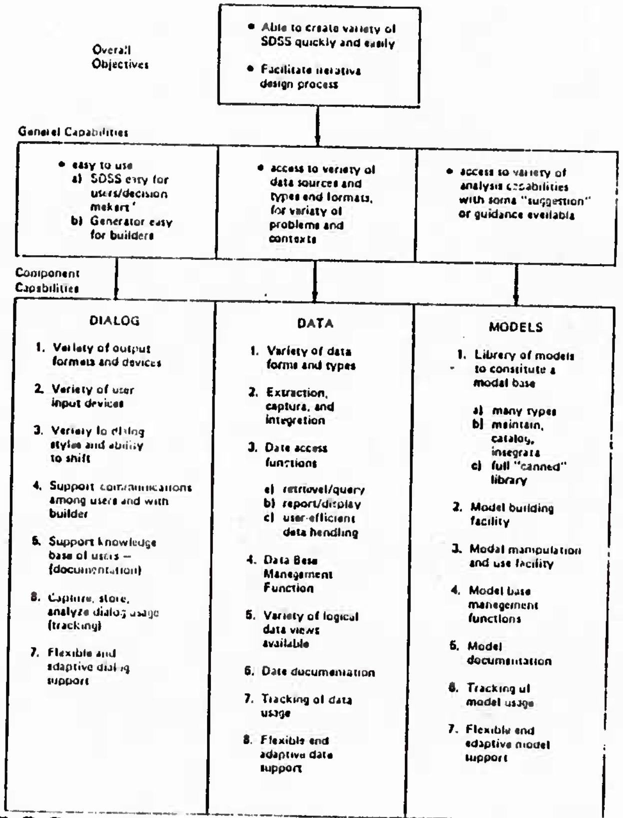
FIGURE 12

PAIR COMPARISON

DIRECT COMPARISON OF ALTERNATIVES A AND B

	(WT)	A	B	DISC 2
CDR STATION	(65)	49	100	3.51
DRIVER VISION	(21)	27	100	1.61
RANGE	(14)	42	100	1.20
SPEED	(50)	72	80	.75
ACCURACY	(75)	68	75	.50
DEPENDABILITY	(10)	35	100	.47
FUEL ECON	(70)	80	90	.33
← 200	ITEMS →			
SWIM	(25)	95	25	-.33
PENETRATION	(50)	82	50	-.83
AIR TRANS	(5)	82	50	-1.01
HELO LIFTABILITY	(25)	90	25	-1.03
NOISE	(30)	95	25	-1.03
IR SIGNATURE	(33)	30	0	-1.19
SMOKE GEN.	(75)	90	25	-3.08

FIGURE 13

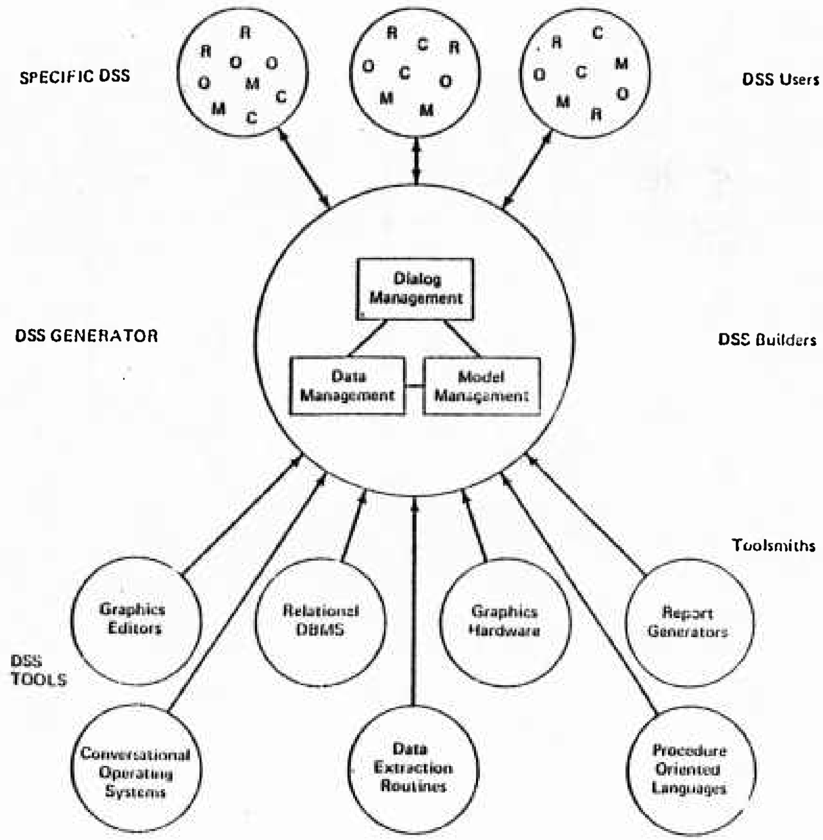


DSS COMPONENT CAPABILITIES

Source: Sprague, Ralph and Carlson E. Building Effective Decision Support Systems. Prentice-Hall 1982

FIGURE 14

ROMC



Source: Sprague, Ralph and Carlson E. Building Effective Decision Support Systems. Prentice-Hall 1982.

FIGURE 15

DSS REQUIREMENTS ANALYSIS - THE ROMC APPROACH

- o REPRESENTATIONS
    - o USER DESIRED INPUT AND OUTPUT CAPABILITIES
    - o FLEXIBLE FORMATS
    - o REPORT GENERATION VARIATIONS
    - o GRAPHICS
    - o COLOR
- o OPERATIONS
    - o ANALYTICAL
    - o MODELING AND STIMULATION
    - o STATISTICS
- o MEMORY AIDS (DATA BASE)
    - o DATA FILES OR BASES
    - o DATA BASE MANAGEMENT SYSTEM (DBMS)
    - o INTERIM RESULTS WORKING SPACE
    - o PERSONAL FILES
    - o LIBRARY OF MODELS
    - o "HELP" SOFTWARE
    - o OTHER SOFTWARE
- CONTROL (COMMUNICATIONS)
    - o COMMAND LANGUAGE
    - o MENUS
    - o LINKAGE WITH DATA BASE AND MODEL BASE

Source: Sprague, Ralph and Carlson E. Building Effective Decision Support Systems. Prentice-Hall 1982.

NASA Procurement Management Technology Program (PMTP)

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Introduction

This paper is designed to provide an overview and system objectives of the NASA PMTP. It involves a brief review and summary of a study conducted by Battle Columbus Laboratories concerning the feasibility and implementation strategy for NASA-wide automated procurement system.

PMTP

PMTP was developed at NASA Headquarters (HQ) under the direction of Dr. Neil F. Lamb. Its purpose is to develop a standard automated system to be implemented NASA-wide. This sytem will be based on standardization of forms and reports across NASA, and integration with word and data processing for the efficient handling of procurement data. The system would be designed to meet the following objectives:

a. one-time capture of data at its source--this would avoid unnecessary duplication of effort;

b. the multiple utility of computer equipment and computerized data--this would increase management's access to various levels of information from different sources;

c. the automation of editing rules and decision criteria--enhances uniformity from various decision criteria;

d. the automation of operational reporting--increases management control;

e. exception reporting;

f. the adhoc inquiry of procurement data bases--increases the ability of procurement personnel to randomly access information sources; and

g. efficient production of procurement documents.

Problems Encountered in the Present System

All NASA centers have some degree of automation, but they lack three essential elements which are contained in the proposed system.

1. Centralization--Through centralization, policy decisions channeled through HQ would no longer be randomly implemented. Changes in system requirements would be a one-time process.

2. Summary Reporting--All summary reporting would be developed from one basic model allowing for better analysis and more frequent use of summary data.

3. Data Input--Data input should be less frequent and more accurate.

System design for the PMTP is based on two principles. One is the <u>commonality</u> of the procurement process system design and implementation. Throughout NASA the procurement process is normally uniform based on the NASA Procurement Regulations and Federal Procurement Policy.

Individuality is the second key element in the PMTP system. Through NASA, different centers and organizations are characterized by a variety of mission requirements and organizational objectives. These include:

a. organizational management--centers tend to implement policies based on their own internal organizational structures and needs;

b. functional--scientific goals and objectives vary among centers; and

c. inertial--each center has sunk cost based on funds already obligated for individual automated systems.

Stucture of the PMTP Study

The PMTP was conducted by Battle Columbus Laboratories and is comprised of seven phases. Each phase addressed a key element in developing the program. Below is a brief summary of six phases.

The Assessment Report was designed to determine the feasibility of an automated procurement system. This was accomplished through a series of field study interviews throughout NASA. Each center was broken down into the different procurement areas and the support areas. A questionnaire was then developed to extract information on the operation of the procurement system and the role various levels play in that system. The final determination from this portion of the study was that the automated procurement system was feasible but that organizational change to integrate the system would be difficult.

The Integration Report provided the basic design and system concepts for the PMTP. It broke NASA Procurement efforts into seven integrated subsystems, or modules each with its own report requirements and document generation. Files, users, and relationships between modules were also defined in this section.

The Hardware Report defined the hardware requirements for the system. Selection of the appropriate hardware and its configuration was based on three areas:

(1) organization objectives, (2) organizational behavior and structure, and (3) cost.

The Training Report involves the training required for the efficient use and operation of the system. It outlines a training schedule required for the effective use of on-line interactive data processing by the different users.

Cost-Benefit Analysis. This portion of the study analyzed the costs associated with the PMTP system and the anticipated benefits from its implementation. The major cost anticipated were the start-up cost for the associated hardware. The quantifiable benefits derived from implementation of the PMTP were determined to be increased productivity which was valued at 3.5 million dollars annually.

Implementation Plan. Implementation for the entire PMTP at all NASA centers was estimated at 3 years. A test sight would be identified initially for the program to iron out bugs. The initial 18 months of the 3-year period would be devoted to testing key elements of system for when it was fully deployed.

System Objectives of the PMTP

The implementation of PMTP is based on a three phase implementation strategy which shall consist of System Definition, System/Subsystem Design, and Development and Implementation. Final PMTP system objectives shall consist of the following automated processes:

Tracking and Forecasting (T&F)
Document Generation
Small Purchases
NASA Procurement Regulation
Source List
NASA Headquarters Reporting

T&F

T&F will involve the collection, processing, updating, and disemination of data concerning the preprocurement, preaward, postaward, and contract close-out stages of the procurement process. A key feature of the T&F will be its ability to monitor information through the various procurement stages and make comparisons of actual dates versus planned dates at any point in time. Data input at the various stages would be captured manually but the system will also have the capability of automatically manipulating data internally. Much of the data input would be used by management either as graphic output or standardized reports.

Document Generation

In developing documents such as Request for Proposal (RFP), Invitation for Bid (IFB), Grants, etc. PMTP will have the capability of automatically accessing data to develop a standard text based on the requirements definition. Once the standard text is identified, the user will add optional or tailor-made material unique to a particular requirement. These would include charts, contract articles, etc. All documents would be developed using standard word processing techniques and would be integrated in an electronic mail system for possible distribution or review.

Small Purchases

Small Purchases' orders are usually processed manually through a repetitive process of analyzing a user requirement, selecting possible sources, initiating a Request for Quotation (RFQ), and selecting the lowest technically acceptable quotation. Under PMTP data will be captured electronically at its source, quotations automatically prepared, and once selection has been made automatically prepare an order. In addition to the generation of purchase documents, the system will have the capability of performing all contract administration functions, such as, recording delivery and acceptance dates for goods. Users or any authorized personnel would have the ability to access PMTP to check the status of any particular requirement.

NASA Procurement Regulation

Revisions and additions to NASA Procurement Regulations are diseminated through the normal internal mail system. Under PMTP any revisions to the regulations would be developed centrally at NASA HQ and transmitted electronically to the various Centers. Even though updates will be centrally controlled through HQ, individual centers will still have the flexibility necessary in order to conform to unique Center requirements.

One major advantage related to automation is that any applicable regulatory change will automatically be applied to other system programs. For example, any regulatory change affecting an article or clause would automatically up-date the document generation function of the sytem.

Source List Automation

All information or data required for source list development, debarred bidders, and past performance evaluation, will be available from a centralized data base. The system will automatically develop source list for user requirements, while taking administrative or socioeconomic criteria into consideration.

NASA HQ Requirements

One of the key features of the NASA automated system will be its ability to collect and diseminate data concerning procurement related activities. The planned method to accomplish this task is through the development of two data files. One file is defined as a "Work File" and will contain data for systems operation. Authorized personnel will be able to use the "Work File" to create and update a "Master File" which will transfer all pertinent data required for NASA HQ's record management. Data from the Master File will be transferred to a HQs file through batch processing. A key characteristic of the data transfer to HQs is the fact that Center records will be available only to the extent necessary to handle HQ's reporting requirement, all other data will remain within individual center operations.

The six system objectives of the Procurement Management Technology Program are designed to increase the productivity, efficiency and professionalism of procurement personnel, as well as, demonstrate government initiative in utilizing computer technology. This effort could serve as a model for other agencies or organizations which may have similar needs. However, care must be taken by using proper cost/benefit analysis techniques to insure a proper allocation of resources and to document any possible cost savings.

Another area for consideration is what effect will automation have on the existing procurement work force. If the work force is properly trained and the system designed with their input system integration can be enhanced. Therefore, proper training and the development of a user friendly system must be a prime consideration.

PROGRAM MANAGER'S SUPPORT SYSTEM (PMSS)

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ABSTRACT

The focal point of the Defense Systems Acquisition Process is the weapon system program manager. With the current climate toward achieving increased decentralization of decision-making responsibility and authority, the demands on the program manager will increase. Not only will the decisions to be made by the program manager increase in number in this climate, but also these decisions will involve issues that are more complex and more critical to the success of the program. Increasingly, the truly crucial decisions in the areas of strategic planning, budgeting, logistic support and the overall acquisition strategy will be made by the program manager.

The relative maturation of management information system (MIS) technology in recent years now enables the program manager to gather and analyze vast quantities of decision-related data. However, these data are generally in "functional" blocks. Much less progress has been made in developing tools for the program manager to integrate and apply these data areas and to actually support him to make decisions. This is particularly true when the decision to be made is non-routine, unstructured and requires the application of the decision-maker's judgment, experience and intuition. A research project has been initiated by the Defense Systems Management College (DSMC) to see if Decision Support Systems (DSS) can be applied in the defense program management arena to help fill this void. The research underway concerns the usefulness and application of DSS in DOD-wide defense systems acquisition and will have implications for all levels of decision-making in the DOD from the Secretary of Defense to the program or functional manager.

INTRODUCTION

This paper addresses a Program Manager's Support System. A PMSS is the application of Decision Support System (DSS) principles, integrated with management information systems (MISs) techniques, into the defense weapons systems program management environment. The evolutionary steps that will be necessary to develop and implement this application will be described in this paper.

The cartoon in Figure 1, which appeared in the Washington Post newspaper in December 1981,[1] is very illustrative of a common situation in which we often find ourselves, especially on a Monday morning. The PMSS is intended to address this dilemma for program managers.

The effort described in this paper is underway at the Defense Systems Management College (DSMC), Fort Belvoir, VA. The principal investigators are Mr. Harold J. Schutt and Mr. Ted Ingalls, who are Professors of Acquisition/Program Management in the Department of Research and Information. Their telephone numbers are: (703) 664-4795/5783 or autovon numbers, 354-4795/5783.

BACKGROUND

The PMSS project at the DSMC was started in the Fall of 1981. A number of discussions were held which revolved around problems that program managers have relative to the amount of data that is available to them and how they, as users of that data, have to handle it. On December 22, 1981 a brainstorming session to consider these problems was held with members of the DSMC faculty and staff. That session was the genesis of this project.

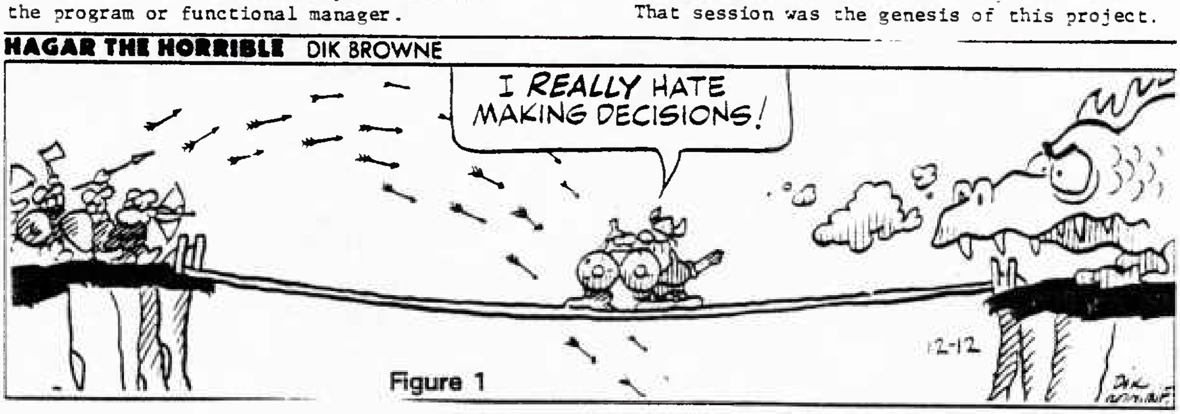

Figure 1

Starting in January 1982, a series of visits were made to determine what DSS or PMSS-type efforts were on-going in academia, industry and DOD acquisition management activities. Through 12 February 1982, two universities, eight companies and four DOD activities were visited.

On 2 February 1982 another session was held with the DSMC staff and faculty in order to structure a program plan for this effort at the DSMC.

On 12 February 1982 the program plan for this project was presented to the DSMC Executive Board. The Executive Board suggested that one of the first efforts should be to conduct a survey of current defense systems program managers to determine what management information and what management information systems the program managers were currently using. This, then, would serve as a baseline from which to evolve a PMSS. Further, the Board requested that an "effective MIS" be defined from the analysis of what MISs the program managers are currently using.

During the period 15 February to 7 April 1982, 21 program managers from the Army, Navy and Air Force were interviewed to collect the data needed to fulfill the Executive Board's request.

On 3 May 1982, a report was made to the DSMC Executive Board on the results of the program manager's management information systems analysis. The overall program plan for continuation of the PMSS project was also presented and approved at that meeting.

STRUCTURE OF PAPER

The description of the Program Managers Support System is addressed through answers to seven questions that have been divided into two groups. The first group has three questions that relate to DSMC's involvement in this project. The second group of four questions produces a description of the PMSS project. This paper will be structured around these questions. At the end of the description portion of this paper is the first status report that has been published on this project.

DSMC's INVOLVEMENT

The first three questions relating to the Program Managers's Support System project center on DSMC's involvement. The three questions which will be addressed in this section are:

1. Why is DSMC involved?
2. How is DSMC involved?
3. Who is involved, both within DSMC and external to DSMC?

WHY IS DSMC INVOLVED?

The answer to this question basically involves three areas. The areas relate to (1) decision-making problems in the program management environment, (2) DSMC's organizational position in DOD, and (3) DSMC has a proposed solution in this area (granted, it may be only one of many possible solutions.) This proposed solution is the PMSS, discussed in this paper.

Decision-Making Problems

It is not intended to go into a discussion of the results of problems that exist in the decision making processes-either within the Defense Department or external to it. There are problems in decision-making processes, both within the DOD and in industry. Because of these problems, DOD and industrial activities have been seeking management tools to improve decision-making processes. This paper describes a new management tool for program managers.

A factor contributing to the difficulties in the decision making process is the difference that exists between the perception and the reality of what is occurring. It is a commonly heard statement in the DOD acquisition community particularly during the budget process, that "programs that <u>appear</u> to have their act together do not lose". The point of this is that very often the preception is more important than the actuality of the situation. One objective of the Program Manager's Support System will be to provide a program manager the capability to better articulate and defend his program by generating alternatives and recommendations that are supported with hard data and analyses. This, in turn, will demonstrate to reviewers that his program is, in fact, under control.

An issue of growing concern in recent years to people in DOD and in industry is the amount of data that managers must deal with. Most people feel that the more prevalent problem is that there is too much data to deal with, rather than the opposite of too little data. However, whether a program manager finds himself in a data poor or a data rich situation, it creates a problem for him.[2] If the environment is data poor and there is insufficient data to support the decision making process, then two alternatives exist. First, the program manager can make a decision today, without the missing data, and take a chance that his decision is the best one. Second, the program manager can delay his decision while he is gathering the additional data required. If the environment is data rich, where there is too much data relative to the decision to be made, then the main problem is in the selection and use of that data that is relevant to the decision to be made. In either environment - data rich or data poor-there are impacts in terms of time and cost. In a data poor environment, there are costs associated with gathering the information that is required. In a data rich environment, it costs more to sort and summarize the data and select that which is pertinent. In either case, the decision making process can be delayed. Delays usually translate into additional costs. Further, delays in decision-making can, in turn, delay deployment of the defense system capability in the field.

There is some amount of data that is appropriate for the decision at hand. One of the objectives of the Program Manager's Support System is to help the program manager arrive at the right amount of data for the decisions that he has to face.

Another common problem in the decision making process is the question of what "path" will be followed. We are here today at the present time. We are concerned with the future which, depending on what our objectives may be, could be three months ahead, six months ahead, or three years, six years, or even ten years or more in the future. The problem is how does one get from the present to the future. It certainly would be nice to be able to take a straight line path in going from the present to the future. See Figure 2. Unfortunately, that is not always feasible. The next best alternative would be to proceed down a path headed in the correct general direction, recognizing that some small deviations may be necessary along the way. This approach is much better than wandering aimlessly with no idea of the correct direction, but this is still certainly not the optimum. Contributing to this problem of planning a course of action is the lack of knowledge about the future state. See Figure 3. The following statement, heard on one of the survey visits, clearly sums up this dilemma - "If you don't know where you are going, any road will take you there." A Program Manager's Support System cannot totally alleviate the problems associated with the future. However, it would be helpful to a program manager to

ALTERNATE PATHS

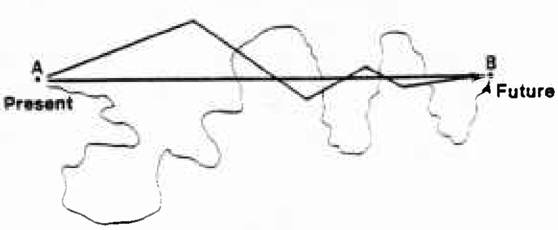

Figure 2

have a capability that would assist him in generating alternatives. By applying the program manager's judgment of future events to these alternatives, he would be aware of the possible consequences of the alternatives under consideration. The ability to generate alternatives, and document their impacts, is one of the objectives of the Program Manager Support System.

FUTURE STATE

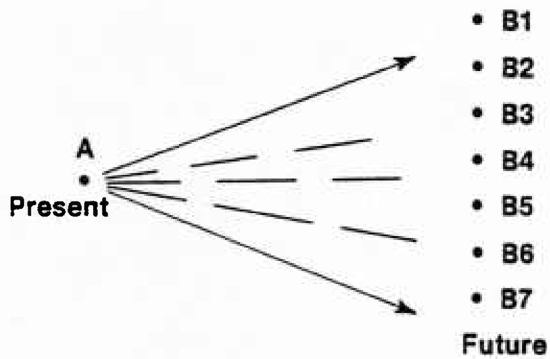

Figure 3

DSMC's Position in DOD

The second area that relates to why DSMC is involved in the development of a Program Manager's Support System has to do with DSMC's organizational position in the DOD.

The DSMC is a DOD educational institution which is charged with the responsibility for providing instruction to DOD program managers, prospective program managers and personnel who will fill key positions in program management offices (PMOs). The DSMC mission is shown in Figure 4. The DSMC implements its overall mission by providing education for acquisition professionals and conducting research, to support and improve defense systems acquisition program management.

DSMC MISSION

- For national and international programs -
  - Conduct advanced courses of study
  - Conduct research into all activities related to . . . defense systems acquisition management
  - Assemble and disseminate information
- Serve as the academy of systems acquisition management for the DOD and military departments

Ref: DOD Dir 5160.55 (Draft)

Figure 4

The DSMC is organizationally positioned at the third level of the Defense Department and supports OSD civilian personnel and civilians and military personnel from the Army, Navy, Air Force and Marine Corps, at all management levels from middle management to general and flag ranks. In addition, the student body has included personnel from other government agencies, such as the Defense Logistics Agency, the General Accounting office, the Defense Communications Agency, the Department of Energy, and the Defense Intelligence Agency. In order to provide a balance in the courses, the goal is to have about 80 to 90 percent of the students coming from the above listed government activities and the remaining students coming from industry. Examples of companies who have participated in courses at DSMC are IBM, Goodyear Aerospace, Martin Marietta, Rockwell International and Lockheed.

The DSMC provides instruction in the defense systems acquisition process through lectures, discussions, case studies, decision exercises, and the like. The objective of the DSMC effort is to provide program managers, or prospective program managers, with improved skills. The above are all important elements of the instructional environment and are ones that one can get their hands on. There is another element, however, that is equally important and a role that DSMC and all educational institutions have. That role can be described in many ways, but what it boils down to is that an educational institution plays a part in changing the mind set of its students. The educational institute does this by bringing the students up to date in modern technology and provides the vehicles so these technologies can be applied. This changing of the mind set is as equally important as the instruction that is provided. In any activity involving computer systems, the mind set of users is very important. People have been "burnt" with systems that were going to provide everything. Now, some re-education and rethinking for new, practical applications is required.

HOW IS DSMC INVOLVED?

DSMC is involved in the Program Manager's Support System project in all elements of an instructional organization. It is anticipated that DSMC will provide consulting services relative to PMSS, particularly during the later stages of this project while implementation is ongoing.

WHO IS INVOLVED?

The PMSS project team is just beginning to be assembled. As time goes on, new members will be added to the team. At DSMC there will be representatives from the Departments of Research and Information, the School of Systems Acquisition Education and groups of students from the PMC course working on research projects. Within the DSMC, the Executive Board will be the sounding board and approving body for this project. Because the Program Manager's Support System concerns all of the services it is desirable to have representatives from the four services as members of the PMSS team. In addition, it is desired to identify representatives from the academic world and industry who would like to work with DSMC in the evolution of this project. It is desired to establish a panel of experts and to set up an exchange program where information may be exchanged between all the participants in the project. Finally, contractors will be hired to support certain elements of this effort and will be added to the project team as required. Since PMSS has a multiservice utility, and will support other elements of the DOD, from time-to-time presentations will be made to the various OSD and service organizations to keep them abreast of the project's progress. These presentations will be provided to all contributing participants.

PMSS PROJECT DESCRIPTION

The second group of questions relating to the Program Manager's Support System project address the subjects of: 1) decision support systems and the transition from decision support systems to a Program Manager's Support System, 2) what a Program Manager's Support System is, and 3) the PMSS project at DSMC. Four questions that will be answered are:

1. What are Decision Support Systems?
2. What disciplines are involved in a Program Manager's Support System?
3. Are PMSS's of benefit to defense systems acquisition and to program management?
4. How are PMSS's to be applied in DOD?

WHAT ARE DSS's?

On 22 Dec 1981, the faculty and staff of DSMC held a session to brainstorm the subject of Decision Support Systems. At that session, participants were asked "What does DSS mean to you?" The responses received are depicted in Figure 5. There is a wide spectrum of what people think DSS means and there is confusion between what MISs are and what DSSs are. The most prevalent concept of what a DSS is - a system to help answer "what if" questions - was also volunteered during the discussion.

WHAT DOES DSS MEAN TO YOU?

- Faster, more accurate decision making
- Getting rid of the dog work
- Support of decision making process with pertinent data
- Any aid to improved decision making
- Increased control on data management
- Timely provision of most and best data available
- Enhanced information for decision making
- Intelligence for decision making
- Support for management decision making
- Decisions, forecasting, AI, information, decision rules, actions
- Data filter (selection for usefulness)
- Aid for supportable decision
- Aid to long range planning
- Data plus decision making process
- "What if -----?"
- Personality dependent

Figure 5

Initially, when this project was started, it was called the DSS project. As time progressed and the project's goals were more clearly defined, it became apparent that DSMC's role should be to apply DSS techniques, along with others, to the program management environment, rather than to just conduct research in DSS techniques. Therefore, the project's title was changed from the DSS project to the PMSS project.

At the onset, it was necessary and important to understand the distinctions between management information systems and decision support systems before trying to develop a Program Manager's Support System. One of the first efforts of this project was to conduct a literature search. From that search a number of definitions of DSS's and a number of approaches relative to the transition from management information systems to DSS's was uncovered. A few examples will be given in the following paragraphs.

Mr. Robert Vierck, Director of Information Services, Dillingham Corporation, considers the evolution from management information systems to DSS's in the context of information resource management.[3] Vierck says that information resource management is the process of managing information in an organization so as to maximize its goals. He goes on to say that information resource management is a management function, that it is a part of the organization just as much as technical management or production management or any other management concepts are, and that to be successful, information resource management requires management attention at a significant level.

When one considers the transition that has occurred from the first management information systems to some of the present systems, one sees a number of changing concepts. In the past, management information systems were fraught with problems such as the following. Management information systems could provide anything that was required; huge data files existed and any report that was required could be generated. Unfortunately, what normally happened was that the management information system reports, designed by the data processing departments, consisted of reams and reams of paper that served few. Another problem that related to the old style of management information systems was that the systems took a long time to be developed. If one had a requirement for a new report, and was lucky, one could get it in a short time. More likely, however, it took from six to nine months to get the report implemented. This was a "bottoms up" approach to developing management information systems.

More recently, management information systems are being designed "top down" and the information requirements are being driven by the users. This is reducing the amount of paper being produced, making the reports more relevant, and resulting in their being implemented quicker.

Vierck has compared management information systems with DSS's (see Figure 6). He categorizes management at three levels: top management, middle management, and supervisory level. He characterizes systems as structured or unstructured and that the sources of the data that the systems rely upon are either internal data or external data. Management information systems are viewed as primarily being structured, as primarily resulting from internal information, and primarily used by lower levels of the organization. Top management levels depend more upon decision support systems. DSSs are characterized as systems which depend more upon external information than internal information and are primarily unstructured.

Dr. Gerald Wagner, President of EXECUCOM, looks at DSSs as executive mind supports. He says that a decision support system is "a system that an executive would utilize with such intimate rapport that it seems to become part of his own mind".[4] Dr. Wagner, states that there are four principal attributes of a decision support system.

(1) They support executives at many levels in dealing with the non-repetitive, ill structured problems of the managerial world rather than performing routine chores which are peripheral to genuine executive functions.

MIS AND DSS

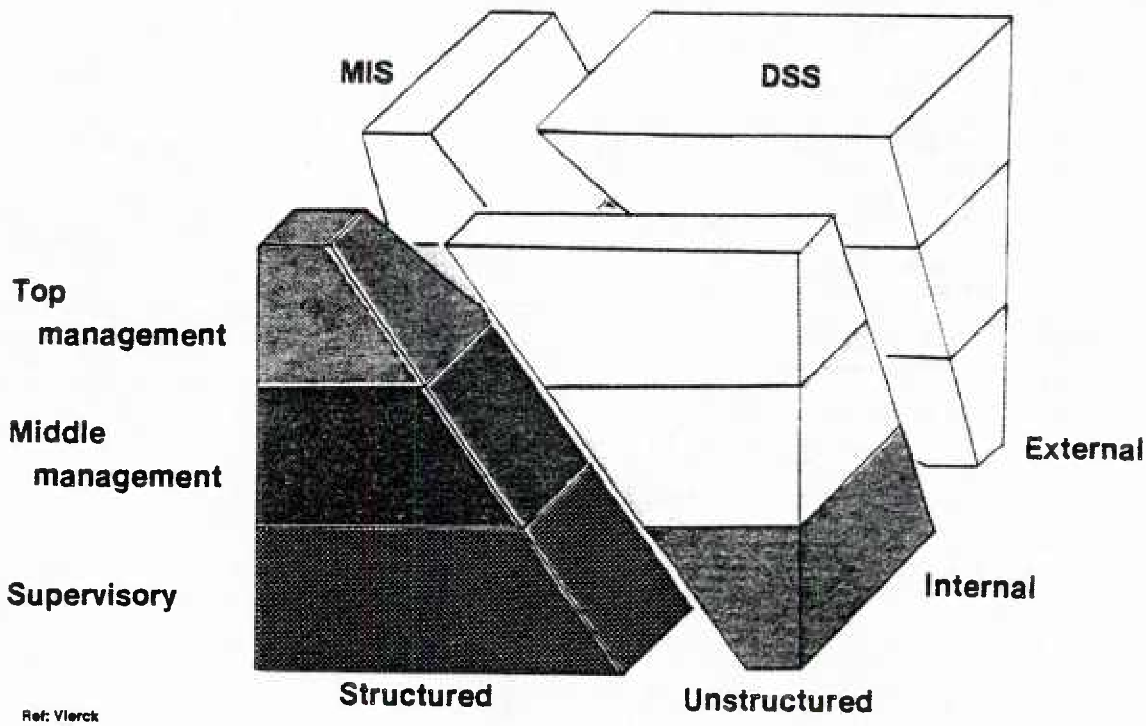

Figure 6

(2) They are developed by an endless, adaptive learning process involving the executives themselves rather than being built by computer specialists to meet precise objectives.

(3) They are used more or less directly and interactively by the executives-perhaps through close subordinates-rather than serving as distant, independent resources.

(4) They mesh with the thought processes of the executives in such a way as to extend and enhance the executives' own understanding and judgment rather than providing the answers to specified questions.

Dr. Wagner considers that the fourth attribute is the most important and that the first three attributes tend to support and feed the fourth attribute.

Dr. Wagner has made some other pertinent comments. Systems tend to fall into one of three categories. First, they may be ad hoc, for one time use, such as when studying a proposed venture to make a one time decision. Second, they may be continuing efforts that are used frequently, such as cash flow analysis systems. The third kind of system is only used occasionally over long time periods. Examples are strategic planning systems and budgeting systems. Dr. Wagner warns us that the capability of DSS's are not justified in terms of dollar savings or increased production, but should be justified rather in terms of increased managerial quality and effectiveness. Finally, Dr. Wagner states that DSSs should be considered to complement MISs, rather than supplanting them.

Doctors Peter G. W. Keen and Michael S. Scott Morton, from the Sloan School of Management at M.I.T., view the relationship between management information systems and decision support systems in a somewhat different light. Their approach is represented by their framework for information systems shown in Figure 7.[5]

Keen and Scott Morton use the terms "structured, semistructured, and unstructured" to characterize the type of decision to be made or the task to be accomplished. At the

A FRAMEWORK FOR INFORMATION SYSTEMS

	MANAGEMENT ACTIVITY			
Type of decision/ task	Operation control	Management control	Strategic planning	Support needed
Structured	1 Inventory reordering	4 Linear programming for manufac-turing	7 Plant location	Clerical, EDP or MS models
Semistruc-tured	2 Bond trading	5 Setting market budgets for consumer products	8 Capital acquisition analysis	DSS
Unstructured	3 Selecting a cover for Time magazine	6 Hiring managers	9 R&D portfolio development	Human intuition

Figure 7

two extremes of the continuum of decision types are: 1) the structured decision which can be defined and bounded so clearly that a manager does not need to be involved and the decision can be given to clerks or to a computer and 2) the unstructured decision where a manager's or executive's personal judgment forms the basis for the decision. Between these extremes falls the area of the semistructured decision where combining the model and data with the manager's judgment provides a more effective solution than either one by itself.

In the context of a Program Manager's Support System this framework would indicate that the structured decisions are those types of decisions that the program manager might delegate to his functional managers at the appropriate level. To support these decisions the data available from existing management information systems is generally adequate. In some cases, especially at the higher levels of management, modeling is beneficial. The semistructured decisions are those requiring support from decision support systems.

The relationships between the original automated data processing (ADP) systems -- which were frequently referred to as classic data processing systems or electronic data processing (EDP) systems -- management

INFORMATION RESOURCE MANAGEMENT ACTIVITIES

	CLASSICAL DP	MIS	DSS
Supports:	Working levels	Middle managemant	Executiva levels
Functions:	Clerical tasks	Business operations	Decision making
Features:	Data oriented		Information oriented
	Transaction driven	On-line input	
		Inquiry capability	
	Processes data	Provides information	Displays information
	Structured, repetitive problems	Structured problems	Non-structured analyses
Process:	Batch	On-line/Batch	Interactive
Results:	Printed, formatted reports	Printed raports (exception)	Screen displays
Data sources:	Internal	Mostly internal	Mostly external
Dev time:	Weeks	Months	Days
Success:	High degree of accuracy	Availability of info in usable form	Responsiveness to "What if" Inquiries
	Positive control		
	Least cost		
Keyword:	Efficiency	Availability	Effectiveness
Examples:	Accounting	Historical/Trends	Forecasting analysis
	Payroll	Order entry	Stratagic planning
		Material req'ts planning	Opportunity selection

Figure 8

information systems and decision support systems are summarized in Figure 8. It can be seen that, in general as we move from EDP through MIS to DSS the following general statements can be made.

1) These systems normally support a higher level in the organization.

2) They become information oriented rather than data oriented.

3) They become more interactive rather than using batch processing techniques.

4) Their utility is measured in their responsiveness to "what if" inquiries rather than their high degree of accuracy and their cost.

The key word relative to these systems is that while the early data processing systems stressed efficiency of operations and management information systems stressed availability of data, decision support systems stress effectiveness. The marriage of the man and the machine to exploit the strengths of both is an objective of the Program Manager's Support System.

WHAT DISCIPLINES ARE INVOLVED?

The development of a Program Manager's Support System involves four different disciplines: Operations Research (OR), Management Science (MS), Computer Science (CS), and Behavioral Science. See Figure 9. Some organizations tend to group Operations Research and Management Science together and would consider that there are only three disciplines involved in this effort.

Of particular importance from an Operations Research view point are the modeling evolutions and mathematical analysis operations. In Management Science an understanding of all

PMSS DISCIPLINES

Program Managers Support Systems			
Operations Research (OR)	Management Science (MS)	Computer Science (CS)	Behavioral Science (BS)
• Modeling	• Organization	• Computers	• Group Dynamics
• Regression Analysis	• Policy and Procedures	• Software	• Small Group Behavior
• Forcasting	• Acquisition Management	• DMBS	• Large Group Behavior
	• Strategic Planning	• Information Storage, Processing and Retrieval	• Man-Machine Relationships
	• Decision Science	• AI	• Human Reaction
	• Planning and Control Systems	• Interactive Graphics	• Heuristics
	• Multi-criteria DM		• Cognitive

Figure 9

of the activities listed is important; however, the most important activities currently relate to strategic planning and decision science. A fairly new activity that is becoming more and more important in this area is multi-criteria decision making. In the world of Computer Science the most important recent innovations are data base management systems and interactive graphics. An increasingly important function for future PMSSs will be the addition of artificial intelligence. Behaviorial scientists have made important contributions in small and large group interactions, and the man-machine relationships. Their newer efforts in human reactions, heuristics and cognitive processes are of increasingly more importance.

The initial work done in this area indicates the name applied to this effort can be very important. Humans tend to react negatively to the name - "Decision Support Systems." Most people in decision-making roles are well educated, confident, experienced people who feel they are capable of making decisions on their own. They reject the idea of systems making decisions for them. Again here, is the matter of perception. The systems do not make decisions, but rather, the systems provide information to help program managers make decisions. With the title of decision support system, the emphasis is on the word "decision" and not on the word "support". Studies in this area indicate it is important to refer to these systems as decision tools. It is preferable to call them "support systems", such as: executive support systems, personnel support systems, group support systems or organizational support systems. In this way, the concentration can be placed on the appropriately active word in the title - that being the word support.

It has also been noted from the visits conducted so far that there is one group within the academic community that refers to the systems as "expert systems".

ARE PMSSs OF BENEFIT?

The questions that must be investigated in the course of the research are whether PMSSs are of benefit 1) to the defense systems acquisition management process and, 2) to program management.

Intuitively, we project that they are and in the course of our research we will determine the validity of this projection. Our hypothesis is that PMSSs can improve the effectiveness and efficiency of the program manager's operation.

HOW ARE PMSSs TO BE APPLIED IN DOD?

The seventh and final question relative to the description of the PMSS project will be divided into two portions. The first portion will address the approach to be used in the implementation of this project and the second portion will address the milestone schedule that is outlined in the plan of action for this project.

The implementation approach to be taken in the development of the PMSS is shown in Figure 10. First, it will be necessary to define the total information requirements of the program manager. It is necessary to

PMSS IMPLEMENTATION APPROACH

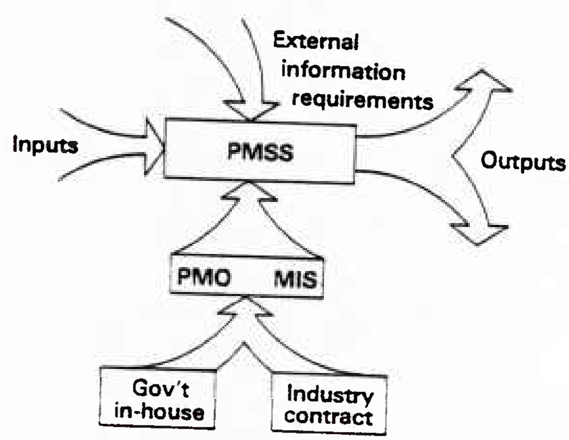

Figure 10

define the external information requirements that are placed on the program manager from above—a top-down approach—along with the internal information requirements of the program manager in order for him to manage his program—the bottoms-up approach. Further, it is important, as part of this process, to define the information requirements of the program management office (PMO) relative to 1) the management of other government activities that are tasked to support the PMO, and 2) the industrial contractors who are developing or producing products for the PMO. By thoroughly defining both the internal and the external information requirements it will be possible to 1) develop the inputs that are necessary for Program Manager's Support System to support both the program manager and the program management office and 2) determine what information must be generated by the program manager to support the levels above him and also what he requires to monitor the activities of the levels below him.

One of the first activities undertaken in this project was to analyze program managers' information systems in order to be able to define an effective Management Information System (MIS) for program managers. This action was directed by the DSMC Executive Board at the 12 February meeting. The results of this analysis are described in the first status report at the end of this paper. This portion of the research found that we are fairly adept at creating historical MISs that address the past and answer the question "What was?" See Figure 11. A next step, beyond historical MISs, is to develop a

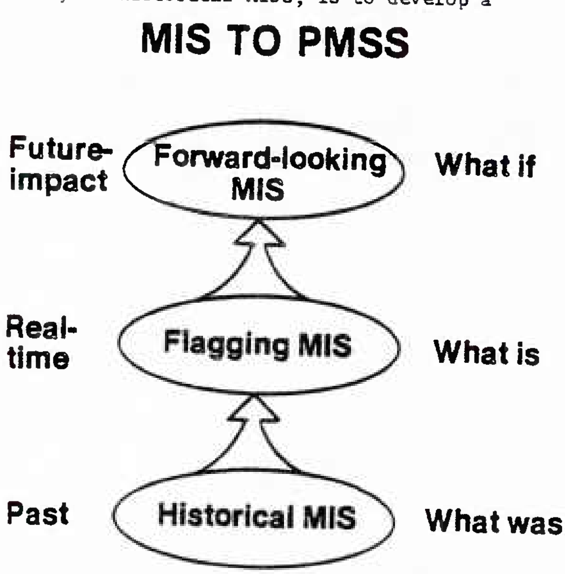

Figure 11

slightly improved MIS that will add "flagging" activities to identify thresholds which are about to be breached, or have just been breached. If the events leading to the breaches can be identified on a real time basis, the current situation becomes clear and appropriate action can be taken. This creates a "what is" mode of operation. The next MIS evolution, to look out into the future, will be the development of a "forward-looking" MIS that can project trends and predict the impact of future events. This evolution will begin to address the "what if" question and is the bottoms-up approach to MIS development. The concept of a PMSS begins to evolve as progress is made from the historical MIS to this "forward-looking" MIS.

Before the bottoms-up approach proceeds too far, however, it is mandatory to define the information requirements placed on the program manager from above so that a fully integrated PMSS design will be possible. Therefore, another very important portion of this project is to determine and define more clearly the program manager's responsibilities, the decisions he must make relative to these responsibilities, and the information he must have to make these decisions. When these two activities—the definition of a forward-looking MIS and the top-down information requirements analysis—have been completed and integrated, the concept for a total, fully integrated Program Manager's Support System can be clearly defined. It must be remembered that a PMSS is a management tool—it is an adjunct to management—not a replacement for management.

What, then, is the structure of the Program Manager's Support System? Referring to Figure 12, it will be noted that at this time the Program Manager's Support System is

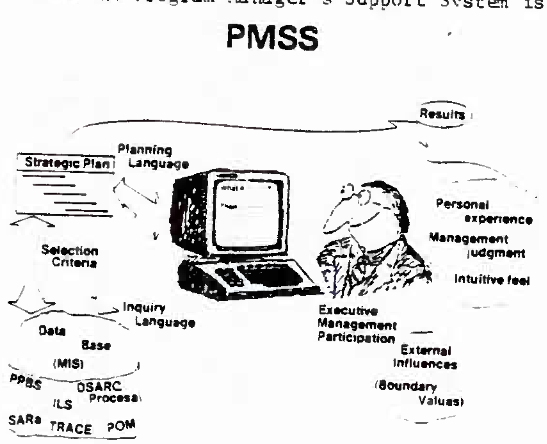

Figure 12

visualized as being the integration of man and machines into a system that works cooperatively in an interactive, user-friendly mode. Hardware and software are required to provide a baseline plan and data base information. A planning language, an inquiry language and some type of selection criteria are also required. Most importantly, what makes this a PMSS, rather than a pure MIS, is participation by executive management. The executive can interactively input to the process his personal experience, his management judgment, and his intuitive feel. The manager can also bring into play the external influences which affect the decision that he is working through. When these elements can be integrated in an interactive fashion a Program Manager's Support System will result. This will yield more effective and efficient decisions.

With this very broad overview of a PMSS in mind, the next paragraphs look at a PMSS from a software and a hardware viewpoint and will briefly describe what is initially planned to be produced as a result of this project.

Information Handling

From an information handling viewpoint, the Program Manager's Support System is viewed as a new form of a data base system as is shown in Figure 13. Typical data base management systems have a data base and a data base management language. Certainly the PMSS will have to include them. Data to feed the data base portion may come from many varieties of mainframe or minisystems, or may be input directly into the system. Within the PMSS, however, there will be a couple of new features. One feature will be a model base containing various models for forecasting, simulation, prediction, and other types of operational analysis. Thus there will have to be a model base management system. To tie these two systems together within the PMSS there will have to be an overall PMSS management system. Users will communicate through terminals to the PMSS. The PMSS management system will communicate to the model base and to the data base and provide the program manager the information necessary to help him make his decision.

PMSS SOFTWARE CONCEPT

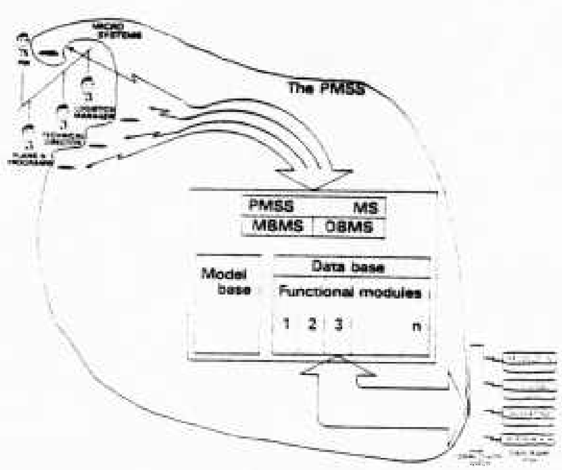

Figure 13

Hardware Configuration

From a hardware configuration standpoint, a few systems have been observed that have been assembled utilizing part of the configuration shown in Figure 14. One system that was observed used a minisystem linked to a series of management information systems that were on mainframes. Within the minisystem data was gathered, assimilated, and analyzed to produce data used for management decisions. It is feasible to add microprocessors to that system. The microprocessors

ONE POSSIBLE ARRANGEMENT

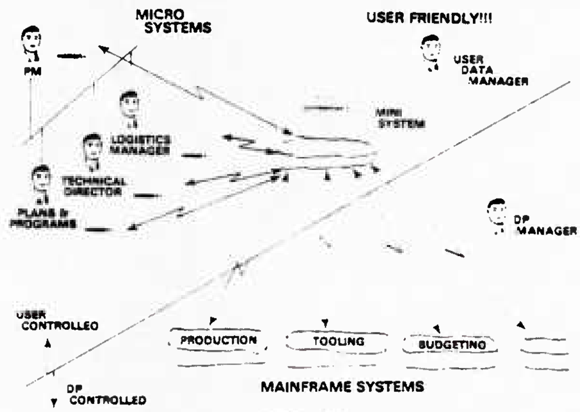

Figure 14

can be used by the program manager, or his first level staff, to directly access the minisystem and extract data from it. Another hardware configuration that is beginning to appear feasible is to take these same microsystems and connect them directly to the mainframe systems through some type of connectivity switch. See Figure 15.

ANOTHER APPROACH

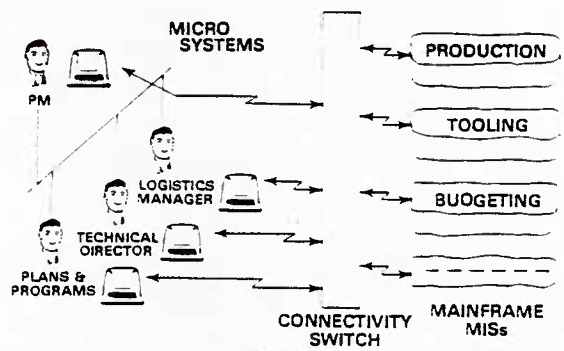

Figure 15

One of the objectives of the research effort at DSMC on the PMSS project is to determine how much of a PMSS operation can be implemented on a microsystem. A micro-based configuration is beginning to appear more and more feasible. Cost effective hardware and software systems are becoming available, a microsystem can be purchased for $6 - 7,000. User-friendly end products are now appearing on the market. They are required for a Program Manager's Support System, because very few, if any, program managers will want to acquire programming skills. There must be English-like, user-friendly systems with which they can interact. Data base management systems are becoming available for microsystems. Telecommunications and network capabilities are available for microsystems now. The graphics capability of microsystems, which is very important for PMSSs, is improving rapidly. The last remaining area of concern is the development of protocols for interfacing between systems. Protocols are being developed.

Therefore, from a conceptual standpoint, a Program Manager's Support System can be assembled. From a hardware standpoint, with current technology, the evolution of a PMSS at a reasonable cost is becoming more and more realizable. From the standpoint of information handling, a PMSS will be realizable when the necessary integrating languages have been developed.

PMSS Project Products

What will DSMC produce during the PMSS project? At this time, DSMC plans to produce three major products:

1) a Guidebook (or Handbook)
2) a set of representative PMSS configurations and specifications
3) a software package

The Guidebook will address the DOD decision making process. It will describe a PMSS and explain how to use a PMSS in the DOD environment.

The representative PMSS configurations and specifications will be suitable for use in implementing a PMSS. If a PMO has an information system on-site, the specifications will help the PMO transition from a MIS operation to a PMSS operation. If the PMO does not have a system the specifications will facilitate obtaining one.

The software package will describe the functional modules and the integrating software for a PMSS. The module inputs will be described and sample output reports shown. Integrating software will be provided. This may be in generic form or in specific form for some systems. The form of this product has not been fully defined. It might be in the form of diskettes or tape.

At this time, it is not known exactly what all of the functional modules will be. One of the current efforts is to determine the most effective configuration. See Figure 16. The different phases of the defense systems acquisition life cycle are being viewed as a continuum rather than as discrete points. This is one axis of the module analysis. Information that is pertinent to the various laws, policies, or processes is being reviewed. This is the other axis of the module analysis. Next a determination will be made as to whether there are intersections between elements of these two axes. If there is an intersection between these two axes, then it must be determined whether an effective module can be built for the element-pairs or not. In the surveys conducted so far, a number of modules have been discovered that relate to acquisition strategies, to statement of work generators, to project control systems, to forecasting, to risk analysis, to decision processes, to financial management processes, to contract monitoring, to cost estimating and in several other areas. Information is now being gathered on these modules to see how they will fit into the overall project.

The Program Manager's Support System, as opposed to a MIS, will contain modules with information that can be used by the modules itself, or that may be integrated interactively. One can play "What if?" analysis between one module and another. For example, if a program manager is facing a potential budget cut, he can operate on the information in the cost module, the schedule module, and the performance module, and determine the interactive effects of that budget cut on each of those activities. From this information he will be able to generate a set of alternatives that will better prepare him for subsequent actions.

Plan of Action

The PMSS project is divided into five phases as follows:

1. Survey of current State-of-the-Art
2. PM Information Requirements Analysis
3. PMSS Architecture Development
4. Demonstration - Validation
5. PMSS Implementation

Figures providing the next level of detail for each of these phases follow. Also a milestone schedule for the project is included.

PMSS MODULE DEFINITION

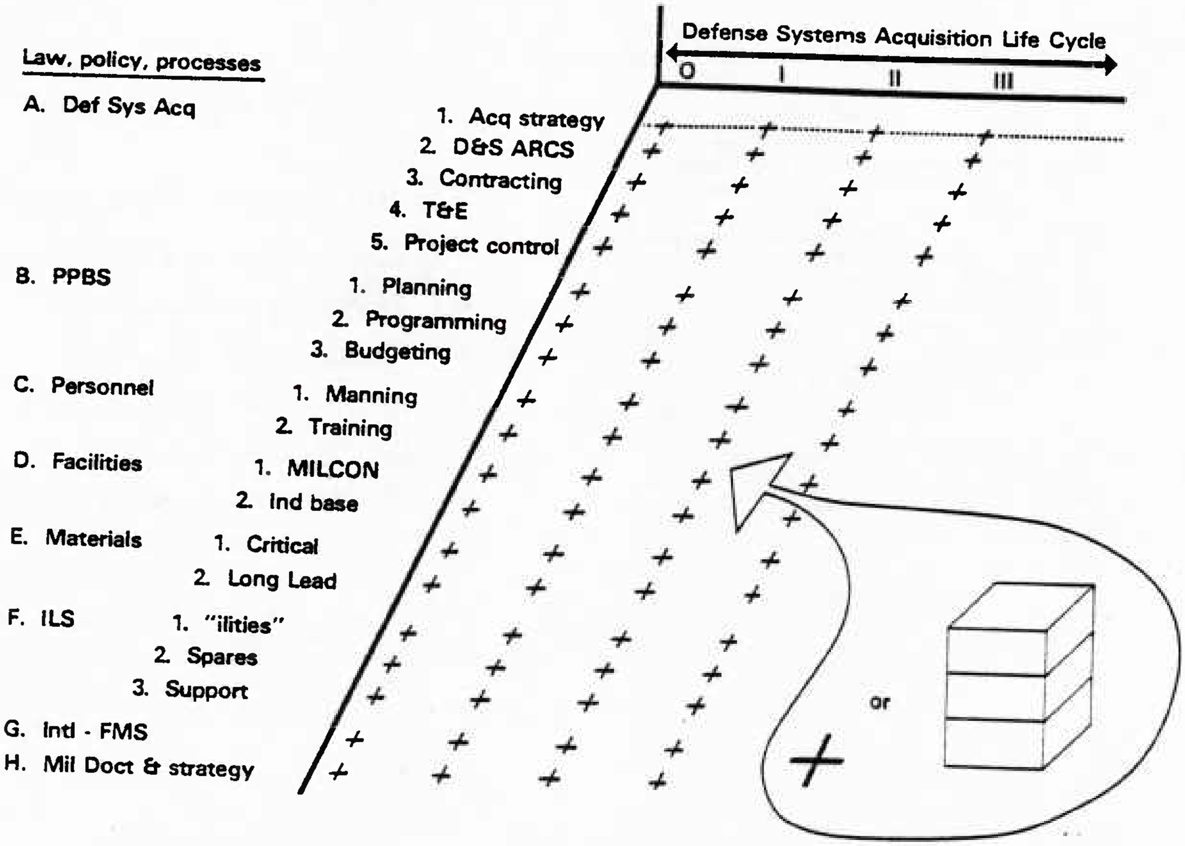

Figure 16

Figure 17 identifies the details of Phase 1. One of the products of the literature search will be a bibliography of books and articles on DSSs. The survey of PM's MISs and the status of defining an effective MIS is the subject of the first status report for this project. The "effective MIS" will be documented and will be reported on in a subsequent status report. When the surveys of academia, DOD activities and industry are completed, and the functional module analysis is finished, a draft PMSS concept will be generated. The instructional strategy has been defined. This material will be included in appropriate courses in DMSC.

PMSS PHASE 1

SURVEY OF CURRENT STATE-OF-THE-ART

1.1 Problem definition
1.2 Conduct literature search
1.3 Survey academia
1.4 Survey DOD activities
1.5 Survey industry
1.6 Establish informal working groups
1.7 Survey PM MISs/define effective MIS
1.8 Define instructional strategy
1.9 Develop module requirements
1.10 Develop PMSS demonstration
1.11 Information briefing
1.12 Publish papers
1.13 Symposium-seminars

Figure 17

PMSS PHASE 2

PM INFORMATION REQUIREMENTS ANALYSIS

2.1 Identify DOD DM process (Above PM - if it impacts PM)
2.2 Identify information requirements placed on the PM
2.3 Define program management responsibilities
2.4 Define program management decisions - alternative generation requirements
2.5 Define program management information requirements
2.6 Select high pay off areas
2.7 Instructional development
2.8 Finalize PMSS concept
2.9 Information briefing
2.10 Publish papers

Figure 18

In Phase 2, shown on Figure 18, the information requirements on the PM from above will be defined and the PMSS concept will be finalized.

Phases 1 and 2 will be completed in FY 82 if present plans prevail. A workshop (or symposium) will be held at the end of Phases 1 and 2 to broadcast information on this project and exchange information on PMSSs.

Phase 3 efforts in FY 83, Figure 19, involve the collection of information on DSS-type modules from the Services, DOD and other government agencies, and industry, and the integration of service unique requirements into the PMSS concept. This will be followed by an architectural development and a demonstration and testing. In phase 3 it is planned to develop the initial drafts of the Guidebook, the Configurations and Specifications, and the Software package.

PHASE 3

ARCHITECTURE DEVELOPMENT

3.1 Integrate Svcs - DOD - Ind activities
3.2 Develop PMSS architecture
3.3 Conduct demonstration and test
3.4 Develop PMSS Guidebook (Handbook)
3.5 Develop representative PMSS configurations and specifications
3.6 Develop software package
3.7 Instructional Implementation
3.8 Information briefing
3.9 Publish paper(s)
3.10 Symposium/seminars

Figure 19

Phase 4, shown in Figure 20, will concern testing of a PMSS system. One model will be tested in the academic environment at DSMC and another at a PMO.

PHASE 4

DEMONSTRATION - VALIDATION

4.1 Conclude software development
4.2 PMSS prototype at DSMC
4.3 PMSS prototype at PMO
4.4 Information briefing
4.5 Publish papers(s)
4.6 Symposium/seminars

Figure 20

In Phase 5, Figure 21, the PMSS products will be revised and updated, based on test results, and promulgated. Consultation will be provided to PMOs to assist them in the implementation of PMSSs.

PMSS PHASE 5

PMSS IMPLEMENTATION

5.1 Guidebook promulgation
5.2 Configurations and Specifications promulgation
5.3 PMSS software package promulgation
5.4 Consulting for implementation PMOs
5.5 Information briefing
5.6 Publish Papers(s)
5.7 Symposium/seminars

Figure 21

Figure 22, depicts the current time schedule.

PMSS PLANNED SCHEDULE

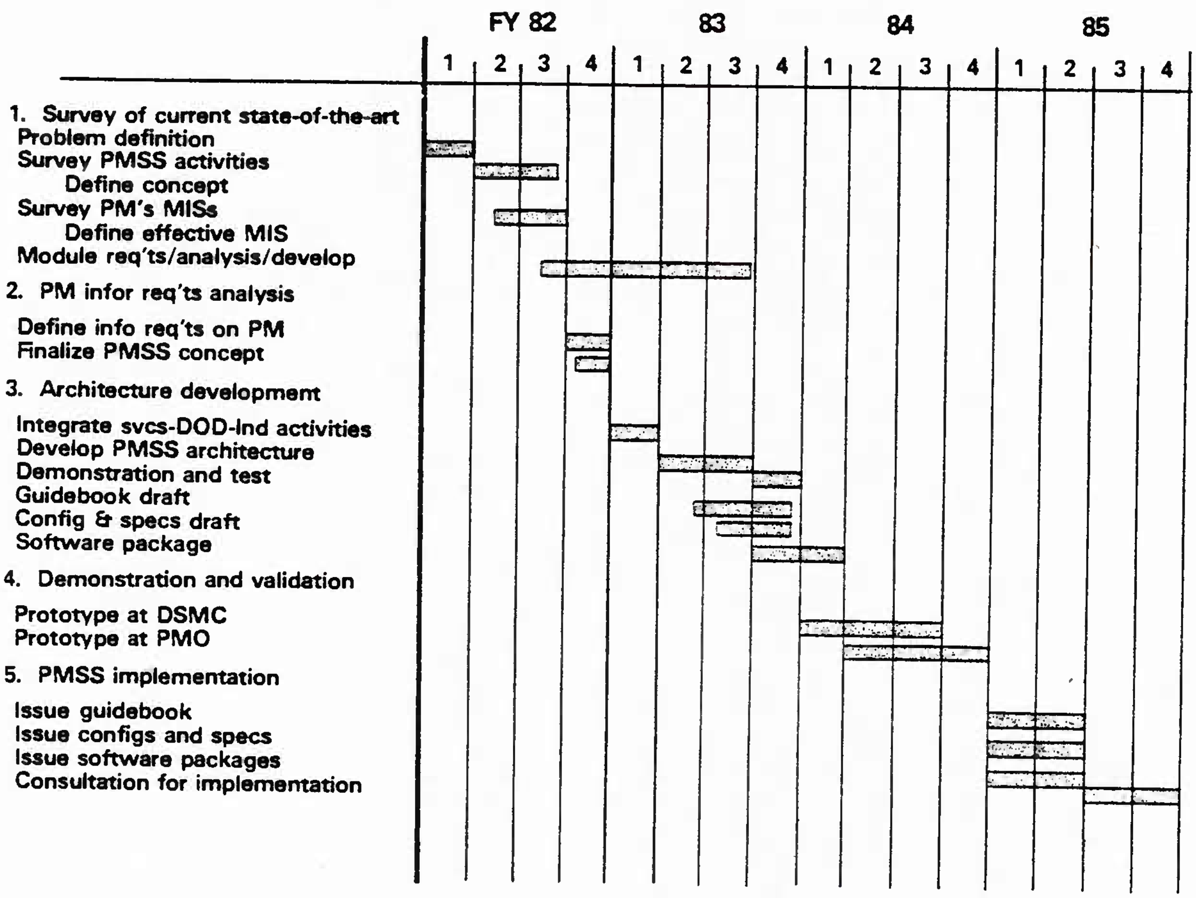

Figure 22

REFERENCES AND FOOTNOTES

1. "Washington Post" 12 Dec 1981.

2. The applicability of data to a particular decision or decisions is, of course, also recognized as a related and critical consideration, in addition to the amount of data available.

3. Vierck, Robert, "Decision Support Systems: An MIS Manager's Perspective," MIS Quarterly, December, 1981.

4. Wagner, Dr. Gerald R., "Decision Support Systems: Computerized Mind Support for Executive Problems," Managerial Planning, September/October 1981.

5. Keen, Peter G.W. and Scott Morton, Michael, S., Decision Support-Systems: An Organizational Perspective, Addison-Wesley, 1978.

FIRST PMSS STATUS REPORT

5 May 1982

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Defense Systems Management College

As part of the effort required to identify the total information requirements of the Defense program manager, a study of the Management Information Systems (MISs) currently in use by program managers (PMs) was initiated in Mid February 1982. The specific objectives of this study were two-fold:

1. To determine what management information and what management information systems program managers are using.

2. To use the information collected to describe an "effective MIS" for DOD program managers.

The research team wishes to express its sincere appreciation to the Program Managers, Deputy Program Managers and staff personnel from the program management offices who contributed to this effort. All participants generously contributed very valuable time and very willingly shared their experiences and knowledge in this area. A genuine desire to improve the process was demonstrated by the openness of the discussions. Wihtout the complete cooperation received, this research effort could not have been accomplished in the time it was.

APPROACH

The approach taken in this study was very straight-forward. Inter-views were conducted with twenty-one program management offices (PMOs) using a relatively simple questionnaire. The questionnaire contained five questions aimed at identifying the kinds of decisions the PMs were making, how they received the information necessary for making these decisions and what "systems" (automated or manual - written or verbal) provided this information. The questionnaire provided a loosely structured format and served to start the discussions off in the intended direction. Generally, it wasn't found necessary to follow the questionnaire precisely because the answers to the questions evolved naturally in the course of the discussions. In all cases, the PMs (and their staffs) were extremely cooperative and were very willing to share their experiences and knowledge. Although the interviews were originally scheduled for one hour, most of the discussions continued for two or three hours because of the interest in this project.

In all cases, an attempt was made to conduct the discussions with the PM himself or his immediate Deputy since this was the level of decision-making being investigated. This proved possible for 17 of the 21 PMOs in the sample.

Sample outputs from the PM's information systems were collected, whenever possible. These samples, plus answers to the questions and other comments received in the interviews, provided the basic data for this research effort. This data was analyzed from two aspects. First, the PM's sources of information were identified. Second, the modules contained in the various PM's MISs were determined and described.

The PMOs that formed the sample for this effort are indicated in Figure 1. The 'A' denotes an Army program; the 'N', a Navy program; and 'AF', an Air Force program. To provide as valid a sample as possible, PMOs that spanned the spectrum of Service, acquisition cycle phase and program size were selected. The seven PMOs from each service are positioned horizontally in Figure 1 to correspond to their phase in the acquisition life cycle. As can be seen, most of the programs included in this investigation were in engineering development or production or were cóncurrently in both phases. The basket PMOs consisting of a collection of relatively small projects having similiar or related products or missions) had projects in all phases of the cycle. The PMOs are located vertically to indicate their relative size in terms of total program dollar value. The programs varied from small projects (total value of approximately \$2 M) within the large basket PMOs to a vert large Navy program with a total program value exceeding \$40B.

ANALYSIS OF THE DATA

PM's Sources of Information

As previously indicated, the data and samples gathered during the interviews were first analyzed to identify the source of the information for the PM. This analysis identified four primary techniques that were being employed by PMs to gather the information they needed for decision-making. These techniques are described as follows:

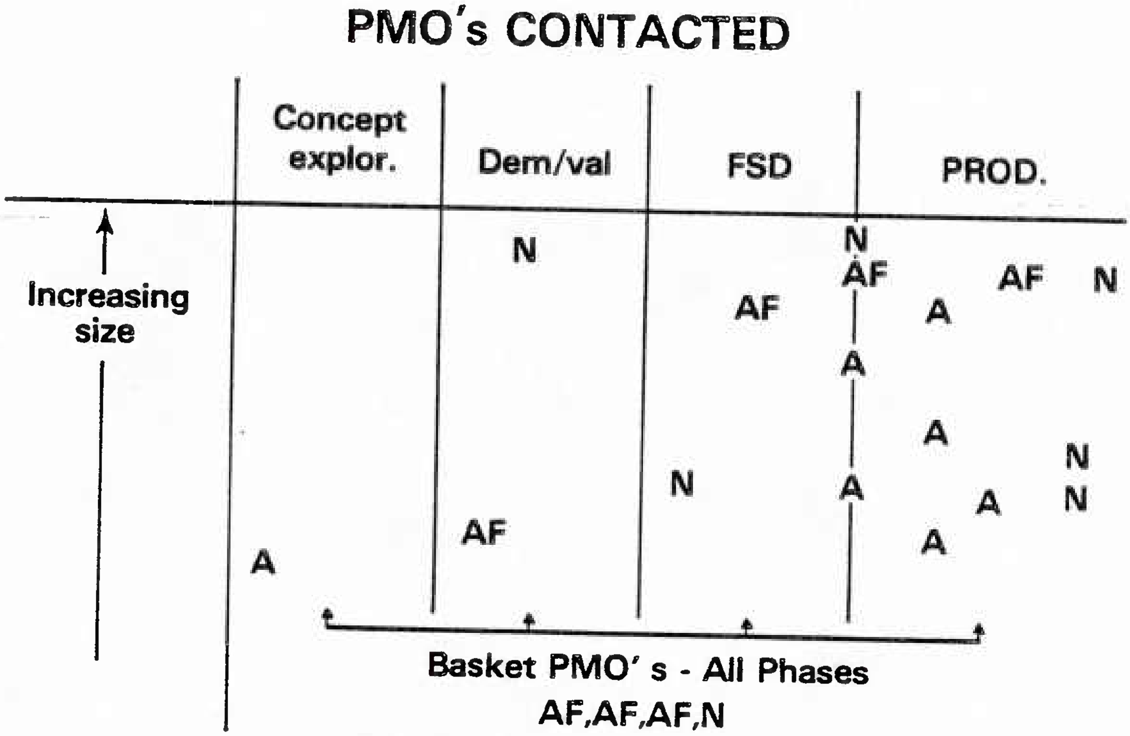

Figure 1

1. Meetings and discussions with staff or contractors on an "as required" basis, i.e. when problems arose and problem-solving activity was required. This activity could be described as management by reaction or by exception. This source of information is characterized as ad hoc meetings.

2. Meetings or briefings that are scheduled or planned but are issue oriented, i.e., they have no previously set agenda. An example of this source would be the commonly-used, weekly staff meeting where the key members of the staff discuss the most pressing problems of that particular week.

3. Scheduled meetings or briefings that are oriented toward reviewing status or approving plans - i.e., agendas are established and the meetings are relatively structured. An example would be a review by the PM of the program plan for a newly accepted project within the PMO.

4. Recurring hard-copy material (whether generated manually or by machine). This material could end up as the PM's notebook, his fact book or as a compilation of computer print-outs.

The next step in the process was to "score" each of the PMs with respect to these four sources of information. The resulting "score-card" is shown as Figure 2. An 'X' indicates that particular PM was evaluated as making significant use (all PMs made some use of all sources) of that source of information. An '⊗' indicates the source that was most significant to each PM. Thus, PM number 14 was "scored" as not making significant use of Ad Hoc Meetings, but relying rather heavily on the other three sources of information - i.e., Issue-Oriented Meetings, Scheduled Meetings with a Set Agenda and Hard Copy. His most significant source was considered to be the Hard Copy material.

A tabulation of the results of this scoring is shown in Figure 3. More PMs (16 in each case) appeared to use Ad Hoc Meetings and Hard Copy as significant sources of information than the other two sources. Of the 16 PMs who made significant use of the Ad Hoc Meetings, 8 were considered to use them as their most significant source. Similarly, 5 PMs were scored as making most significant use of both Hard Copy and Scheduled Meetings with Set Agenda.

SIGNIFICANT SOURCES OF INFO FOR THE PM

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Ad hoc meetings Management by exception	⊗		⊗	X	X	⊗	⊗	X	⊗				X		⊗		⊗			⊗	
Issue-oriented meetings No agenda			X			X	X		X	X		⊗		X	X	⊗	X	⊗		X	
Scheduled meetings Set agenda	X	⊗		⊗						⊗	⊗			X	X		X				⊗
Hard copy		X	X		⊗	X	X	⊗		X	X	X	⊗	⊗		X	X	X	⊗	X	

Figure 2

SIGNIFICANT SOURCES OF INFO FOR THE PM

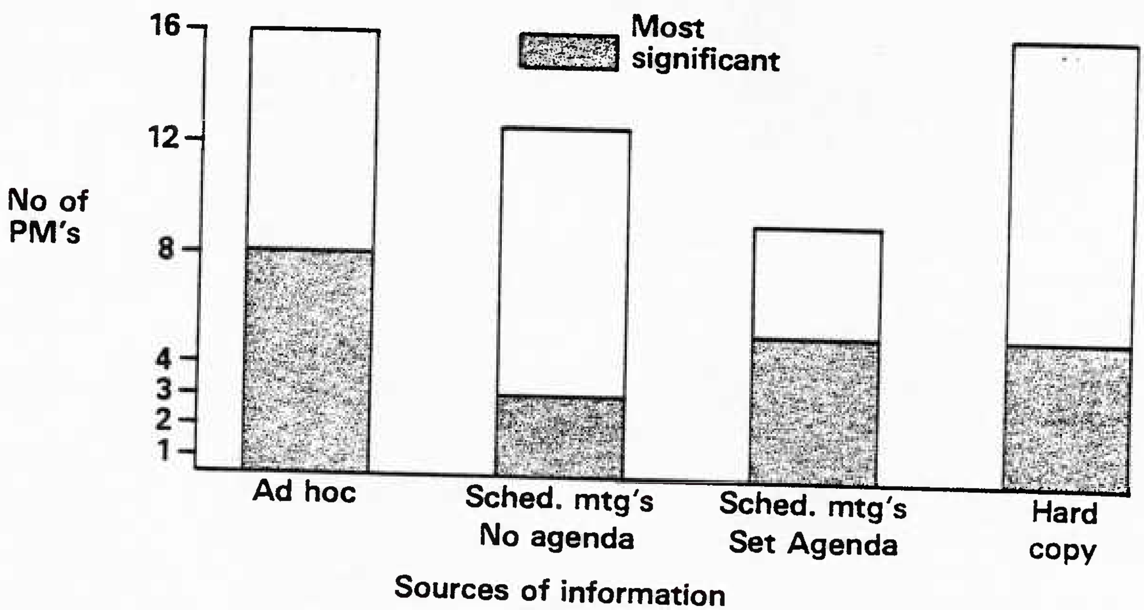

Figure 3

Figure 4 shows this same data arranged by the Services. In each source category, the first column represents the Army programs, the second, the Navy and the third, the Air Force. This Figure indicates that the Services make about equal use of the different sources of information, although the Army didn't tend to use the Scheduled Meetings with a Set Agenda and the Air Force used Hard Copy less than the other Services. When the most significant sources are considered, the differences between the Services become more distinct - none of the Navy PMs were scored as making most significant use of Scheduled Meetings with No Agenda, none of the Army PMs used Scheduled Meetings with a Set Agenda as their most significant source and none of the Air Force PMs used Hard Copy material as their most significant source.

MIS Modules Being Used

The data gathered from the 21 PM's was also analyzed to determine the functional elements, or modules, contained in the PMs' MISs. In this case, the focus was placed on the MIS as a system that produces hard copy information either manually or automatically.

After reviewing the data collected in some detail and having made a number of tentative categorizations, the list of functional modules as shown in Figure 5 evolved. This list covers all of the functional areas observed in the data collected and as such, represents a 'complete' MIS. The subtopical areas appearing under each of the twelve major modules are not meant to be all inclusive, but rather are cited as examples of the kinds of topics to be covered in the particular area.

After establishing this list of modules a "scoring" of the individual PMs, relative to this list, was made. This score card is shown as Figure 6. Using PM Number 14 as an example again, it can be seen that evidence was found that he had modules in the areas of Planning, Scheduling, In-House Tasking, Contracts and Technical Management. It is of interest to note from this Figure that: 1) looking at the columns, a number of the PMs (e.g., 3, 4, 8, 9. 11, 12, and 17) had very few of the modules and 2) looking at the rows, some of the modules (e.g., Planning, Deployment and Operational Status and In-House Tasking) were used by only a few PMs.

The next two figures (Figure 7 and Figure 8) depict the modules used by the PMs categorixed by Service. For each module, the vertical columns represent the percentage of the Army, Navy and Air Force programs (in that order) that used that particular module. For example, there was evidence of a Planning module being used by 1 Army and 1 Air Force program, while 4 Navy programs had documentation from their MISs that was categorized as coming from the Planning functional area. These Figures show the following trends:

(1) The Army PMs tended to emphasize the technical aspects of their programs (i.e., Scheduling, Contracts, Technical Management, Configuration Management and ILS modules)

(2) The Navy PMs placed more emphasis on planning than the other Services

(3) The Air Force PMs were more concerned with the financial status of their programs (i.e., Current Project Status, Budgeting and POM Development and Financial Management modules).

Figure 9 indicates that as each program proceeds through its life cycle, it tends to complete its MIS by adding more of the functional modules. Program in Full-Scale Development and those in Production concurrently with Full-Scale Development had 11 of the 12 modules. Programs in Concept Exploration and Demonstration/Validation had a total of 5 and 8 modules respectively.

As mentioned previously, the data collection phase of this investigation into PM's MISs has just been completed. As a result, the analysis of this data is still on-going. It's planned that several other factors will be evaluated to weigh their influence on the sources of information for the PM and the make-up of the PM's MIS. These other factors will include the size of the program, the size of the PM's staff and the maturity of the program. The results of these additional analyses will be provided in a future status report.

OVERALL PERCEPTIONS

In this section the research team will report on some initial "perceptions". Because the data analysis has not yet been completed, these will be labeled as perceptions rather than "conclusions". Though it is acknowledged that it is normally inappropriate to report on perceptions before the complete analysis of the research has been done, these items are considered significant enough to report on now.

It was apparent from the research that most of the PMs gathered the information used for decision-making on an "ad hoc" basis or when the need arose. This is probably not a surprising finding to anyone familiar with the acquisition process. In any case it is clear that "ad hoc" information gathering is a way of life in the DOD program management environment.

On the one hand, where the "ad hoc" basis was the most significant source of information for some PMs, it reflected a situation where those PMs and staff are having to fight "brush fires" (solving today's most urgent problems) and are forced into a mode of managing by reaction. On the other hand, in some PMOs, this use of the "ad hoc" meeting was an adjunct to a well-planned, well documented program that also made extensive use of hard copy information. In these cases, the hard copy documented the baseline plan for the lower level managers to execute, requiring the PM to become involved only when deviations to the plan were required or occurred. The need for deviations, of course, arose at random and they were generally resolved in informal, ad-hoc meetings. This is management by exception.

Regardless of which mode of operation is driving the situation, to most effectively support a program manager, a PMSS development will have to take cognizance of the need for instantaneous information and support that modus operandi.

As reported here, the research so far has considered two factors -- the Service and the phase of the program. It is planned to evaluate other factors including program value, PMO staff size and program maturity. While all these factors appear to influence the PM's sources of information and the modules contained in his MIS, the research team believes that there is yet another group of factors - such as management style, PM experience and external requirements - which also play a major role. These factors are much more difficult to describe and their influence on the PM's information sources and his MIS may not be possible to measure. Nevertheless, one must be aware that these other factors exist and recognize that they do, in fact, play a significant role.

Another observation, based on the analysis of the MISs, is that most MISs do not provide a capability to aid the program manager and his staff in the planning and forecasting function. Even the most extensive MISs reviewed during this research activity were primarily structured to provide large amounts of historical data in all of the functional areas and some data on the current status of the project. However, in only a few cases, was there much information that would aid the PM in planning the next phases of his program or in forecasting potential problem areas. In other words - it seemed that the existing MISs were designed for, and in some cases did an exceptionally good job of, answering the question "What was?" -- and in a few instances answering the question "What is?" But, only a few have made any attempt to address the question "What if?"

Primarily for this reason, the research team felt that existing MISs were most useful for management levels in the PMO below the PM or his deputy. At the PM level, the primary focus of management efforts should be on the "big picture" items and the general direction the program should be following. The large amount of data and level of detail, when coupled with the primary focus on program history, decrease the immediate utility of existing MISs to the PM. It is the opinion of the research team that what would be of most benefit to the PM is a MIS that adds a "forward looking" capability - a MIS that could provide assistance to the PM in answering the question - "What if?"

WHAT'S NEXT?

The next portion of the research effort will complete the analysis of the data gathered and define an "effective MIS" for a PMO. It is expected that this will take approximately two months to complete. Another status report will be published when that effort is finished.

PM's SIGNIFICANT SOURCES BY SERVICE

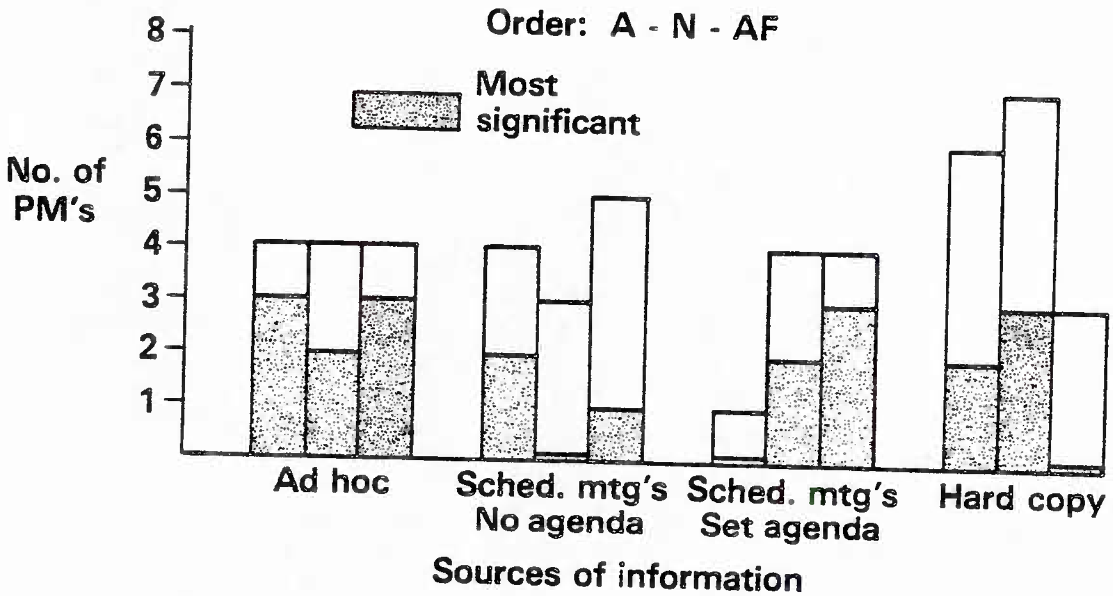

Figure 4

EFFECTIVE MIS FUNCTIONAL MODULES

- General overview (non-product)
  - General ID - (mission)
  - Organization
  - Personnel
  - Security - (security classification guide)
- Current project status (product)
  - General - (operational mission, threat, issues)
  - Project descriptions
  - Project overviews
- Planning
  - WBS
  - Risk analysis
  - Acquisition strategy
  - PMP
  - Transition to production plan - production facilitization
- Deployment and operational status
  - US deployment
  - International programs
  - Operational status
- Scheduling
  - Milestones
    - Listings
    - Gantt/Bar
  - Line of balance
  - Networks
  - PERT/CPM
- Budgeting/POM development
  - Cost estimating - (LCC, DTC, etc.)
  - POM development
  - The budget - up to appropriation
- Financial management
  - Allocation
  - I/O/E status
- In-house tasking
  - Planning
  - Issue
  - Monitoring
- Contracts
  - Procurement planning (e.g., - APs)
  - Procurement coordination (pre CA)
  - Contract status (post CA)
- Technical management
  - Engineering
  - Production mgt (GFE/CFE)
  - Technical performance monitoring
  - Testing
- Configuration management
- ILS
  - Maintenance planning
  - Logistic planning (tech manuals, spares, support equipment)
  - Training

Figure 5

EXISTING MIS MODULES BY PROGRAM

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
General overview	X		X	X						X						X			X		X
Current projected status	X	X	X	X	X		X			X			X			X			X	X	X
Planning		X			X			X					X	X							X
Deployment & operational status										X			X								
Scheduling	X	X	X	X	X	X	X	X	X	X		X	X	X		X		X	X	X	X
Budget/POM development		X	X		X										X	X			X	X	X
Financial management	X	X		X				X	X	X		X	X			X	X	X		X	X
In-house tasking		X			X									X							
Contracts	X	X	X			X	X	X		X	X	X	X	X		X	X	X	X	X	X
Technical management	X	X			X	X				X		X	X	X		X		X	X	X	X
Configuration management		X			X	X	X			X			X			X		X	X	X	
ILS		X			X	X	X			X	X		X			X		X	X		X

Figure 6

MIS MODULES BY SERVICE

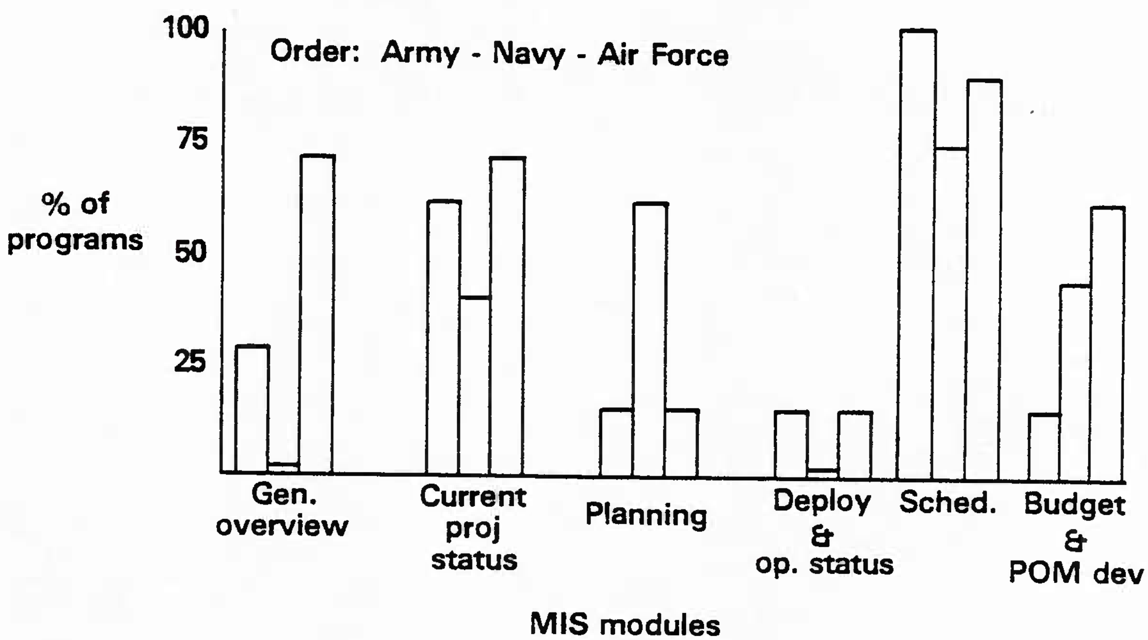

Figure 7

MIS MODULES BY SERVICE

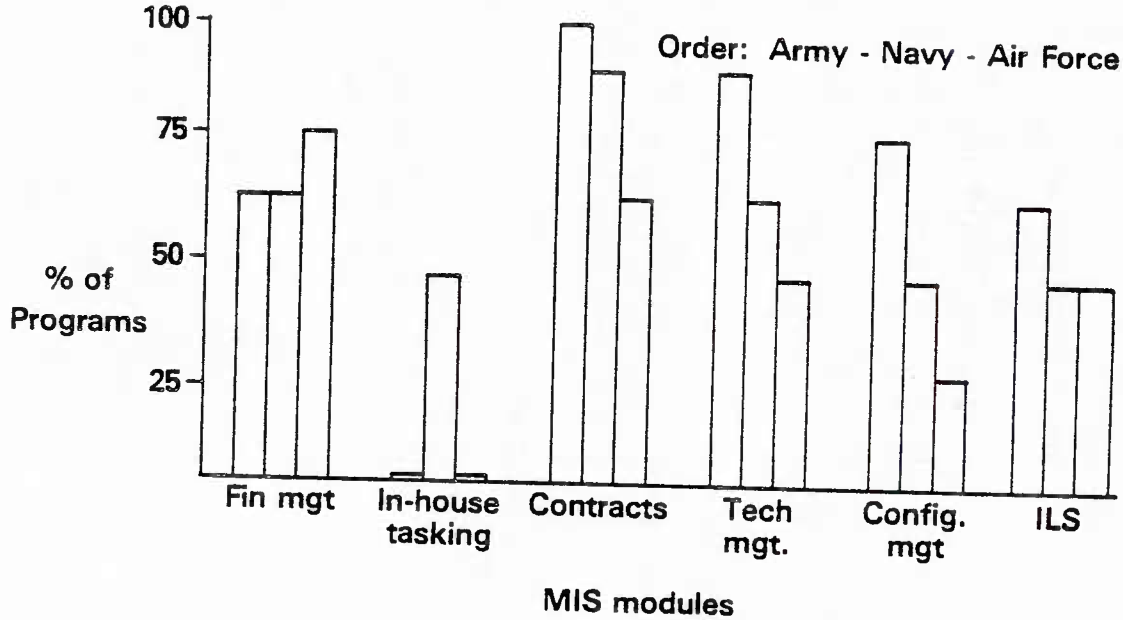

Figure 8

MIS MODULES BY PROGRAM STAGE

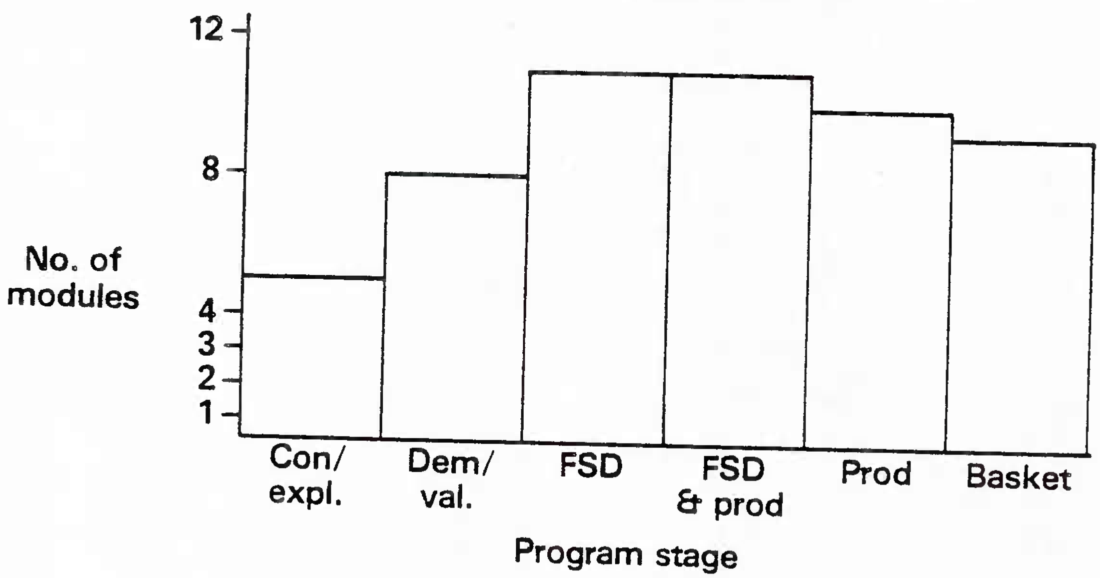

Figure 9

AN INFORMATION SYSTEM FOR NMC ACQUISITON PROGRAM MANAGEMENT

J. Sharon Short
Naval Material Command, Washington, D.C.

ABSTRACT

Naval Material Command (NAVMAT) is developing an acquisition information system. This system will not only make it easier for top management to be more currently well-informed, but could lead to a change in data being reviewed on a terminal display vs. reams of paper reports. The system, NMC Selected Acquisitions Tracking System (NSATS), gives quick and pertinent information for NAVMAT managers and appropriate Systems Command Managers.

The paper looks at the development phases of NSATS: manual, automated prototype and real-time response. The theme is NSATS as an actual system with discussion of ideas and the impact on the acquisition decision-making process.

The NSATS system merges the NAVMAT organization and the management of acquisition. This merger can be seen in the many functional areas covered by the tracking system. For effective information processing the automated system has many capabilities for users with no computer background. Examples include rapid return of information and trending patterns of particular areas, graphical interpretation of data, historical traceability of information, sorted listings of acquisition programs and data base management support. The report covers mechanics needed for operation (updating, query of the data base, reports and screen displays), a plan for the real-time system and an outlook including commonality with other data bases.

INTRODUCTION

The purpose of NSATS is to provide timely and pertinent information regarding the qualitative status of selected Navy acquisition programs and to assist in the early identification and solution of program problems. All major Navy Acquisition programs (Acquisition Categories I, IIS, and IIC) are reported via the NSATS report-the Acquisition Program Status Report, NAVMAT Form 5200/5 (Rev 2/82). Some examples of major programs are ACAT I - LAMPS MK-III, TRIDENT II SUB SYSTEM; ACAT IIS - S-3 Weapon System Improvement, A6/AWSACS; and ACAT IIC Mobile Sea Range, OTH Targeting, and SH-60 CV Variant.

Program managers complete the report. The reports are forwarded to the Chief of Naval Material (CNM) via the Systems Commanders. Analysis and dissemination of this information is performed by the Naval Material Command (NAVMAT) Acquisition Divisions.

REPORT CONTENT AND DEFINITIONS

The NSATS reports give some detail in seven assessment areas plus an overall program assessment. These areas are resources, financial, cost, performance, schedule, documentation, and logistics.

Status of the assessment areas is indicated by:

- (G) green - essentially on plan
- (Y) yellow - potential deviation from plan
- (R) red - significant deviation from plan

It should be noted that the status is a subjective measurement made by the program manager/acquisition manager.

Plan is defined as the acquisition program plan given in the appropriate Navy authorizing document for the program, such as the Decision Coordinating Paper (DCP), Navy Decision Coordinating Paper (NDCP), or related program plan.

NSATS HISTORY

In 1979 the concept of NSATS was implemented by a NAVMAT instruction. By 1980 management began reviewing the benefits of automating this tracking system. An NSATS Working Group was established in November 1980 for the purpose of evaluating NSATS in terms of user requirements and recommending changes/ improvements to the CNM. The working group conducted a survey to identify user requirements with regard to the Systems Commands (AIR, SEA, and ELEX) and NAVMAT. Experts in acquistion strategy, DOD and Navy budgeting, weapon system supportability, contracting, and overall program management were contacted for comments on data the group had identified for top program management (macro management) needs.

As a result of this effort the group presented three alternatives for NSATS to the Chief of Naval Material (CNM) in February 1981.

These alternatives were as follows:

1. Status quo, the system remains a detailed four page report.

2. A few minor changes, system is basically same.

3. Significant changes, a one page executive summary with some policy revisions.

The CNM approved the one page executive summary in lieu of the four page detailed report. After an unsuccessful interim period using the executive summary report, NAVMAT management made the decision to return to a detailed report.

MANUAL SYSTEM TO AUTOMATED PROTOTYPE

NSATS has been a manual tracking system since its conception. This has been extremely limiting for rapidly summarizing the information, conducting analysis, and providing easy access to the data for all interested parties.

During the Spring of 1981, a series of demonstrations were given to several executive managers and flag officers including the CNM, VCNM, and DCNM. The primary objective of this effort was that management could visually review the benefits offered by automation.

Comments from the demonstration were documented to be considered during the development phase of automation. Some of these comments were as follows:

- track the NAVMAT action taken on problem programs
- have capability for higher - level authority to query a limited number of data fields
- welcomed efficient query capabilities to more easily and rapidly retrieve data on a specific program or programs, e.g., finding a program manager's assessment on a specific program; determine all reporting programs for a particular quarter with cost (RED) and schedule (RED); search for all programs reporting the Plan as a "NDCP" and view the plan dates.
- Expressed the management requirement for linking to existing data bases (FYDP, CPR's etc.)
- Addressed linking the SYSCOMs to the HQNAVMAT data base.

(It was felt this linking would be beneficial as a management tool for the SYSCOMs and the CNM/NAVMAT staff.)

Overall the demonstrations accomplished the objective of introducing visually some of the capabilities available by automating NSATS. This gave management an opportunity to identify the benefits automation can bring to the organization.

We have reviewed the Air Force and Army acquisition program management information systems. The Air Force has developed a system, SMART (Summary Assessment Review Trends) which has been operational since 1978. The information collected is somewhat similar to NSATS. The Army is in the early stages of an overall system. Their automated PERT charts for scheduling have proven to be useful. "Lessons learned" have impacted our decisions on automation of NSATS.

The next phase of NSATS is the automated prototype. NSATS had been considered to be included in the short-range plans for a NAVMAT Management Information System (MIS). Early this year this decision was changed and management decided to develop a NSATS prototype.

The prototype timeshare system is a short term investment. A primary advantage is the opportunity to become more knowledgeable prior to determining the most effective direction for NSATS automation. It allows:

- Determination of data which must be retained and kept alive for corporate memory
- Elimination of manual effort now required to summarize data and produce simple lists
- Additional time available for analysis of data
- Verification of easy access to data for all interested parties
- Experimentation of analytical and graphic capabilities of system

The prototype concept will give us a baseline in terms of desired hardware, easy-to-use software, and overall system costs. With the timeshare system, investment is made only on system usage with a non-commitment to hardware. Disadvantages were not overlooked. One main problem with a prototype system is not having a fully operational system for this time period.

Software for the prototype will be supported by a data base management system.

There are many system capabilities available for users of this software and no computer background is necessary. Engineers, program analysts, and excutive level management will be the primary users.

Password security will enable the system to allow specific users to update the data base, while other users can only view all or portions of the data via screen displays or hardcopy reports. A basic set of reports and graphs are to be developed for the users. Graphical interpretations of the data base will be attainable thru a plotter.

REAL-TIME IN PM's OFFICE

An additional effort is underway at NAVMAT in the area of acquisition program information. A pilot system is being developed which will involve five Naval Air Systems Command (NAVAIR) program managers with the NSATS timeshare system. Data will be available on a real-time basis for the progarm manager via a Video Display Terminal (VDT) with a printer. Program information in addition to NSATS data, can be queried, updated, printed, and stored. It is anticipated that program baselines for cost and schedule will be included in the data base to enhance the capability for identifying program problems early. System development is planned to begin early June.

This real-time system will impact the acquisition decision-making process. Program managers will have information at their fingertips for rapid review and the system will provide an easy tool for maintaining current data. This will decrease manual files that must be retained.

FUTURE OUTLOOK

In the future is an opportunity for other report data to be automated, decreasing time required for reports to pass thru the approval chains. Executive level managers could view the reported information on a desk top terminal (VDT). Management decisions could be based on more current data from a central access point instead of reams of paper.

There is a need to consider in the future the linking to other existing data bases. Benefits must be measured against costs prior to commitments.

SUMMARY

The automated prototype of NSATS provides a means for more effective acquisition information exchange and processing. A total of 110 NMC programs (ACAT I, IIS and IIC) are tracked by NSATS. This total encompasses $16B (50% of Navy R,D,T&E & Procurement) for FY82. The involvement of NAVAIR program managers with a real-time system will definitely improve the acquisition decision-making process by providing data rapidly and having an opportunity for decisions to be based on fact-supported information.

A NEW APPROACH TO ANALYZING COST PERFORMANCE REPORTS

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ABSTRACT

This paper presents a practical approach to the analysis of cost and schedule data (C/SCSC, CPR, C/SSR). The Air Force Weapons Laboratory (AFWL) has developed a unique computer-based approach to analyzing contractor generated Cost Performance Reports (CPRs). The benefits of the program and the components of the program are explained in this paper. The approach presented for analyzing contractor cost and schedule data has the potential for application to many DOD contracts.

PURPOSE

The purpose of this paper is to demonstrate that the use of a computer-based approach to the analysis of cost performance reports provides timely and cost-effective information that forms the basis for program management decisions.

THE NEED

The Air Force Weapons Laboratory, like many organizations, has experienced difficulty analyzing and tracking contractor cost and schedule performance. There are many reasons for this difficulty, including more contracts and resultant reports than can be effectively analyzed manually; a limited number of trained people to analyze contractor generated cost performance reports; a lack of understanding and appreciation of the analysis by project officers: less than satisfactory contractor reports; etc. The objective of analysis is to identify when contracted work will not be accomplished on schedule and within cost. Achieving this objective requires a comprehensive analysis of contractor data, the identification of problem areas, and assuring that management is advised when action is required. To pay thousands of dollars for contractual data that has been specified on the DD Form 1423, Contract Data Requirements List, and then not use the data to effectively manage a contract or program is irresponsible. Therefore, the need became evident and a computer-based cost/schedule analysis program was developed that would meet management requirements and overcome the shortcomings of the manual analysis of cost performance reports.

OVERVIEW

The cost/schedule analysis program provides the means for assessing contract cost and schedule performance in terms of both dollars and percent accomplishment. Problems and trends are identified and the cost to completion for a contract is estimated. Anyone can extract pertinent data from cost performance reports (CPRs) and input the data into the computer. The cost/schedule analysis program then operates on the data, analyzes the contract cost and schedule situation, and then provides a numerical assessment and graphics package that reflect monthly status. This information is provided to the program manager and management. The computer-based cost and schedule analysis program is not used for all contracts. It is most useful and cost effective for those contracts, typically cost type contracts, that have some type of cost performance reporting required. Data Item DI-F-6000C, Cost Performance Report, or DI-F-6010, Cost/Schedule Status Report are examples of such reports. The program has proven that cost overruns and schedule slippages can be identified early. In addition, the extent of an anticipated cost and/or schedule variance and the impact of this variance can be estimated. There have been several projects in the Laboratory where this technique has accurately predicted overruns and schedule slippages.

THE PROGRAM

Figure 1, Cost/Schedule Analysis Program (C/SAP) System Update, is used by the analyst as a source document for transcribing data from a contractor's Cost Performance Report (CPR) and entering that data into the computer. Basic contract data is shown at the top of the form. The Budgeted Cost of Work Scheduled (BCWS), Budgeted Cost of Work Performed (BCWP), Actual Cost of Work Performed (ACWP), Budget at Completion (BAC) and Latest Revised Estimate (LRE) are recorded monthly for each level of the work breakdown structure (WBS). The Management Reserve (MR) is only recorded at the total contract level which is level I of the WBS. Figure 2 is a summary of the terms and formulae used in cost and schedule analysis.

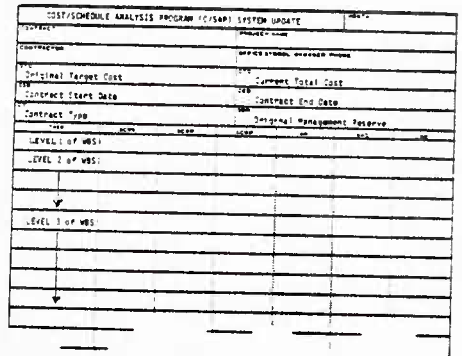

FIGURE 1. COST/SCHEDULE ANALYSIS PROGRAM SYSTEM UPDATE

TERMINOLOGY

BCWS	BUDGETED COST OF WORK SCHEDULED
BCWP	BUDGETED COST OF WORK PERFORMED
ACWP	ACTUAL COST OF WORK PERFORMED
MR	MANAGEMENT RESERVE
EAC	ESTIMATE AT COMPLETION
LRE	LATEST REVISED ESTIMATE
BAC	BUDGET AT COMPLETION
UB	UNDISTRIBUTED BUDGET
ETC	ESTIMATE TO COMPLETE
BCWR	BUDGETED COST OF WORK REMAINING

COMMON CAUSES FOR VARIANCE

FAVORABLE

- POOR INITIAL PLANNING OR ESTIMATING
- TECHNICAL BREAK THROUGH
- COST OF LABOR OR MATERIAL LOWER THAN PLAN
- FRONT END LOADING
- METHOD OF EARNING BCWP

UNFAVORABLE

- POOR INITIAL PLANNING OR ESTIMATING
- TECHNICAL PROBLEM
- COST OF LABOR OR MATERIAL HIGHER THAN PLAN
- INFLATION
- NEW LABOR CONTRACTS
- WORK STOPPAGE

DEPARTMENT OF THE AIR FORCE
AIR FORCE WEAPONS LABORATORY (AFSC)
BUSINESS MANAGEMENT (PRA)
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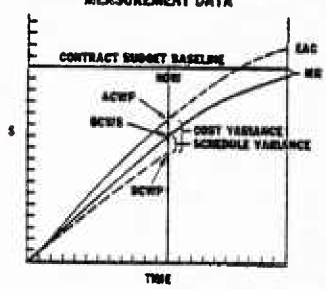
USE OF CONTRACTOR PERFORMANCE MEASUREMENT DATA



CPR - COST PERFORMANCE REPORT
CSSR - COST/SCHEDULE STATUS REPORT
PURPOSE: TO OBTAIN CONTRACT COST AND SCHEDULE STATUS INFORMATION

FORMULAE FOR ANALYSIS

VARIANCE

COST VARIANCE ($) = BCWP-ACWP

SCHEDULE VARIANCE ($) = BCWP-BCWS

COST VARIANCE (%) $= \frac{BCWP-ACWP}{BCWP}$

SCHEDULE VARIANCE (%) $= \frac{BCWP-BCWS}{BCWS}$

PERFORMANCE INDICES

COST PERFORMANCE INDICES (CPI) $= \frac{BCWP}{ACWP}$

SCHEDULE PERFORMANCE INDICES (SPI) $= \frac{BCWP}{BCWS}$

TO COMPLETE PERFORMANCE INDEX (TCPI)

$\frac{WORK\ REMAINING}{MONEY\ REMAINING} = \frac{BAC-BCWP}{LRE-ACWP}$

*MANAGEMENT RESERVE SHOULD NOT NORMALLY BE INCLUDED IN COMPUTATION

% SCHEDULED/COMPLETE/SPENT

% SCHEDULED $= \frac{BCWS}{BAC^*}$

% COMPLETE $= \frac{BCWP}{BAC^*}$

% SPENT $= \frac{ACWP}{BAC}$

ESTIMATE AT COMPLETION (EAC)
(CONSIDERS COST VARIANCES ONLY)

$EAC = \frac{BAC^*}{CPI}$

ESTIMATE AT COMPLETION (EAC) WITH PERFORMANCE FACTORING (PF)
(CONSIDERS COST & SCHEDULE CONDITIONS)

$PF = 1.0 - \left[\left(\frac{BCWP-ACWP}{BCWP}\right) + \left(.75 \times \frac{BCWP-BCWS}{BCWS}\right)\right]$

$BCWR = BAC^* - BCWP$

$ETC = PF \times BCWR$

$EAC = ETC + ACWP$

FIGURE 2. TERMS AND FORMULAE

```
                       80-C-00     PROJECT DELTA                  PRA/TYLER/6151

   ***CONTRACT DATA***                                              ***SEPRI CUMULATIVE DATA***

 * ORIGINAL TARGET COST     15200                                  CUMULATIVE BCWS              11123.20 *
 * CURRENT TARGET COST      17000.                                 CUMULATIVE BCWP              10072.70 *
 * START DATE               MAY80                                  CUMULATIVE ACWP               9926.60 *
 * END DATE                 JUL82                                  INITIAL MGMT RESERVE          1038.80 *
 * CONTRACT TYPE            CPAF                                   REMAINING MGMT RESERVE        1367.10 *

        THIS DATA BASED ON LATEST CONTRACTOR FURNISHED COST AND SCHEDULE INFORMATION

   ***CUMULATIVE COST DATA***                                      ***CUMULATIVE SCHEDULE DATA***

  COST VARIANCE-----------$     146.10                     SCHEDULE VARIANCE-------$  -1050.50
  COST VARIANCE-----------%       1.45                     SCHEDULE VARIANCE-------%     -9.44
  MGT RESERVE INDEX--------       2.69                     WEEKS AHEAD/BEHIND(-)----     -5.70

  CURRENT MONTH CPI--------       1.00                     CURRENT MONTH SPI--------      1.18
  3 MONTH CPI AVERAGE------        .92                     3 MONTH SPI AVERAGE------      1.05
  CUMULATIVE CPI-----------       1.01                     CUMULATIVE SPI-----------       .91

  % SPENT(BAC-MR REM)-----%      63.79                     % SCHEDULED--------------     71.40
  %SPENT (CENTRS LRE)-----%      58.60                     % COMPLETE (BAC-MR REM)-%     64.73
  ACWP RATE (PER MONTH)---$     803.92                     BCWP RATE(PER MONTH)----$    592.51
  MONTHS LEFT (ACWP RATE)--      12.11                     MONTHS LEFT (BCWP RATE)--     11.69

                          ***ESTIMATES AT COMPLETION AT COST***

                                        EAC       BAC+MR      $ VAC      % VAC     CONTRACT CONDITION

     CONTRACTOR FURNISHED LRE------   16938.30   17000.00      61.70       .36
     BASED ON CURRENT MONTH CPI----   15411.09   17000.00    1588.91      9.35
     BASED ON 3 MONTH CPI----------   15875.00   17000.00    1125.00      6.62
     BASED ON CUM CPI -------------   15335.49   17000.00    1664.51      9.79
     BASED ON ACWP REGRESSION------   15092.30   17000.00    1907.70     11.22
     BASED ON WEIGHTED SPI/CPI-----   15724.25   17000.00    1275.75      7.50
     BASED ON TREND WTD SPI/CPI----   16048.38   17000.00     951.62      5.60          BLUE

            ****COMMENTS****                                       ****COMMENTS****
   **CONTRACT IS  5.7 WEEKS  BEHIND SCHEDULE.**         **MGT RESERVE(MR) INCREASED-NEEDS REVIEW.**
**CONTRACT IS      $146.10 K  UNDER PLANNED COST.**                 **BAC INCREASED**
```

FIGURE 3. COST PERFORMANCE REVIEW ANALYSIS ($000)

Figure 3, Cost Performance Review Analysis, depicts the first sheet of the analysis package. A hypothetical example is used for this paper. The sheet is divided into several discrete sections. Basic contract information such as target cost, contract start/end dates, contract type, as well as cumulative BCWS, BCWP, ACWP and initial and remaining management reserve is shown at the top of Fig. 3. The middle part of the analysis cover sheet shows how well, or how poorly, a contractor is doing in the cost and schedule area. The lefthand side of the middle section has several calculations for cost data such as cost variance, cost performance indices (CPI), and the monthly ACWP rate. Similarly, the righthand side of the middle section of the analysis cover sheet shows the same type of information for schedule. In addition, the schedule variance also indicates the weeks the contract is ahead or behind schedule (5.7 weeks behind schedule in this case). Also, schedule performance indices (SPI) are displayed. Notice that the current month SPI is 1.18 but the cumulative SPI is 0.91. This means that the contractor is ahead of schedule for the current month but behind schedule since contract start date.

The bottom portion of Fig. 3 provides several estimates at completion (EAC) for the contract, the budget at completion (BAC) and the management reserve (MR), as well as the dollar variance. Thus, the contractor's latest revised estimate (LRE) is compared with several other estimates. Among the better estimates are the trend weighted SPI and CPI. It should be noted that the computer program has about 46 comments that are automatically printed, based upon their relevance, at the bottom of the page. For example, this hypothetical contract is 5.7 weeks behind schedule and $146,000 under planned cost. Based upon Level I analysis of this contract, the contract is condition coded blue. Four condition color codes are used: blue indicates underruns of more than 3 percent; green means an underrun or overrun of up to 3 percent; an overrun of more than 3 percent but less than 8 percent is coded yellow; and, condition red means that there is a projected overrun of 8 percent or more. The project officers have found the information presented in Fig. 3 particularly useful.

THE GRAPHICS PACKAGE

One of the most unique aspects of the Cost/Schedule Analysis Program (C/SAP) is its graphics package. Project officers are provided five graphs with the analysis cover sheet (Fig. 3). These graphs are raw data - cumulative; cost/schedule variance - cumulative; cost performance index - cumulative and three month moving average for the last 12 months; schedule performance index - cumulative and three month moving average for the last 12 months; and, the estimate at completion.

The first graph (Fig. 4) is a plot of the cumulative raw data for the last 12 months for BCWS, BCWP, and ACWP. It is easy to see the dollar difference between BCWP and BCWS. This difference represents the scheduled variance (SV) in dollars. Since "S" is above "P", an unfavorable schedule variance exists with respect to the performance measurement baseline. The cost variance (CV) in dollars is represented by the vertical distance between "P" and "A". For this hypothetical contract, the CV is favorable because the actual cost of the work performed is costing less than the performance measurement baseline (budget). The analyst needs to be aware that the vertical distance between "P" and "A" is decreasing and the potential exists for the CV to become unfavorable by ACWP exceeding BCWP. As can be seen from the graph there was $6.4M of work scheduled in April, $5.6M of work was performed, but the actual cost was $5M. Therefore, this contract was about 13 percent behind schedule and 12 percent under cost.

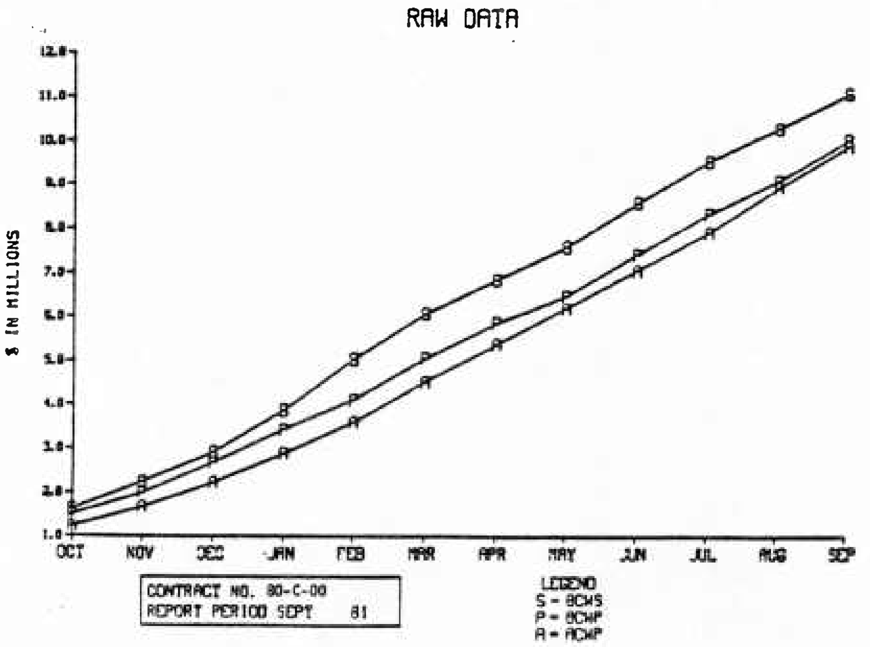


FIGURE 4. RAW DATA, CUMULATIVE

The second of the five graphs (Fig. 5) shows the cumulative cost and schedule variance for the last 12 months in percent. In this particular case, the cost variance (upper portion of the chart) has been steadily decreasing from an 18 percent positive variance (underrun) to about a 2 percent positive variance. While the cost picture is still in good shape for this contract, the downward trend is reason for concern. The analyst should look further and determine the reasons for the negative slope of the cost variance. The schedule variance (lower portion of the chart) shows that the contractor has been behind schedule for the last 12 months as indicated by the negative schedule variance. However, schedule performance has been improving for the last 8 months. This chart is particularly helpful in assessing the trends that are occurring in both the cost and schedule areas.

The Cost Performance Chart (Fig. 6) graphically depicts the cumulative cost performance index (CPI Cum) and the average cost performance index (CPI Avg). The CPI Cumulative is determined by: $\frac{\text{BCWP (Cum)}}{\text{ACWP (Cum)}}$.

This index indicates the value of work performed for each dollar spent since the contract began. The CPI average is:

$$\frac{\text{Current mo. BCWP (Cum) - Previous 4 mos. BCWP (Cum)}}{\text{Current mo. ACWP (Cum) - Previous 4 mos. ACWP (Cum)}}$$

This indice indicates the value of work performed for each dollar spent since the last month. Notice a value equal to or greater than 1.00 is considered good.

The Schedule Performance Chart (Fig.7) is used to show trends in the Schedule Performance Index (Cum) and the Schedule Performance Index (Avg). The SPI (Cum) is determined by:

$$\frac{\text{BCWP (Cum)}}{\text{BCWS (Cum)}}$$

This indice indicates the value of work performed compared to the dollar value of work scheduled since the start of the contract. For example, in April the SPI (Cum) was about 0.85. This means that since the contract start date, the contractor has accomplished \$0.85 worth of work for every dollar of work that was scheduled. Such performance is obviously inadequate and, if performance does not improve, there will be a cost overrun and probable need for a schedule extension. The SPI (Avg) is similarly calculated to indicate the value of work performed in comparison with the dollar value of work scheduled. The SPI (Avg) is determined by:

$$\frac{\text{Current mo. Cum BCWP - Previous 4 mos. Cum BCWP}}{\text{Current mo. Cum BCWS - Previous 4 mos. Cum BCWS}}$$

For this example, the SPI (Avg) was 0.90 in December. This means that for every \$1.00 of work scheduled only \$.90 worth of work was performed. This condition also indicates a possible contract cost overrun.

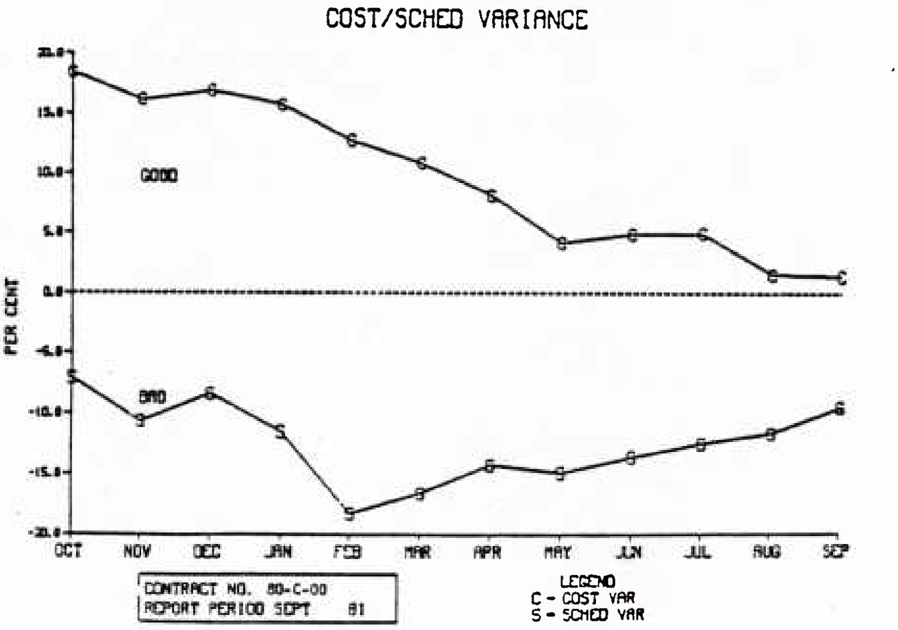


FIGURE 5. COST/SCHEDULE VARIANCE - CUMULATIVE

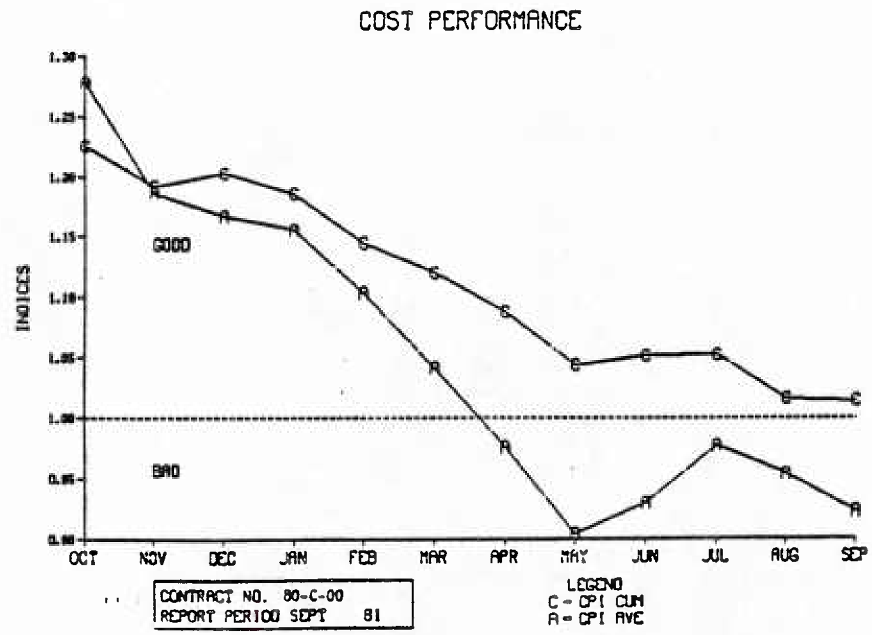


FIGURE 6. COST PERFORMANCE INDICES (CUMULATIVE AND AVERAGE)

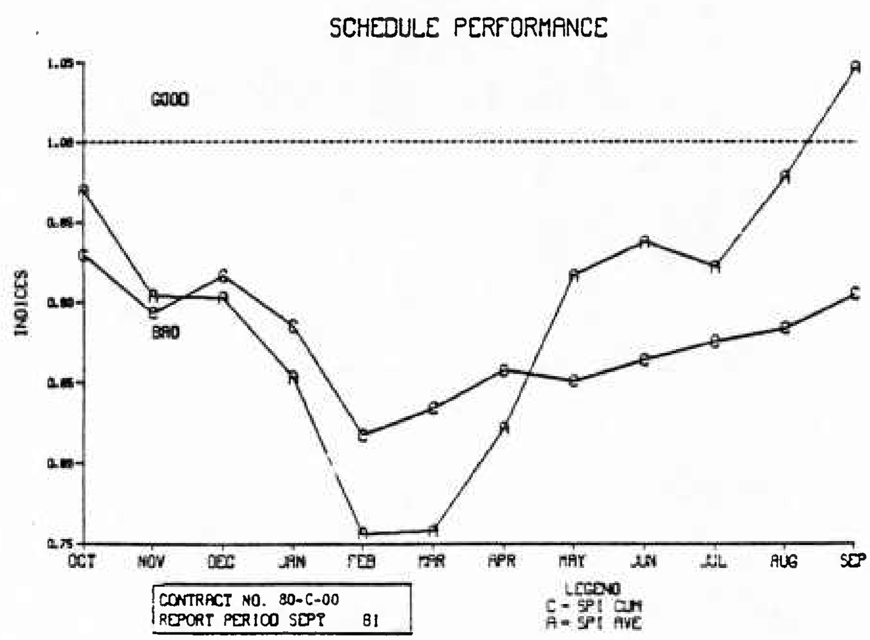


FIGURE 7. SCHEDULE PERFORMANCE INDICES (CUMULATIVE AND AVERAGE)

The Executive Summary (Fig. 10) is designed to highlight to top management on one sheet of paper, the current status of a contract. The Executive Summary is not as extensive as the graphics package and comments provided to the project officer nor is it as extensive as the Program Management Summary that is provided to middle management. The Executive Summary does give a quick picture of the status of a particular contract. It indicates the problem areas that may require management attention. For the hypothetical contract in this paper, the contract condition is yellow, a $291,000 overrun is projected, the contract is three weeks behind schedule and $522,800 over planned cost. A unique aspect of the Executive Summary is the highlighting of the critical program drivers. In this case, three critical areas are all over planned cost.

EXECUTIVE SUMMARY (EXAMPLE)

80-C-00 PROJECT DELTA PRA/TYLER/6151 YELLOW

1. **ORIGINAL TARGET COST $8.5 M** 2. **CURRENT TARGET COST $8.5 M**
3. **OUR ESTIMATE AT COMPLETION $8.8 M** 4. **PROJECTED 291 K OVERRUN**
5. **CONTRACT 3.0 WEEKS BEHIND SCHEDULE, $522.8 K OVER PLANNED COST, $932 K MANAGEMENT RESERVE**
6. **PROGRAM DRIVERS**
   - **OPTICAL RESONATOR ASSEMBLY (13% OVERRUN, $33 K)**
   - **EXHAUST MANIFOLD ASSEMBLY (46% OVERRUN, $54 K)**
   - **OPTICAL RESONATOR MGMT (94% OVERRUN, $143 K)**
7. **CONTRACT COMPLETION: FEB 83**

FIGURE 10. EXECUTIVE SUMMARY

THE PROGRAM

The Air Force Weapons Laboratory has developed the software for both the HP 1000 and CDC 6600 computers. It generally takes less than 30 minutes per month per contract to load the data from the cost performance report and to complete the analysis. The data is extracted from the contract cost reports and input into the computer. About 40 contracts are currently included in the computer data base. This represents about 300 Contract Work Breakdown Structure (CWBS) lower level reporting elements. The primary cost for developing this system was the software. The continuing monthly costs are relatively insignificant and consist primarily of computer time and paper; however, improvements to the software are made when needed.

CONCLUSION

This paper has explained the cost/schedule analysis program (C/SAP) developed by the Air Force Weapons Laboratory that is being used to manage contracts. The program eliminates the need for the manual, time consuming, number crunching analyses of contractor generated cost performance reports. Problem areas are quickly identified and cost and schedule trends are highlighted so that corrective action can be taken. The cost/schedule analysis program permits the effective evaluation of cost and schedule reports with a minimum number of people. Excellent and timely information is provided to managers. The cost/schedule analysis program has increased productivity and is providing critical information that serves as the basis of informed management decision making.

PANEL C

PRODUCTIVITY

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PRODUCTIVITY ENHANCEMENT
A Clear and Present Challenge

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ABSTRACT

Today, the leadership of the United States in productivity is being challenged seriously by the other industrialized countries of the free world. The current decline in the rate of productivity growth is impacting both defense systems production and the economic and social progress of the United States. To combat the decline, the Department of Defense (DOD) Acquisition Improvement Program--launched in the spring of 1981 by the Office of the Secretary of Defense--includes productivity enhancement as one of its objectives.

This paper describes how the definition of productivity has been changing over the past five decades. A comparison is made of the productivity growth in the United States with the productivity growth in other industrialized countries of the world. The principal reasons for productivity growth and decline are identified and explained. Also, the key factors impacting productivity--the work force, capital investment, and technology--are discussed in some detail.

I believe that the United States can ill afford to have the rate of productivity growth continue to decline. Managers should be rewarded on the basis of how well they are able to integrate the work force, capital investment, and new technology to enhance productivity.

I. INTRODUCTION

The United States has made great strides in science and engineering through its free enterprise system. However, the leadership of this country in productivity enhancement is being seriously challenged by the industrialized countries of the free world. Thirty years ago, 80 percent of all technological innovations were marketed by the United States. Today, the U.S. is marketing less than 50 percent. What are the DOD and the defense contractors doing to enhance productivity during this period of inflation and recession? This paper will present the results of an investigation into this matter.

Productivity enhancement is important to both industry and DOD management. In industry, productivity growth leads to lower costs, and provides an opportunity for lower priced products and/or higher profits. It also makes possible increased compensatory benefits for employees. In the DOD, productivity growth helps to ensure that defense system programs will meet cost and schedule targets, thus providing more resources for other defense needs. Recognizing the importance of productivity enhancement, the Office of the Secretary of Defense (OSD) has established productivity enhancement as one of the goals to be met in the DOD Acquisition Improvement Program ... a program launched in the spring of 1981 by Frank C. Carlucci, Deputy Secretary of Defense.

II. DEFINITION OF PRODUCTIVITY

The productivity of any industrial firm is a measure of how well the resources in that firm are brought together and used to accomplish a set of results. Productivity isn't just an increase in the volume out the backdoor, although this is one element. Traditionally, productivity has been defined as the acceptable output per labor hour.[1] Using this definition, we would quickly discover that in a firm with many employees and little automation, productivity depends principally upon human achievement.[2] On the other hand, in a firm where automation predominates, the human contributions to productivity play a lesser role.

Fred Steingraber has written a fine summary of how the definition of productivity has changed over the years. This is the way he sees it:

> ... the definition of productivity has changed considerably over the past fifty years. Back in the 40s and 50s the measurement of productivity focused on output, or the production of as much as possible. In the 60s and 70s, quantity was no longer as important as efficiency, or production at the lowest possible cost. Now in the 80s, given the constraints imposed by scarcities, regulations, changes in job skill and cost mix, and greater international competition, the productivity emphasis is on effectiveness. Corporations are increasingly liable for the quality of their products and the services they offer. (Corporations) are considered social entities, not just economic

> entities. And, as social entities, (they) are held accountable for attitudes toward issues ranging from the environment to the quality of life in the work place and ultimately to the quality of the product delivered. As a result, the definition of productivity as output over input is useless unless we realize that output now includes in addition to product such factors as quality, service, and safety, while the input is government, unions, people, money, technology, information, motivation ...[3]

Productivity is more than output over input. It is the relationship of the quantity and quality of products, goods, and services produced to the quantity of resources (personnel, capital, facilities, machine tools and equipment, materials, and information) required to produce them. In order to improve productivity in an industrial firm, both the output (performance achieved) and the input (resources consumed) must be capable of measurement. The ratio set forth below provides a measure of how well the expended resources are able to accomplish the established performance objectives, i.e., the ratio provides a measure of the value added.

$$\text{PRODUCTIVITY} = \frac{\text{PERFORMANCE ACHIEVED}}{\text{RESOURCES CONSUMED}}$$

George Kuper of the National Commission on Productivity and Work Quality,[4] has defined productivity in a different way. He describes productivity as a comparison of the magnitude of the results (effectiveness) with the magnitude of the resouces used (efficiency). His formula, which appears equally acceptable to the one above, can be expressed in this manner:

$$\text{PRODUCTIVITY} = \frac{\text{EFFECTIVENESS}}{\text{EFFICIENCY}}$$

Today, when the defense market is dynamic and changing, the key to productivity growth depends to a greater extent upon technological innovation and the manufacturing technology employed than upon capital investment or resourceful workers. At this point it is important to understand where the U.S. ranks in productivity growth among the industrialized nations of the free-world. Unfortunately, the U.S. is now last in the rankings. This provides us with a measure of the attention that we, as a nation, have been giving to this important subject. Some of the details are discussed below.

III. TRENDS IN PRODUCTIVITY GROWTH

Until the last two decades, most U.S. managers took little interest in either European or Japanese management practices or production systems. This may be attributed principally to the fact that the U.S. has been the number one industrial nation. In recent years, however, both the U.S. and Europe have been losing their dominance in many different industries to the Japanese. The results of recent studies of Japanese improvements in productivity, product quality, and management have become the bases for changes in industrial practices worldwide.

During the 1950s and 1960s the U.S. maintained a relatively high productivity growth rate. During the 1970s the growth rate declined, but the U.S. is still ahead of the rest of the world. The Bureau of Labor Statistics in the Department of Labor indicates that when comparing the real gross domestic production per employed person—the national measure of productivity—the United Kingdom is 39.5 percent behind the U.S., Italy trails by 39.4 percent, Japan by 31.6 percent, West Germany by 11.3 percent, France by 10.6 percent, and Canada and The Netherlands by 8 percent. The challenge to the U.S. from other countries is a real one. It will take commitment — commitment to more innovation and commitment to strong leadership.[5] See Figure 1.

GROSS DOMESTIC PRODUCTION PER EMPLOYED PERSON BY NATION: 1950 - 1980

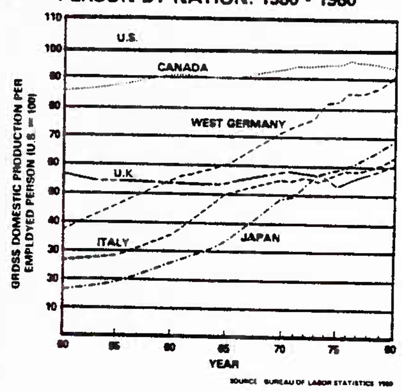


FIGURE 1.

The international productivity rating relative to manufacturing of many industrial nations of the free world is depicted in Figure 2. When viewing Figure 2, the obvious question that one might ask is: Why does the productivity rating of the United States look so bad when compared with other

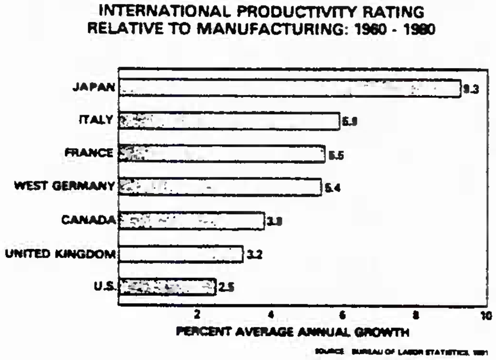


FIGURE 2.

industrialized countries? Part of the answer is that productivity has two meanings. One concerns the work force - how hard people are working. The U.S. looks good on this basis. The other concerns the number of end products or the dollar value of the end products people are producing per hour. On this basis, the U.S. does not look as good. Referring again to the figures of the Bureau of Labor Statistics, one finds that the gain in manufacturing productivity in the U.S. from 1970 to 1980 is less than increases in Japan and several European countries. See Figure 3.[6]

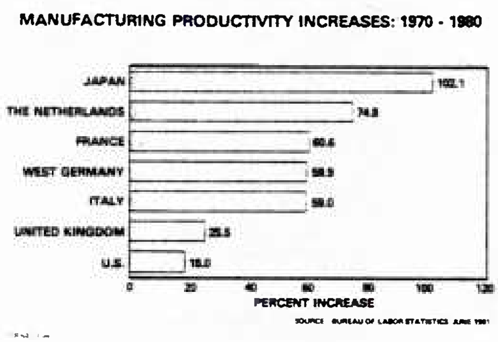


FIGURE 3.

The trend is disturbing. If it continues, it will undermine: the ability of the U.S. to compete in the world markets, the U.S. standard of living, and the ability of the DOD to acquire defense systems at affordable prices.

The productivity gains in other countries didn't just happen. The gains came about as a result of the application of computer-integrated manufacturing technology and a well-conceived management philosophy and style. It involved a resolution by managers of industrial firms to:

- Use the work force imaginatively and flexibly, and recognize that the people in the work force know how to increase productivity.
- Make workers feel they are part of the "team."
- Make workers a part of the communication channel and listen to what they have to say.
- Recognize the dignity of each worker, and the worker's right to privacy.

And there is a bright side to this story. Thomas J. Peters of McKinsey and Company and Stanford University found in a recent study that the best run and most successful U.S. industrial firms are outperforming typical Japanese firms in the three areas where their managers also excel. These areas are:

- Handling members of the work force with individualized concern and thoughtfulness.
- Focusing on the quality of the product.
- Paying extraordinary attention to the needs of the user.

IV. FACTORS THAT INFLUENCE PRODUCTIVITY

Although it is clear that productivity in the U.S. has stagnated, the factors that influence productivity growth are known; however, because of their complex interrelationships, it is difficult (if not impossible) to determine the specific effect of each one. The rest of this article will focus on the key factors: the work force, capital investment, and technology. Now, let's consider each of these factors.

V. PEOPLE FACTOR

The members of the work force represent an integral part of the productivity growth picture. This is portrayed in Figure 4.

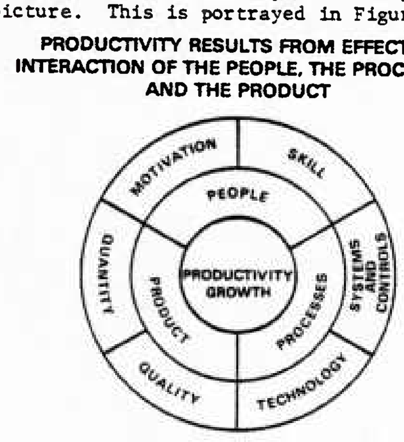


FIGURE 4.

Referring to this figure, you can see that each of the three categories - people (work force), processes, and product — is composed of subordinate elements, any one of which can impact productivity growth. Productivity growth occurs when the cumulative effect of the interdependent elements is imposed.

a. Quality of the Work Force

The quality of the work force effects productivity. As the quality increases or decreases, the productivity increases or decreases. There has been a decline in the quality of the work force in the U.S during the past few years. This decline can be attributed to a rise in the proportion of young and inexperienced workers in the work force and the decrease in the average work effort. Also, the lack of motivation of many young workers has had an adverse affect on productivity.

One of the actions that needs to be taken to increase productivity in our industrial firms is to increase the annual supply of engineering graduates. A critical problem in our high technology industries is that of sustaining the growth potential inherent in the industry with so few new engineering and scientific graduates. During the past decade, the number of engineers working in industry rose 62 percent in Japan and 59 percent in West Germany; however, the number of engineers in the U.S. dropped 13 percent. According to the American Electronics Association (AEA), in 1981 there were about 13,000 new engineering graduates to fill the 29,000 openings for electrical engineers and computer software engineers. In 1985 there will be only 15,000 engineering graduates to fill the 51,000 openings that will be available at that time. One of the contributors to this problem is the shortage of engineering faculty members. In 1980, for example, 15 percent of the engineering faculty positions were unfilled.

Then, there is a problem of turnover. The engineers who have prime responsibility for technological innovation turn over about every 10 years. Typically, following graduation, engineers focus on developing and applying new technology. Then, after ten years, they join the ranks of management. This means that educators influence 10 percent of the engineering work force annually through the new graduates to whom the technology has been transmitted. It is incumbent, then, on the members of engineering faculties to keep abreast of the state-of-the-art in their specialty areas so the latest knowledge can be imparted to the students.

b. Quality of Management

One of the keys to productivity enhancement within any organization is management. The attitudes, actions, and personal examples of management pervade the organization and affect directly the attitudes, actions, and motivation of the work force. It is from management that the workers generally take their cues. Accordingly, astute managers must convey clearly the importance they place on productivity, and their desire to enhance productivity throughout the organization. Unfortunately, actions that mangement takes to improve productivity in one organization may not work out well when applied to another organization. Therefore, it is important for managers to assess the situation within their organization before taking specific actions to enhance productivity.

A manager concerned with improving productivity might begin by conducting a critical self-examination and then taking action to overcome the deficiences found. Chart 1 provides a basis for such an

Chart 1. Management Self-Examination

Do I try to discover employee needs and respond to them?

Do I discuss job performance with each employee periodically, and encourage him/her to improve performance, thereby enhancing productivity?

Do I try to maintain or improve the productivity of my employees—who may have different values, attitudes, and motivations than I have—through training and education?

Do I recognize and reward subordinates who continue to complete their assignments in a satisfactory manner?

Do I ever remove incentives from employees who appear to be performing below a "standard," forgetting they may be already performing to the best of their abilities and cannot do better?

Do I hold forums on a planned basis to exchange ideas, to identify problems or potential problems within the organization, and to promote cohesiveness within the organization?

Do I encourage healthy competition between organizational units as a method for stimulating improvement in productivity?

Do I conduct confrontation meetings in which representatives from each organizational unit involved in a specific disagreement meet to iron out differences?

Do I delegate some of my management functions to subordinates who, by experience, training/education, and interest, have shown evidence of being ready and able to assume more responsible work?

Do I set a good personal example for employees, and meet their expectations?

Do I manage time effectively? Have I established priorities, developed plans, and scheduled the workload to ensure the best investment of the time available to accomplish the tasks to be done?

Do I provide suitable physical working conditions for my employees?

Do I inspire employees to search for more productive and less costly ways to do things?

Do I apply such techniques as work simplification and standardization?

Do I encourage technological innovation and use of the advanced products of technology?

Do I eliminate functions found to be redundant or unnecessary?

Do I minimize disruptions to the work being performed?

Do I minimize the amount of paperwork required to accomplish each assignment?

Do I encourage effective communication within the organization and use the proper channels of communication myself?

Do I provide for feedback on work in progress?

examination. Any question that does not generate a strong "yes" response identifies an area where the manager must try to change his (her) performance.

c. Cooperation Between Management and the Work Force

Cooperation is another key to productivity and the quality of work in industry. The question is: How does one obtain cooperation between management and the work force?

There are several steps that management can take, namely:

- Open a line of communication by holding weekly "rap" sessions.
- Organize groups with employees from various functional organizations. "Quality Circles" and "Productivity Circles" are examples of such groups. The title is unimportant; what the groups do is important.
- When the line of communication is open, listen with an open mind.
- Investigate the merits of suggestions made by the "circles."
- Implement changes based on the merits of suggestions received.
- Announce the actions taken by management.

When management takes the steps listed above, the workers will recognize that their cooperation is important.

d. Pitfalls

There are several pitfalls of a general nature that a manager in industry or government may encounter when trying to enhance productivity, namely:

- The plan for improving productivity may not be implemented properly.
- Improvement in productivity in one organizational unit might take place at the expense of another unit.
- If improvement in productivity is not sufficient, employees might drift back to "the same old way" of doing things.
- The pace in seeking productivity improvements must be maintained. If management enthusiasm is too much or too little, efforts to improve productivity might fail.
- Some short-term improvements might turn out to be counter-productive over a longer period of time.

One of the most common frustrations for management in attempting to increase productivity occurs when there is a short burst of worker enthusiasm with a corresponding improvement in productivity, only to be followed by a sudden decline in enthusiasm. The chief reason for such failures might be manager tunnel-vision ... the failure of the manager to recognize that there are many interrelationships that have to be developed.

There are several approaches to productivity enhancement where manager tunnel-vision can occur, for example:

- Productivity problems are limited to manufacturing. Problems appear in manufacturing, but they are seldom the only causes of declining productivity.
- Work incentives. Direct labor is productive; however, production workers sometimes "go into business for themselves" when they are placed on an incentive plan. They play games ... games that will increase their own income ... often at the expense of productivity. For example, they hoard tools, materials, and/or knowledge.
- Special campaigns. Managers sometimes believe that special campaigns or pep talks will increase worker motivation and, thereby, improve productivity. Too often managers concentrate on the symptoms of a problem and not on its causes. When the campaigns are over, and the pep talks are forgotten, the workers sometimes return to their old habits.
- Cost reduction across-the-board. Cost reduction plans have to be tuned finely. When costs are cut across-the-board, say 8 or 10 percent, they might only touch the surface of inefficiency in one department and seriously weaken the ability of another department to accomplish its role. Caution has to be exercised in any cost-reduction program.
- Self-improvement. When higher-level management permits functional departments to set their own goals and to meet them in the way they deem to be most appropriate, the opportunity to coordinate activities between departments is diminished. If a department overacts, that department might actually reduce productivity by creating a conflict with another department--a conflict that did not exist previously.
- Competition. Managers sometimes think that competition between workers (or departments) will benefit the organization. Unfortunately, the opposite might occur. The cooperative attitude that existed between workers (or departments) might become damaged during the competition. If so, a counter-productive environment will emerge.

- Crackdown on absenteeism and tardiness. Some managers are prone to think that the cause of absenteeism and tardiness originates in the work force, and that disciplinary action will solve the problem. This might not be so. The problem might be caused by poor working conditions, poor organization of the work to be accomplished, or weak management. Absenteeism and tardiness can be reduced by correcting conditions that brought them about in the first place.
- New hires. When seeking the best-qualified person to fill a vacancy, managers should avoid hiring a better-educated person than the position requires. Organizations cannot afford to have under-utilized talent on hand for extended periods because motivation will become a problem and productivity will fall off.[7]

Each one of the management approaches cited above can be taken with the objective of enhancing productivity. However, as indicated, the approach taken might create a new problem, even if it successfully solves a problem at hand. Management should recognize that many productivity problems can be solved only by an attack on several fronts at once.

A recent issue of the newsletter "Productivity," indicated that people--the work force--are the most essential ingredient in any productivity improvement program.[8]

MEASURES IN EFFECTIVENESS IN IMPROVING PRODUCTIVITY

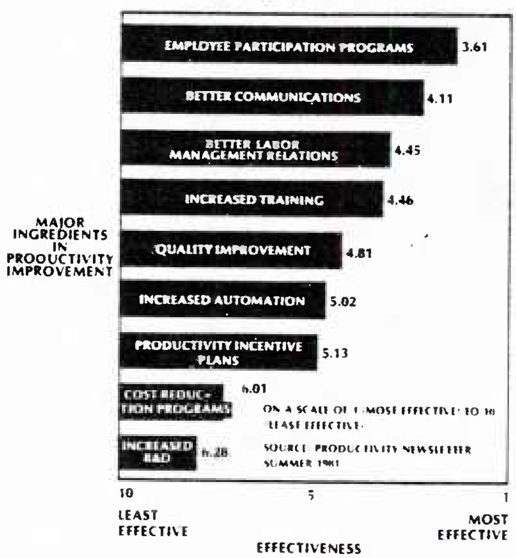


FIGURE 5.

The publisher of the newsletter, Norman Bodek, reporting on the results of his survey, stated that the most effective way to bolster productivity is through employee participation programs (Figure 5). Better communications ranks second, followed by improved labor-management relations, increased training, improved quality, increased automation, and others. More than half of the companies surveyed have some kind of employee-participation program.

Now, let's turn to the factors that affect investment in technology.

VI. FACTORS AFFECTING INVESTMENT IN TECHNOLOGY

a. The Situation at the Start of the 1980s

Capital investment is absolutely necessary if productivity is to be enhanced. At the start of 1982 the picture is grim. The cumulative U.S. capital investment requirement for the 1980s is about 5 trillion dollars. This figure exceeds the sum total of all capital investments made between 1900 and 1980. It will average 350 billion dollars more per year than was spent in the last 20 years.[9]

According to the annual survey by McGraw-Hill, capital investment plans--after adjustment for inflation--show no growth in 1982. Other surveys indicate there may be as much as a 2.5 to 3.5 percent decline. This is bad news. In the 1960s capital investment increased an average six percent a year, and in the 1970s it increased an average of four percent a year, after adjustments were made for inflation.

b. Reasons for Declining Investment

1. Inflation

During the 1970s, the average annual inflation rate was 7 percent. In the 1980s, the average inflation rate may be 9 or 10 percent. This increase over the 1970s will add about 650 billion dollars to the capital required by the private sector. Just at the time we need more capital than ever before in our history, industry is facing lower earnings, high interest rates, less equity financing, eroding profits, and lower bond ratings. The portion of U.S. capital stock (technology equipment - and facilities) that is five years old or less has been declining steadily since 1969, and the share of our total investment identified for building technological capital has been declining at an alarming rate.

Inflation affects productivity negatively. Look at what has been happening. The prime rate changed twice between 1934 and 1948. It changed 16 times in the 1950s and again in the 1960s. In the 1970s it changed 130 times, and, in 1980, 39 times. It might change more than 200 times in the 1980s. It is very difficult for any business, including defense, to plan adequately with changes of this nature. What does this do to productivity?

Productivity is influenced by the dollars industrial firms are able to set aside for investment in new technology, equipment, and plants. The Japanese set aside about one-third of their economy annually for investment in new technology, equipment and plants over the 15 year period ending in 1979. During that period, the productivity in Japan grew about eight percent a year. For the 15 years ending in 1979 the West Germans set aside about 25 percent of their economy annually for the same purpose and their productivity grew about five percent. From 1962 to 1979, our country set aside between 10 and 12 percent of its economy for capital spending. Our annual rate of productivity growth was about 2.5 percent annually from 1962 to 1977, and there was no increase at all in 1978. In 1979, it was minus two percent. It seems apparent, then, if the U.S. is looking for a way to improve productivity, it needs to stimulate capital spending.[10]

2. Short-Term Outlook

Tom Wolfe, contemporary author and social critic, believes that the greatest source of productivity loss in the U.S. in the 1970s was in the short-term orientation of industrial managers. Managers who occupy their positions for short periods of time, either because of job rotation or turnover, are not prone to make long-term investment decisions ... substantial capital investments. Further, industrial firms have problems in executing long-range and consistent company strategies when management changes frequently. Finally, there seems to be a trend away from the Chief Executive Officers in the defense industry with engineering backgrounds to those with financial backgrounds. Perhaps some of our problems today are the result of the muted voices of engineering and manufacturing executive when key policy decisions are made.

Wolfe bemoans the rise of self-centeredness in our social fabric. Unfortunately, the lack of commitment he has observed in our social fabric has begun to appear in our industrial fabric too. The stockholders in our industrial firms are demanding higher short-term earnings. But industrial growth calls for capital investment and this reduces short-term profits. How, then, can we convince the management of industrial firms in the U.S. to make long-term commitments to research and development, automating the factory, and corporate growth, if promotion policies and compensation systems continue to provide them with rewards for their short-term accomplishments?

U.S. industry must continue to stimulate research and development (R&D) and encourage innovation. Richard L. Terrell, Vice Chairman of the Board, General Motors Corporation, has pointed out that industrial firms should "... break new ground." There is always some risk in doing the untested, but there are also great gains to be realized when we experiment and when we succeed." Mr. Terrell's challenge is well founded. If U.S. industry had accepted this challenge sooner, the percentage of the gross national product (GNP) in the U.S. that goes into industrial R&D may not have dropped so precipitously between 1960 and 1980 (Figure 6).

INDUSTRIAL SPENDING IN U.S. FOR RESEARCH AND DEVELOPMENT

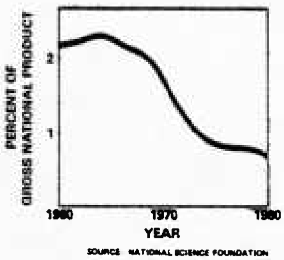


FIGURE 6.

c. Symptoms of the Problem

For the past several years there has been a serious deterioration of the U.S. defense industrial base.[11] Along with this deterioration, productivity has fallen off. Martin Baily believes that a reasonable case can be made that the slowdown in productivity can be associated with the decline in capital investment and the quality of the work force. He says that "... some capital goods have become obsolete and capital spending has been used for purposes other than raising productivity .... Much of the capital stock (technology, equipment, and facilities) is obsolete."[12] On the other hand, much of the recent decline in productivity can be attributed to slack in our factories.

A special panel of the House of Armed Services Committee, which studied the status of our defense industrial base in some detail, reported the following findings at the end of 1980:

- A continuing deterioration and contraction of the defense industrial base.
- Lack of a plan for defense industrial base preparedness.
- Turbulence in defense system (weapons) programs.
- A shortage of critical materials and a growing dependence on uncertain foreign sources for these materials.
- Restrictive procurement policies and procedures.
- Tax and profit policies that discourage capital investment.
- Diffused responsibility for the condition of the industrial base.[13]

If the deterioration of the defense industrial base continues, the U.S. will not be able to regain the rate of productivity growth it once enjoyed, and the cost of defense systems will continue to rise.

d. Solutions to the Problem

1. Centers for Industrial Technology

Public Law 96-480 addressed the problem of outdated plants and equipment by encouraging U.S. industrial firms to renovate or replace those that are outdated with technologically superior plants and equipment. This law provided $285 million over five years to create centers for industrial technology at universities and non-profit institutions. It had been hoped that this would encourage the coordination of the research resources of the universities, the private sector, and the government. Unfortunately, the provisions of the law have not been fully funded.

2. Taxes and Depreciation

The tax policy changes contained in the Economic Recovery Act of 1981 have not revived the economy. Some economists think it will take two or three years before the impact of the changes will be felt.

One of the reasons that defense contractors have been reluctant to make any capital investments at this time is because of the restrictions contained in Cost Accounting Standard (CAS) 409, "Depreciation of Tangible Assets." This standard prohibits rapid depreciation of capital equipment and fails to recognize replacement depreciation costs. The CAS 409 cannot be changed without the approval of a CAS Board. Such a board no longer exists. The Joint Logistics Commanders, recognizing the need for a change to CAS 409, sent a letter to the Deputy Secretary of Defense (DEPSECDEF) on 9 October 1981, urging that some action be taken. In response, the DUSDRE (acquisition management) is supporting the establishment of a CAS function within the Office of Management and Budget. If such a function is organized, a board could then be formed to take the necessary corrective action on CAS 409, or any other Cost Accounting Standard requiring a change.

3. Contract Financing and Profit Policy

The Deputy Secretary of Defense has requested that (1) contracts be structured to permit defense contractors to share in cost reductions that result from productivity enhancement, and (2) profit levels commensurate with risk and contractor investment be negotiated.

In support of this request, a DOD Task Force for Improving Industrial Responsiveness has prepared a draft guide, "Improving Productivity," which provides instructions for contracting officers. The instructions explain how to tailor the current contract-incentive clauses—within the authority provided in the appropriate section of the defense acquisition regulation (DAR)—to motivate contractors to make capital investments that will enhance productivity.

The DUSDRE (acquisition management) in a June 1981 memorandum requested that the services and the Defense Logistics Agency (DLA) instruct field elements to select the contract type most appropriate to the risks involved. Implementation of this action should help to ensure adequate profit motivation for defense contractors and encourage productivity improvement.

Relative to profits, the DEPSECDEF has requested that the services grant equitable economic price adjustment (EPA) clauses in appropriate procurements. To carry out this request, the DAR Council is considering revisions to the current EPA coverage that will recognize the impact of inflation on profits. The revision under consideration should provide greater assurance to both contractors and subcontractors that they will not be penalized by unpredictable cost fluctuations.

The DOD Authorization Act of 1982, signed 1 December 1981, repealed the profit limitations on aircraft and ship procurements contained in the Vinson-Trammell Act of 1934. The new act authorizes the President, upon declaration of war or national emergency, to prescribe regulations that he may deem necessary to control excessive profits on defense contracts. A revision to the DAR will be issued by July 1982 to reflect the elimination of the excess profit provisions.

We have considered the factors that affect investment in technology. Now, let's consider what technology can do to spur productivity growth.

VII. WHAT TECHNOLOGY CAN DO FOR PRODUCTIVITY

a. Need for Application of Technology

"Economic growth, technological innovation ... these are the components of progress. These are the engines that drive our country forward," says Herbert E. Meyer, an editor of Fortune.[14] The enhancement of productivity is not only affected by the results of research and development, but by application and acceptance of new technology. According to Frank Batten, president of the New York Stock Exchange, "... productivity growth (results from) the application of new technology to the production of goods and services." Mr. Batten believes that more than half of the net productivity growth from 1948 to 1977 can be attributed to technological advances.[15] This is somewhat higher than Bodek found in his survey.

b. Automated Factory

There are far-reaching implications associated with the introduction of the automated factory into the U.S. industrial environment. The advent of factory automation is an exciting and challenging field ... one which government and industry believe will reduce operating costs and increase productivity. However, the approach that management takes to introduce automation may be of equal importance to the new field itself.

A well-managed industrial firm is one in which there is an effective integration of the work force and advanced technology. The genesis of such an organization is an implementation plan that includes education of the work force for factory automation; early identification of new manufacturing processes that will lend themselves to automation; manpower/ workload forecasting that takes into account factory automation; and a mechanism for worker feedback. The concept of a computer-integrated factory of the future is shown in Figure 7.

A comprehensive strategy is necessary to improve the quality and reliability of products manufactured. With insufficient or poor planning, an atmosphere could be created within an industrial firm in which the work force rebels against management. When the work force is educated, and a well-conceived plan for factory automation is implemented, the transition to the automated factory will proceed smoothly, and productivity enhancement will follow.

COMPUTER-INTEGRATED FACTORY OF THE FUTURE

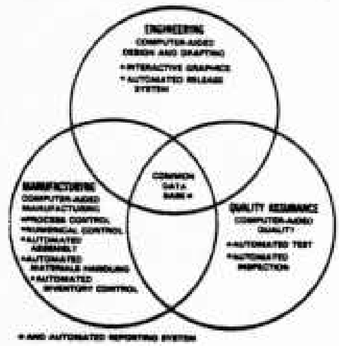


FIGURE 7.

c. Robotics

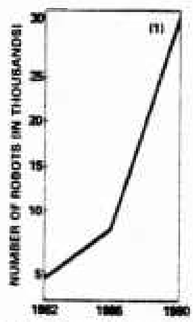
A robot is a programmable, multifunctional manipulator designed to move material, parts, components and end items, tools, and specialized devices through variable programmed motions for the performance of a variety of tasks. When George Devol patented the first robot 35 years ago, he saw a bright future for this technology. He recognized, even then, that robots could provide one of the least expensive approaches to productivity enhancement. Today robots are being used for the following tasks: machine loading/ unloading, spraying, palletizing/depalletizing, grinding/deburring/ polishing, tool carrying, forging, welding, and assembling.

It is imperative that U.S. industry and the government foster more widespread use of industrial robots. The application of robots was one of the keys to the remarkably high levels of productivity achieved by the Japanese in the 1970s. If the U.S. does not make a stronger commitment to robotics and other innovative technologies in the near future, its economy will continue to decline and our industries will lose more ground to competition from abroad. The accelerated depreciation provided in the recent changes to the tax law, along with additional tax credits for installation of innovative technologies such as robots, should give rise to increased productivity in the U.S.

The Robot Institute of America (RIA) suggests that U.S. industry assign high priority to the installation of robots, especially in dangerous, dirty, and dull jobs, "recognizing that robots are one of the quickest and cheapest ways to increase productivity." Also, industry must accept the responsibility for retraining workers who are displaced by robots. Industry managers will have to communicate with the work force and help the workers to understand the advantages of using robots. Further, industrial managers will have to develop plans so workers will share in the benefits of increased productivity.

Currently, there are about 5,000 robots in use in the U.S. This is less than half the number in use in Japan. But the U.S. robotic boom is just beginning (see Figure 8). In 1980, robot sales in the U.S. totaled $90 million ... $40 million more than 1979 sales. The 1979/1980 sales represent a quantum jump from the $1.5 million in 1969 sales. Recently, knowledgeable observers of the robotics market have been predicting that U.S. robot sales will reach $500 million annually by 1985, and $2 billion by 1990.

PROJECTED USE OF INDUSTRIAL ROBOTS IN THE UNITED STATES



(1) THIS FIGURE MAY REACH 40,000 BY 1990

FIGURE 8.

d. <u>Advanced Computerized Manufacturing</u>

Someone has said that "if robots are becoming the tireless arms and eyes of production, then computers are their minds." The versatility of the computer has made it one of the principal elements leading to the automation of the factory. According to the Center for Productivity of the National Science Foundation, computer-aided design (CAD), computer-aided manufacturing (CAM), and computer-aided test (CAT) have more potential to radically increase productivity than any development since electricity.

The question is: What role will advanced computerized manufacturing system play in the currently emerging Third Industrial Revolution? Advanced computerized manufacturing systems will assist people in all of the processes necessary to translate the specific requirements of a product into its final physical configuration. These systems will play a major role in such areas as design, analysis, detailing, documentation, numerical control (N/C) programming, tooling, fabrication, assembly, quality assurance, and testing. The application of CAD/CAM at Westinghouse, for example, has resulted in a 25 percent reduction in manufacturing lead time, and as much as a 400 percent increase in productivity.

Advanced computerized manufacturing systems originated at the Massachusetts Institute of Technology (MIT) with the development of numerical-controlled machine (N/C) tools. Then, in the 1960s, APT (Automatic Programming for Tools) was developed as the language for N/C programming. This effort was followed in 1963 by Ivan Sutherland's MIT doctoral thesis, "Sketchpad," which provided one of the first basic implementations of an interactive computer graphics system for computer-aided drafting. The General Motors DAC-1 (Design Augmented by Computer) and the Lockheed CADAM (Computer-Graphics Augmented Design and Manufacturing) in the mid-1960s followed.

Today, with the availability of low-cost minicomputers, a design engineer can sit in front of a large CRT screen and graphically construct the three-dimensional geometric model of a part. When he is finished, a manufacturing engineer can use the part's geometric data base. Through interaction with a graphics CRT, N/C machining tapes can be derived and toolpaths verified. Process plans can be created and bills of material can be generated for the manufacturing process.

The declining cost of computer power — about 50 percent every 30 months — will enable defense contractors to increase their use and thus greatly increase productivity. Through the use of these advanced systems, the productivity of design engineers, draftsmen, and manufacturing engineers has increased by a factor of from 2 to 1 to more than 20 to 1 in situations where there is a large amount of repetition or engineering change activity. The General Electric Company, for example, has indicated that the time for tool design has been reduced 25 percent by installation of a Computervision CAD/CAM system. In high technology industries, such as computers, electronic instruments, and telecommunications, productivity is now increasing at an annual rate of over 4 percent. This compares favorably with 2 percent or below for other industrial sectors.

The new flexible manufacturing systems in which several numerically controlled production machines are grouped, along with a transport system, under the control of a main computer, are impacting productivity substantially. Using this type of manufacturing system, machine-tool utilization has increased as much as 45 percent in some companies.

e. <u>Manufacturing Technology Program</u>

The DOD Manufacturing Technology Program (MANTECH) was initiated a few years ago to improve the producitivty and responsiveness of the defense industrial base. In this program, the government shares with industry the risks and costs of establishing and applying new and/or improved manufacturing technologies. Today, the MANTECH program is one of the largest single sources of industrial productivity enhancement information in the U.S.

f. Technology Modernization Program

Capital investment and manufactring technology innovations are key factors in productivity enhancement. The program for determining the advanced manufacturing technology needed, and the capital investment required to apply advanced technology, is referred to as the Technology Modernization (TECHMOD) Program. This program, initiated by the Air Force, involves the coupling of need and advanced manufacturing technology by providing defense contractors, as well as subcontractors, with incentives for capitalization.

g. Service Technology Programs

As a part of the DOD Acquisition Improvement Program initiated on 30 April 1981, the military services have accomplished the following relative to increasing productivity in contracts for defense systems:

- The Army implemented an Industrial Productivity Improvement (IPI) Program after receiving approval of its plans from the Secretary of the Army. An IPI Program is being used at the Rockwell HELLFIRE missile plant, the Martin Marietta Pershing II missile plant, the General Dynamics M-1 tank plant, and others. The Army is requesting a low of 86.9 million dollars in FY 83 and a high of 269.9 million dollars in FY 87 for the IPI Program.
- The Navy has invested $77 million in MANTECH during the past five years. It has budgeted $8 million for FY 82 and up to $70 million per year in the out years. During the next five years the Navy's MANTECH Program will emphasize four areas, namely: aircraft and air combat systems, shipbuilding technology, ship combat systems, and electronics.
- The Air Force has a TECHMOD Program. When applied to the F-16 aircraft program, TECHMOD provided the first successful demonstration that government costs could be reduced during acquisition. The initial success of the F-16 TECHMOD Program prompted the Air Force to consider application of the concept to other systems that will have long production runs.

The new MANTECH Program Initiative is now underway. It will provide productivity and production efficiency improvements for the B-1B industrial base. Initial assessments indicate that a 5 to 1 payoff is possible.[16]

VIII. SUMMARY AND FINAL THOUGHTS

The rate of productivity growth in the U.S. has been declining for many years. This decline cannot be attributed to a single cause, and a single action will not readily change the way it has been going. It will take a combination of actions.

The increased use of new technologies such as industrial robots, CAD/CAM/CAT, and new flexible manufacturing systems, will enhance productivity. At the same time, it will challenge both industrial managers and leaders of our educational institutions to meet the need to train (or retrain) the work force on a scale never before attempted. About 45 million jobs will be affected by the automation of U.S. factories and offices. Fortunately, the changeover will take place over many years. The management of our firms can ease the shock of transition by: giving the work force ample notice of impending changes; bringing the work force in on decisions involving automation; and explaining to the work force the advantage of the changeovers. The leaders of our educational institutions will have to find ways to satisfy the need to train new members of the industrial work force and to retrain the old members so all can be qualified to assume new assignments.

Productivity enhancement is especially important in the defense systems acquisition business. It is only through enhanced productivity that we can continue to afford defense (weapon) systems in sufficient quantities to deter or counter any foreign threat to our way of life. In the U.S. we have reached the point at which it has become difficult to sustain the rate of productivity growth we attained in the past. Continuing technological innovation and increased capital investment will help, but they cannot enhance productivity without a work force in tune with the need. The ability, attitude, and action of the people in the work force will have a pronounced affect on the future growth of productivity in this country.

Tomorrow we will grade our managers on how well they were able to use the advanced technology, capital, and human resources they were given today to enhance productivity. We will hold our managers less accountable for short-term performance than for long-term performance and their contributions to productivity enhancement. Peter F. Drucker noted authority on management, summed it up very well when he said, "Productivity is the first test of managements' competence."

BIBLIOGRAPHY

1. Labor hour denotes the amount of productive work a man or woman can turn out in one hour of effort.

2. Automation, as used here, applies to computers used to control machine tool and other manufacturing operations with a feedback loop that provides information relative to the progress of each operation, thus permitting adjustments (corrections) to be made in the operation, if necessary.

3. Fred G. Steingraber, "Improving Productivity in the U.S.: The Real Strategic Challenge," an address at the Manufacturing Services Seminar, Los Angeles, CA, October 27, 1981.

4. George Kuper, "Productivity: A National Concern," Productivity in Policing, Police Foundation (established by the Ford Foundation), New York, NY, 1975, pp. 1-3.

5. David D. Acker, "Managing Human Resources in the Eighties," DSMC Concepts, Volume 5, Number 1, Winter 1982, pp. 98-112.

6. Acker.

7. Editors of Boardroom Reports, The Book of Business Knowledge, Boardroom Books, New York, NY 1970.

8. Based on data from the "Productivity" newsletter as reported in Mechanical Engineering, September 1981.

9. William Van Dusen Wishard, "Productivity and American World Competitiveness," an address delivered at the Meidinger, Inc. annual luncheon in Louisville, KY, December 1, 1981.

10. Irwin L. Kellner, "Productivity," Manufacturers Hanover Trust Company Economic Report, February 1980.

11. Defense industrial base, as used here, encompasses those elements of industry in the U.S. that contribute to defense-related work and whose production capacity and technical expertise are required to meet national security needs.

12. Martin Neil Baily, "Productivity in a Changing World," The Brookings Bulletin, Volume 18, Number 1, Summer 1981.

13. U.S. Congress, House Committee on Armed Services, Report of the Defense Industrial Base Panel, "The Ailing Defense Industrial Base: Unready for Crisis," 96th Congress, 2nd Session, December 31, 1980, page 1.

14. Herbert E. Meyer, The War Against Progress, Storm-King Publishers, New York, NY, 1979.

15. The New York Stock Exchange, "Reaching a Higher Standard of Living", New York, NY, January 1979.

16. Department of Defense Acquisition Improvement Task Force Report, December 23, 1981.

TECHNOLOGY MODERNIZATION
INTEGRATING THEORY AND EXPERIENCE

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"UNREADY FOR CRISIS"

In a recent survey, the Lou Harris Poll posed this question: "How serious is the problem of declining productivity in the United States?" The answer varied, based on the perspective of the group sampled. On one end, only 42% of labor union leaders felt that it is a serious problem. Among their management counterparts however, 92% felt that it is indeed a serious problem. The U.S. Congress concurred in this dim view, with 89% of its members agreeing that the productivity problem has reached crisis proportions.(1)

The results of this poll support a December 1980 report published by the Defense Industrial Base Panel of the House Armed Services Committee. Entitled "The Ailing Defense Industrial Base: Unready for Crisis", the report concluded that the "defense industrial base is deteriorating", and supported that conclusion with these findings:(2)

- The defense industrial base is unbalanced; while excess production capacity generally exists at the prime contractor level, there are serious deficiencies at the subcontractor level.

- Leadtimes for military equipment have increased significantly during the past three years.

- Skilled manpower shortages exist now and are projected to continue through the decade.

- The U.S. is becoming increasingly dependent on foreign sources for critical raw materials as well as for some specialized components needed in military equipment.

- Productivity growth rates for the manufacturing sector of the U.S. economy are the lowest among all free world industrialized nations; the productivity growth rate of the defense sector is lower than the overall manufacturing sector.

- The means for capital investment in new technology, facilities and machinery have been constrained by inflation, unfavorable tax policies, and management priorities.

Almost all of these conclusions are based on factors that are components of productivity: process, product and people factors. But what is the cause of our problem? In the United States, there is ample motivation, and an abundance of capable individuals, tools, and other resources necessary to improve productivity. Further, in terms of technology, the U.S. maintains a substantial lead over other nations of the world. According to a report issued in 1980 by the Japanese Ministry of International Trade, out of 71 industrial sectors rated, we are equal to or better than Japan or West Germany in all but two. By this measure, we have a sound foundation of technological resources on which to build.(3)

The need to find appropriate methods to exploit our superior technologies is a key factor in our effort to seek answers to the productivity problem. This necessity is gaining acceptance in academic as well as industry and Government management circles. Professor Wickham Skinner of the Harvard Business School clearly articulates this need when he states:

> "The availability of equipment and mechanisms has far outrun the ability of the modern factory system to absorb these new technologies. Somehow management in the manufacturing world has apparently been unable to fully assimilate the new technologies which engineers and scientists have made available. We have the ironic situation of industry loaded with unused technology yet in trouble in terms of competition and costs."

Professor Skinner goes on to note that the "factory of the future" will always remain in the future unless a critical change is made in our approach to manufacturing management.

Along the same lines, Professor W. A. Reynolds, Chairman of Industrial Engineering, University of Hong Kong, writes that standing alone, knowledge contributes nothing to the welfare of mankind.(4) It must pass through the barriers of research and development, possibility, cost justification, and market reception. At each level, these barriers hold back a burgeoning reservoir of processes and techniques, allowing a mere trickle of innovations to find their way to the production floor. Traditional manufacturing technology (MANTECH) activities lift the barriers between basic scientific knowledge and technologically possible techniques by establishing achievable and economical methods of manufacture. MANTECH projects create the initial opening in the economic and human factors floodgates by demonstrating and achieving factory floor applicability (Fig. 1). The next step is to lift the barriers even further - to facilitate widespread implementation and assimilation into the regular production process.

WHAT IS TECHNOLOGY MODERNIZATION?

Technology Modernization - better known as Tech Mod - is a partnership between a contractor and the Air Force. It is directed at systematically bringing new and existing manufacturing technologies, and the capital investments needed to implement them, onto the production floor of the contractor's facility. Tech Mod is a cooperative venture in which the Air Force may provide "seed money" for the evaluation of factory needs and the development of applicable manufacturing technologies. As his part of the bargain, the contractor provides the necessary investment in capital equipment to ensure that the technologies and other productivity enhancing initiatives are placed on the factory floor and integrated into the manufacturing process. A Tech Mod is generally accomplished in a three phase effort (see Tech Mod Phasing, Fig 2):

- Phase I is a "top down factory analysis" which both evaluates the needs of the overall facility and identifies candidate manufacturing technologies which are applicable to the types of systems produced in the facility. At the culmination of Phase I is a negotiated "business deal" between the Air Force and the contractor. The business deal establishes a contractual relationship geared to the uplifting of factory wide productivity for the mutual benefit of both parties. The heart of the business deal is a willingness by both sides to engage in a "win-win" relationship. In this context, the contractor agrees to reduce system costs (based on the resulting productivity increase), while the Air Force agrees to allow increased return to the contractor (based on the level of productivity enhancement and cost reduction). Considerations include incentives, benefit sharing arrangements, and return on investment hurdles. The business deal establishes the groundrules for Phases II and III.

- Phase II is the development of the technologies and design of the factory modernization enhancements. Phase II also identifies implementation plans, specifies hardware/software operational requirements and validates specific applications through method demonstrations.

- Phase III is implementation of the Tech Mod, including purchase and installation of capital equipment to implement those Phase II candidates that demonstrate highest potential payback.

The Air Force experienced initial success with its Tech Mod on the F-16 program. Since that time it has greatly expanded the effort, encompassing virtually all aspects of the aerospace industrial base, including aircraft, propulsion, missiles and electronics. Tech Mod has been extended beyond the prime contractor level and is gaining increasing momentum with the key subcontractors and vendors which constitute the aerospace industry's foundation. Tech Mod is a major element in the Air Force productivity enhancement strategy.

WHY TECH MOD?

Tech Mod offers two very strong selling points. First, it forges a direct link between the manufacturing technologies developed by the Air Force Wright Aeronautical Laboratories (AFWAL) and the factory floor. Second, it offers an alternative to the piecemeal approach to capital investment which has become characteristic of American industry.

For years the AFWAL Manufacturing Technology (MANTECH) Division has pioneered the development of innovative production methods, techniques and processes. Numerical control of machine tools is but one example of the many

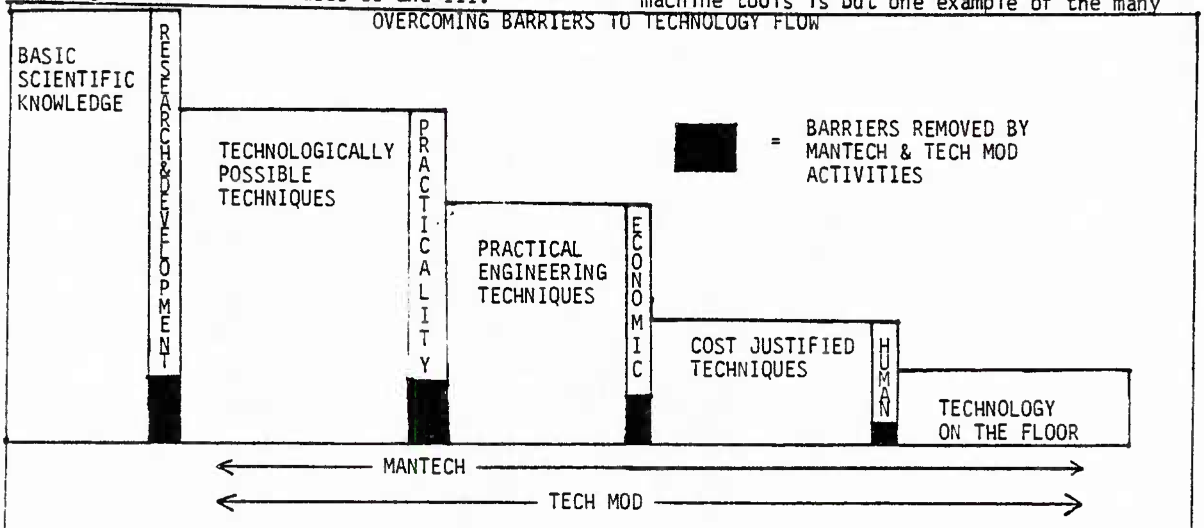

Figure 1.

AFWAL efforts which have helped to revolutionize manufacturing throughout the world. Despite this success in developing new manufacturing techniques, it became apparent that there was a need for a stronger link between those technologies and their widespread application on Air Force production programs. Tech Mod provides that link. The objective of a MANTECH project is to establish and demonstrate the practicality and economic viability of new technology. MANTECH provides first case factory floor application of the technology. There is no explicit requirement however, for the technology to achieve broad based implementation. Tech Mod, with its emphasis on business and contractual considerations, ensures that selected technologies achieve large scale assimilation into the regular production process.

MANTECH and Tech Mod complement one another. The demonstrated practicality of MANTECH projects can be translated into widespread production floor application through the link to Tech Mod. The MANTECH projects of today can become the Tech Mod candidates of tomorrow, with Tech Mod serving as the vehicle for attainment of additional applications. Some examples of MANTECH projects which have made the transition from the laboratory to the factory floor through Tech Mod are depicted in Fig. 3.(5)

In addition to forging the link to MANTECH, Tech Mod helps to overcome the piecemeal approach to capital investment. By concentrating on the total factory, and seeking to group technologies and equipment into work cells and work centers, Tech Mod offers a strategic approach to productivity enhancement. This approach is defined in the tools developed as part of the Integrated Computer Aided Manufacturing (ICAM) Program. Through ICAM, a system of factory architecture and hierarchies has been devised to help in the strategic "top down factory analysis" process. A primary tool is "ICAM definition" (IDEF) which provides the roadmap for evaluating factory needs and developing an overall approach to the most effective grouping of manufacturing technologies with new and existing capital equipment. The result is a plan for the total factory which leads to improvements at every level of the production process.(6)

The merging of forces for increased productivity through Tech Mod is illustrated by an on-going effort with a major producer of jet engines. Since 1980, the company has planned to expand its capability, and as a result of these activities, decided to construct a new plant. The original concept was to build a facility for the manufacture of nickel-alloy turbine disks and titanium-alloy compressor disks, and ship them to another location to undergo final machining on existing equipment. As a result of the introduction of the Tech Mod Program, the company has proposed to construct a facility that will not only

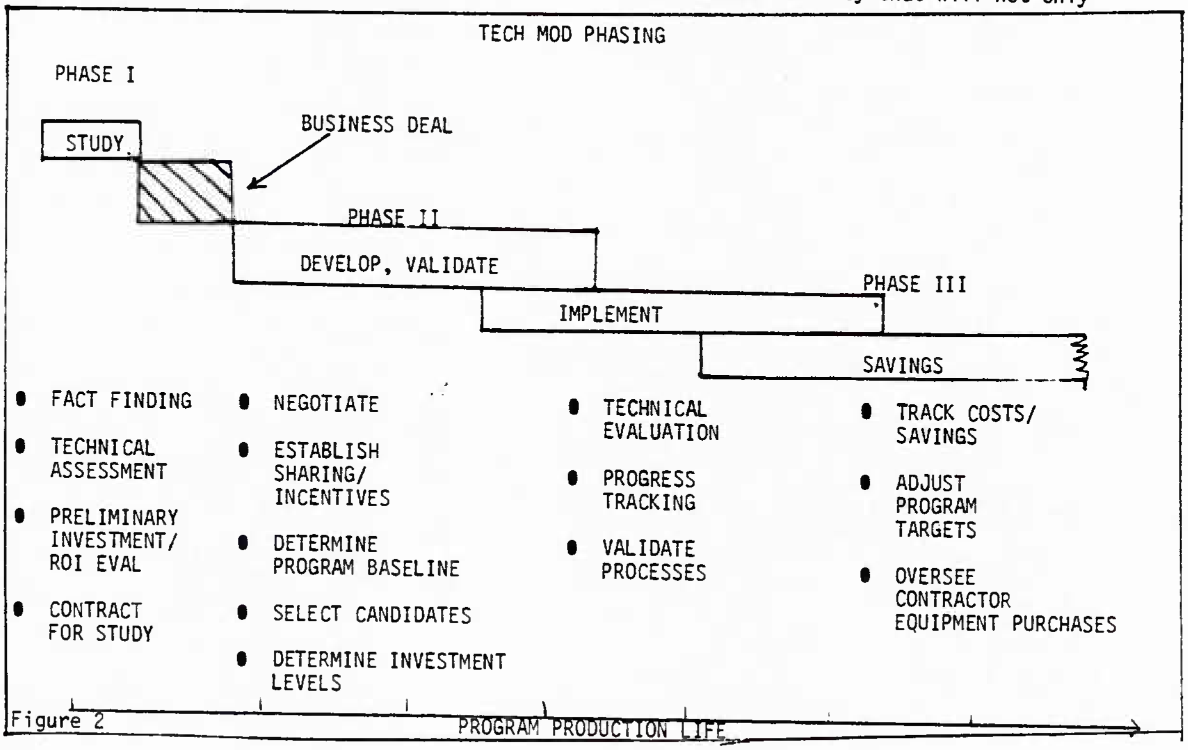

Figure 2

manufacture the disks, but bring them to their final form, using the ICAM concepts to achieve the most cost-effective manufacturing techniques.

The disk manufacturing facility will incorporate the latest state-of-the-art technologies in the metal working industry. More than 100 computers of various kinds will control every phase of the manufacturing operation. Production scheduling, machining, and parts inspection will be done automatically. A major thrust will be automation of materials handling. Material will travel throughout by an automated system of unmanned vehicles, conveyors, and overhead monorails, following pre-set production schedules programmed within a central computer. About 50 robots will be used to transfer materials throughout the facility. Finished disks will be delivered for assembly into production engines.

TECHNOLOGY TRANSITIONED FROM MANTECH TO TECH MOD

(EXAMPLES)

MANTECH	TECH MOD
HERMETIC CHIP CARRIERS	AMRAAM, LANTIRN, JTIDS
ADVANCED COMPOSITES	F-16
PRINTED WIRING BOARD PROCESSING TECHNIQUES	WESTINGHOUSE, SEEK TALK, LANTIRN, SINGER
CAPACITANCE HOLE PROBE	C-5, B-1
CONFORMAL COATINGS ON PWBs	AMRAAM, LANTIRN, JTIDS, WESTINGHOUSE

Figure 3.

To facilitate this, the company proposes to participate in each of the three Tech Mod phases. During the first phase, the company will perform a factory analysis, including: evaluation of total factory needs based on current manufacturing methods, identification and screening of candidate manufacturing technologies to be included in the total concept, formulation of these tasks into a totally integrated factory concept, generation of a business plan designed to share the savings between the company and the Air Force in a manner that provides both parties with an acceptable return on investment, and participation of subcontractors. The second phase will develop and validate enabling technologies necessary to implement the selected technology concepts identified in Phase I. Phase III will integrate production equipment and software to verify and validate the performance relative to the baselines established in Phase II.(7)

Some of the technologically possible techniques were economically feasible, and a portion of them would have been used in the original plan. But with the Air Force supported Tech Mod program, additional techniques will be explored and put into use. The net result is the production of compressor disks in their final form, using the most productive methods. The Air Force and the contractor will share in the economic benefits which accrue from this effort (see Fig 4).

This is only one example of a company rethinking its approach to capital investment following its familiarization with the Tech Mod concept. Tech Mod is successfully opening the floodgates and providing much-needed direction for the channeling of the technology reservoir to a thirsty industrial base.

CONTRACTUAL CONSIDERATIONS

The best laid technical and managerial plans are nothing more than sophisticated exercises until they are translated into practice through a contract. Opening the economic barriers between technologically possible techniques, and implemented techniques is accomplished through our contracting tools. Although there is no prescribed way to contract for Tech Mod, there are tools by which the Air Force and contractors can achieve a creative, satisfactory business arrangement.

A major step toward the development of a successful Tech Mod contract is recognition of the ways in which it differs from a typical system contract. As stated earlier, Tech Mod is dependent on a "win-win" relationship between the Government and the contractor. This might require a change in some long held attitudes on both sides. An understanding of the fundamental differences between Tech Mod and other kinds of contracts is helpful in the reshaping of these attitudes. A critical difference is the end item. In a system acquisition, we contract for a piece of hardware which must meet certain cost, schedule and performance requirements. In a Tech Mod, the "deliverable" is a quantifiable improvement in productivity which can be translated into reduced hardware costs. A brief rundown of these differences is further outlined below and in Fig 5.(8)

- Acquisition contracts are typically for deliverable hardware. The outputs of Technology Modernization efforts are more modern, efficient factories, benefiting the U.S. industrial base.

- Weapon systems are acquired to satisfy Air Force operational requirements, while Tech Mod objectives are across-the-board factory productivity improvements leading to significant cost reductions. Tech Mod initiatives also enhance a contractor's competitive posture, both in the U.S. and in international markets.

- Weapon system design receives the major technical focus on system acquisition programs. Within Tech Mod, the technical emphasis is on advancing manufacturing and quality technologies and finding new applications for existing technologies to produce the weapon system more efficiently and less expensively.

- When addressing production economics under system acquisition contracts, management emphasizes cost control, often with Design to Cost and Life Cycle Cost objectives. Tech Mods comprehensively attack high cost drivers throughout the factory to effect significant savings both through cost reductions and avoidance.

- System Acquisition funding is viewed simply as the cost to obtain weapon systems. Tech Mod funds are considered a joint contractor and Government investment opportunity with attractive payoffs to both.

- The business relationship in a Tech Mod program is quite unique in that, instead of the Government acting as customer with the contractor as the source of supply, we literally form a business partnership, sharing both the risks and rewards of advancing technology and modernizing industrial plants.

Recognition of the differences between Tech Mod and a system acquisition is a major step toward development of a successful contracting approach. Contracting for a Tech Mod involves consideration of factors that are not common in a typical system acquisition, providing an excellent opportunity to exercise the widely discussed tenets of "contracting for productivity".

THE PRESENT AND THE FUTURE

At this writing, the Air Force Aeronautical Systems Division (ASD) has over a dozen different Tech Mods underway or in the works. These range from initial government/contractor productivity improvement plans to existing contracts resulting in hard cost savings. Tri-service cooperation to increase productivity through Tech Mods is also gaining momentum. Picking up the Air Force lead, both the Army and Navy have expressed interest and provided support to various Tech Mod ventures.

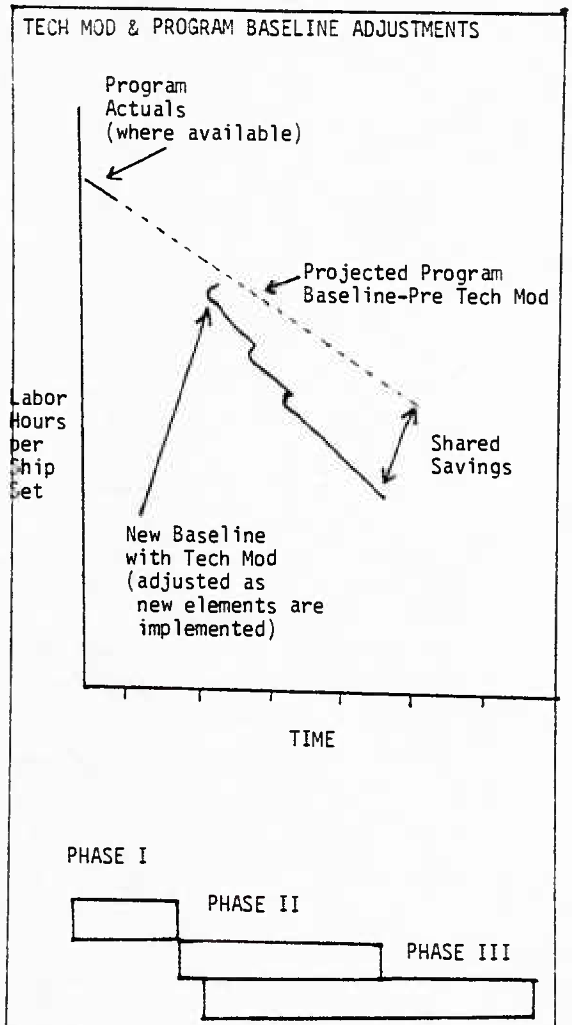

Figure 4.

Air Force Systems Command and Air Force Logistics Command recently developed an initial "Aerospace Industrial Base/Productivity Enhancement Strategy". The cornerstone of the strategy is the industrial base sector concept. In this concept, the strategy divides the aerospace industrial base into eight sectors and attacks those sectors both individually and collectively. Although not yet fully adopted, this approach recognizes that it is necessary to go beyond isolated successes on individual programs and expand the concept for the benefit of the entire industrial base. Preliminarily, eight sectors have been identified. They are:

I Aircraft
II Propulsion

COMPARISON WITH SYSTEMS ACQUISITION		
	ACQUISITION	TECH MOD
OUTPUT	WEAPON SYSTEM HARDWARE	FACTORY MODERNIZATION
OBJECTIVES	WEAPON SYSTEM PERFORMANCE OPERATIONAL SUPPORT	IMPROVE PRODUCTIVITY REDUCE COSTS
TECHNICAL FOCUS	WEAPON SYSTEM DESIGN	MANUFACTURING/QUALITY TECHNOLOGY APPLICATIONS
ECONOMIC FOCUS	COST CONTROL	COST REDUCTION/AVOIDANCE
FUNDING FOR	OPERATIONAL REQUIREMENTS	INVESTMENT OPPORTUNITY
GOVERNMENT/ CONTRACTOR RELATIONS	CUSTOMER/SOURCE	PARTNERSHIP
INTER-COMMUNICATIONS	SOMETIMES GUARDED	OPEN

Figure 5

III Electronics
IV Missiles
V Munitions
VI Space
VII Organic Repair
VIII Basic Industries

For each of these sectors, a series of goals and target areas can be established. The target areas can then be further divided to highlight problem areas such as high cost, lack of capacity, and labor intensity. The sectors need not be restricted to prime contractors within the aerospace base. The vital sub-contractor network, which the Congressional Defense Industrial Base Panel found to have "serious deficiencies" can be given special emphasis. In fact, Sector VIII, Basic Industries, is devoted entirely to those critical areas which form the foundation of the industrial base. Sector VIII currently contains such Tech Mod ventures as efforts seeking to improve the U.S. forging industry, and to improve the U.S. industrial base for traveling wave tubes. Sector VIII can be expanded to include more key industries in the future. In addition, major subcontractor Tech Mods are included as part of several other sectors.

The sector approach provides a strong linkage to the "Manufacturing Technology Thrust Plan" prepared by the AFWAL MANTECH Division. By forging this link between the two elements of the strategy, opportunities for optimum incorporation of proven MANTECH projects into Tech Mods are possible. For example, a MANTECH project expected to be proven in 1984-85, will be ripe for consideration as part of a Tech Mod beginning in the 1984 and beyond period. Conversely, MANTECH programs can be initiated in anticipation of solid implementation opportunities on Tech Mods scheduled to begin in the future. This close relationship will foster enhanced technology transfer and provide greater assurance than ever that basic scientific knowledge will pass R&D, engineering, economic and other filters to find its way to the factory floor.

CONCLUSION

We have dramatized the deterioration of our defense industrial base, and its solid connection with declining productivity. In examining the barriers to the knowledge flow, it is apparent that there is no lack of technology - the problem is with our ability to absorb it all. Technology Modernization is a vehicle that increases the utilized technologies by providing a management structure which commits the Government and contractors to lift the barriers of technology flow. The systematic way of evaluating the total factory, and applying the best new technologies are the technical components, and an innovative contracting strategy are the moving forces of the Tech Mod thrust.

Since OOD acquisition actions make a large impact on the U.S. economy, these actions can shape the productivity picture of this Country. This challenge is reflected in the thinking of Deputy Secretary of Defense Carlucci: "THE DOD HAS A VERY IMPORTANT ROLE ... TO PROVIDE A BUSINESS CLIMATE CONOUCIVE TO INOUSTRY NEEOS IN INVESTING IN NEW TECHNOLOGY AND EFFICIENT PRODUCTIVE CAPABILITY." Technology Modernization will take us a long way toward living up to this role.

REFERENCES

(1) Results of an Institute Survey, Industrial Engineering. Vol 13, No. 10, October 1981, p. 38.

(2) The Ailing Oefense Industrial Base: Unready for Crisis, U.S. Government Printing Office, Washington, 1980.

(3) R.T. Kramer, "Productivity: An Engineering Perspective", Production Engineering, November 1981, p. 22.

(4) W.A. Reynolds, "The Engineer and His Work Today", AIIE News - Management, Vol. XIV, No. 3, Winter 1980.

(5) Or V.J. Russo, "Overview of the Air Force Manufacturing Technology and Technology Modernization Programs", Presentation at HQ AFSC, 1 Apr 1982.

(6) B.A. Kosmal, "System Engineering Methods for Technology Modernization Programs", ICAM Industry Days, Jan 1982.

(7) Based on the work of AFSC/ASO/Oeputy for Propulsion, Oirectorate of Manufacturing/Quality Assurance, A. Moore.

(8) Based concepts developed by L. Fry, Oeputy Oirector, Manufacturing/Quality Assurance and R.C. Kirchoff, Procuring Contracting Officer AFSC/ASO/Deputy for Airlift & Trainer Systems.

PANEL D

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REPORT ON THE DEVELOPMENT OF A PROTOTYPE COMPUTERIZED MODEL AND DATA BASE FOR USE IN COMPARING ACQUISITION STRATEGIES

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ABSTRACT

The authors have developed a prototype computerized model for comparing acquisition strategies. The model parameters and logical assumptions are based upon a large and varied data base. Use of the model involves an interactive menu selection process to obtain a general description of the weapon system concept and program objectives. The model and the user then interact to successively reduce the number of strategy alternatives to a small set containing the preferred alternatives for a particular situation. Reasonable agreement with program experience has been demonstrated.

INTRODUCTION

The results discussed in this paper evolved from a study completed in January 1981. This study investigated the feasibility of developing an analytic model to aid in selecting an acquisition strategy for research, development, and production of major weapon systems. The development of such a model was deemed feasible in a prior report which also described a preliminary modeling approach.* However, uncertainty still existed concerning implementation. Was it possible, in a real-world sense, to develop and implement such a model that would provide reasonable results? To answer this question, it was decided to attempt to develop and demonstrate a prototype computerized model and data base (along the lines described in the feasibility assessment) for evaluating acquisition strategy alternatives. This paper discusses the results of this effort.

The scope of this initial development effort was intentionally limited to two categories of weapon systems: tactical missiles and selected electronic subsystems. These were selected because of their broad service base and their interdependencies (e.g., electronic subsystems are typically key components of tactical missiles). Expansion of the model and supporting data base to other weapon systems could be done.

The first step in the model development was to define a usable concept of acquisition strategy. The Defense Systems Management College (DSMC) defines acquisition strategy as "the overall concept for planning and organizing resources to develop, procure, support and dispose of weapons systems designed to satisfy an approved mission need."

Consistent with this definition, the acquisition strategy concept is defined in a macroperspective and considered to consist of 25 strategy alternatives spanning four acquisition phases (Figure 1).

The primary objective of Phase 0 is defined as the examination and selection of feasible solutions to a perceived operational need. Given a feasible concept, the principal objective of Phase 1 is to demonstrate that the required technology is an engineering application rather than an experimental one. After proving the maturity of necessary technology, Phase 2 primarily deals with analysis and refinement of the system design to ensure attainment of required thresholds.

The model requires that one option from each of the four phases must be selected to define a complete acquisition strategy which will transform a weapons system concept into an operational system. This hypothesis assumes that the nature of this process does not change significantly over time. The same basic tasks are required to develop a weapon system today as

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* Cox, Larry W. and Hullander, Robert A., "Feasibility and Development Study for a System Acquisition Strategy Model -- Final Report," The Analytic Sciences Corporation, Technical Report TR-1375, 12 January 1981.

PHASE 0: Concept Exploration

- Directed concept
- By non-industrial firms
- By industrial firms
- Jointly

PHASE 1: Demonstration and Validation (D&V)

- Waive
- Contract definition
  - by non-industrial firm(s)
  - by single industrial firm
  - by multiple industrial firms
- Subsystem/component development
  - by non-industrial firm(s)
  - by single industrial firm
  - by multiple industrial firms
- System prototype
  - by non-industrial firm(s)
  - by single industrial firm
  - by multiple industrial firms

PHASE 2: Full-Scale Development (FSD)

- Incremental development
  - by single source
  - by multiple sources
- Partial concurrency
  - by single source
  - by multiple sources
- Full (extreme) concurrency (Single source)

PHASE 3: Production and Deployment

- Single source, no options
- Single source with options
- Single source, multi-year contract
- Leader-follower
- Licensing
- Second sourcing

Figure 1 Acquisition Strategy Alternatives

were required 20 or 30 years ago. The order in which the tasks are performed may differ, the nature of overlap among the tasks may vary, and the names associated with the activities may change; however, the basic tasks remain relatively static. (Histories of missile development programs support this hypothesis.)

A basic assumption embodied in the model is that the results achieved in prior programs are indicative of results which can be expected from similar acquisition strategy choices in future programs. Thus the lessons learned in prior programs can provide invaluable guidance in choosing the acquisition strategy consistent with the goals and objectives of a program today.

The model has been structured to reflect a logical process often used by a program manager in selecting an acquisition strategy. This process consists of four basic steps:

- Identify all feasible strategies
- Reduce the set of feasible strategies to a smaller set with the highest probabilities of achieving the desired result
- Further reduce the set of possible strategies by financial limitations
- Perform detailed comparative analysis of those remaining to eliminate "second best" options.

SUPPORTING DATA AND INTERNAL RELATIONSHIPS

The development of the prototype model required a large and varied amount of data covering the four acquisition phases. Two categories of data, program history and judgmental data, were required. Internal relationships in the model have their foundation in these data. Frequently data were sufficient only to identify trends and general relationships from which mathematical formulations were derived. For the most part, the methodology is a heuristic, empirical one, which lends itself to validation and modification through rigorous data analysis. Additional data can be used to accept, reject, or modify many of the postulated relationships.

Program history data centered on the following specific program parameters:

- Strategy used in the acquisition phase
- Length of phase
- Cost of phase
- Risk levels
- Interval between start of Phase 2 and IOC
- Overlap between production and development
- Second source start-up costs
- Learning curve parameters
- First unit cost
- Production rate parameters.

The data base developed consists of data on 37 programs plus ancillary data. This proved adequate for prototype demonstration, but the data cannot be considered complete. A summary of the amount of system historical data by phase is presented in Table 1.

TABLE 1

SUMMARY OF SYSTEM DATA BY PHASE

Acquisition Phase	No. of Systems With Data
Concept Exploration	9
Demonstration and Validation	16
Full Scale Development	17
Production	26

Results of the data analysis indicated a high correlation between the cost of pursuing a development phase alternative and the level of technical risk. In other words, development cost is directly proportional to technical risk. Because of this, the cost of pursuing each development phase alternative is described in terms of a normal (Gaussian) probability distribution with mean and standard deviation determined from the data analysis after removing the influence of technical risk. Technical risk factors thus become a key determinant of development cost.

The time required to complete each phase alternative is represented as a normal probability distribution with mean and standard deviation derived from the data analysis. Little correlation between time and risk was evident in the data.

The degree of concurrency between FSD and production affects the time required to achieve initial operational capability (IOC) as well as initial production options. To estimate time to IOC, a normal probability distribution is assumed with the mean and standard deviation determined from data analysis. For production options, the model assumes that it is not possible to develop a second production source during the period of concurrency when FSD and early production activities overlap. The higher the degree of concurrency, the longer the delay before a second production source can be established. This is represented in the model by a normal probability distribution with mean and variance determined from the data analysis.

The majority of the relationships incorporated into the production phase stem from prior research by the authors and their colleagues.* Data collected during this effort was combined with data previously analyzed to generate two generic sets of parameters, one suitable for tactical missiles and one suitable for electronic subsystems.

One additional aspect relating to production cost became evident during data analysis. Although the amount of supporting data is currently small, there is clear evidence that competition during FSD suppresses (compared to single source FSD) subsequent production costs, at least for the first few years. This is incorporated in the model.

Judgmental data included in the model dealt with measuring the ability of each alternative to reduce technical risks to a manageable level. A questionnaire was used to obtain subjective assessments from knowledgeable individuals. Since the required type of information limited the degree of simplification, the questionnaire proved difficult for respondents unless verbally administered, and response was limited. Additional data would allow a more rigorous approach.

From the available data, the authors derived an estimate of the probability that each strategy alternative would reduce technical risk from each of several arbitrarily-defined pre-phase levels to lower end-phase levels. This information formed the nucleus of risk reduction matrices which were generated for each strategy/phase alternative and for each risk category. These risk reduction matrices, when combined with input parameters and historical data, become key determinants of both estimated development costs and probabilities of achieving program objectives.

With the relationships described, time, cost, risk reduction, and tradeoffs among these factors constitute the principal determinants of the model. Their interrelationships should become apparent in subsequent sections.

MODEL OVERVIEW

The prototype model consists of three segments displayed in Figure 2. The objective of the first segment is to build a user-defined scenario through computer-generated questions and user responses. The first series of questions cover the user's system category (new missile, missile mod, or electronic subsystem); the program's location in the acquisition cycle (prior to Phase 0, 1, or 2); options pursued in prior phases if the user is not starting at Phase 0; and elimination of any options the user considers infeasible in his or her particular base.

The next series of questions concern technical risk. In this model, technical risk is defined in three categories as follows:

- Level of technology advance - the concept embodied in this category is the magnitude of the technology increase over the existing state of the art

*Cox, Larry W. and Gansler, Jacques S., "Evaluating the Impact of Quantity, Rate and Competition," CONCEPTS, The Journal of Defense Systems Acquisition Management, Vol. 4, No. 4, Autumn 1981.

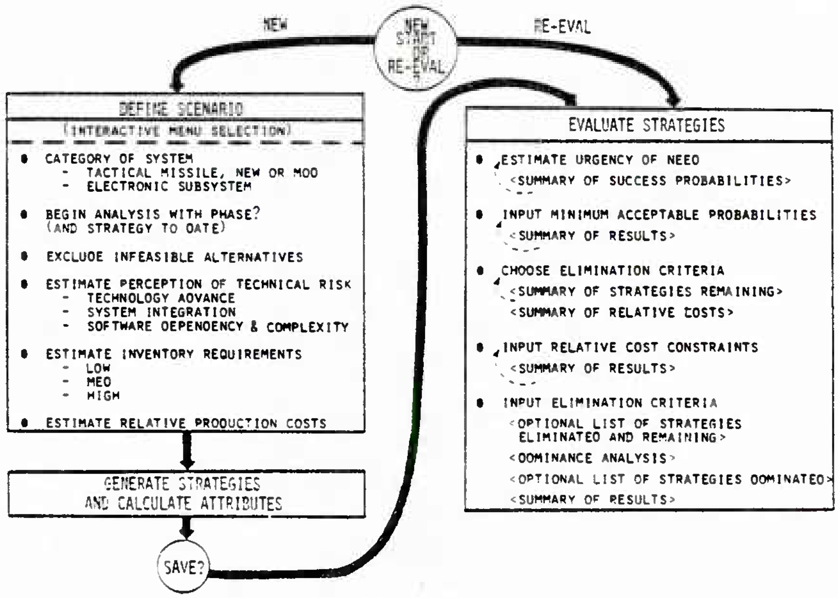


Figure 2 Model Overview

- Degree of required system integration - a large weapon system with many complex internal and external interfaces is a high-technology risk program, not necessarily because it embodies advanced technology, but because it is vulnerable to a large number of error sources

- Level of software dependency and complexity - a weapon system using off-the-shelf components with few interfaces may still be dependent on a large and complex computer software development effort. If the software is critical to the operation of the system, its development could pace the development of the entire system.

For each category, the user expresses the levels of risk on an arbitrary scale from one to nine. A one corresponds to virtually no risk, while a nine corresponds to maximum risk.

In addition to estimating the risk in each category, the user is asked for his degree of confidence in that estimate. Again, this is defined by an arbitrary scale from one to nine where one stands for total uncertainty and nine stands for total certainty.

The user is next asked to estimate his inventory requirements and the number of years of production for a low, medium, and high quantity estimate. The final input to the baseline scenario is an estimate of the system's relative production cost compared to all systems in that weapon system category. An arbitrary scale from one to nine, one being low cost, nine high cost, is used. As before, the user is asked for his degree of confidence in this estimate using the previously defined scale. This concludes the first segment of the model.

The second segment of the model requires no user involvement. Based upon the input provided during the prior phase, the model generates a set of allowable acquisition strategies and computes several attributes for each: the probability distribution of the time required to reach initial operational capability (IOC), the probability distribution of the development cost, the probability distribution of production cost for each estimate of inventory requirements, and the probability distributions of the technical risk remaining at the completion of FSD.

The objective of the final segment of the model is to reduce the set of feasible strategies generated in the second segment. This is accomplished through a sequence of computer-generated questions and the corresponding user responses.

The first series of questions concerns urgency of need. The user estimates the earliest desired and latest acceptable IOC from the beginning of his initial phase. The model then calculates and displays the probability that each strategy will meet these criteria for three levels of pre-production design stability. These levels are as follows:

- Level 1 - Virtually all technical risk has been eliminated. The system is ready for mass production
- Level 2 - Minor technical problems persist, but minor system modifications during production should resolve them
- Level 3 - Somewhat more significant technical problems remain. Limited production only (perhaps in conjunction with planned product improvement) is recommended.

The user then selects the minimum acceptable probabilities for each level for both estimates of IOC. The strategy alternatives are compared by each of these six criteria and the results are summarized in a table which shows the following:

- The number of strategies that satisfy all six criteria
- Additional strategies that satisfy five criteria and are within a probability of 0.10 on the sixth
- Additional strategies that satisfy four criteria and are within a probability of 0.10 on the other two
- Additional strategies that satisfy three criteria and are within a probability of 0.10 on the other three.

The user selects the acceptable number of remaining strategies from this table for further analysis.

The next series of questions permits the user to place cost constraints on the remaining strategies. The computer displays the relative development and total program costs of each alternative for each of the three inventory estimates. The user can specify maximum relative cost levels for development cost and for total program cost for each of the three quantity estimates. The strategies are compared by these four criteria and the results are displayed in a table which shows the following:

- The number of strategies that satisfy all four criteria
- Additional strategies that satisfy three criteria and are within .10 on the fourth
- Additional strategies that satisfy two criteria and are within .10 on the other two.

Again the user selects the acceptable number of remaining strategies from this list.

The final portion of the evaluation segment requires no user involvement. The remaining strategies are compared to each other to determine any "second-best" choices. Basically, one strategy is considered to dominate another if it is clearly superior to the other strategy in at least one (or more) attribute(s) and is at least as good on all others. This comparison is not performed in an absolute sense. Rather, two attributes are considered to be equivalent if they are reasonably close to each other. Similarly, for one attribute to be considered superior to another, it must be better by more than a prespecified threshold.

The results of the analysis consist of strategies not eliminated by one or more criteria. Typically, only a small number of strategies remain. These are displayed, together with the following principal attributes:

- Probability of success for the earliest desired IOC by level of design stability
- Probability of success for the latest acceptable IOC by level of design stability
- Relative development cost
- Relative total program cost by low, moderate, and high inventory estimates.

AN ILLUSTRATIVE EXAMPLE

This hypothetical example concerns the development of a new tactical missile system. The weapon system concept was directed (i.e., the concept exploration phase was skipped), and the analysis is to begin with Phase 1 - Demonstration and Validation. All strategy alternatives included in the model are considered feasible. Parameters defining the perception of technical risk are as follows:

Risk Category	Risk Level	Confidence Level
Technology Advance	7 - Major	7 - Reasonably Certain
System Integration	7 - Major	7 - Reasonably Certain
Software Dependency and Complexity	7 - Major	9 - Absolutely Certain

Estimates of inventory requirements are as follows:

- Low estimate - 2,000 systems produced over two years
- Moderate estimate - 20,000 systems produced over eight years
- High estimate - 60,000 systems produced over 15 years.

Relative production costs were estimated as average (5) with a confidence level of 5 (sounds reasonable).

From this input, 264 possible acquisition strategies were generated.

Earliest desired IOC and latest acceptable IOC estimates are 144 months (12 years) and 168 months (14 years). Probabilities of success generated are displayed in Figure 3. The minimum acceptable probabilities selected are circled.

The result was that 21 of the 30 strategies were eliminated as being "second-best" options. The output summary of results is displayed in Figure 4.

The implications of these results are as follows:

- For the high-risk situation described, when urgency of need is not great, one should build a full system prototype during D&V and perform incremental FSD. Tradeoffs exist between non-industrial and industrial firms, as well as between single and dual source FSD.

TABLE 1
EARLIEST DESIRED IOC

Probability of success at least as great as:

	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
LEVEL 1	186	168	108	90	(30)	18	0	0	0
LEVEL 2	228	186	168	108	90	(30)	18	0	0
LEVEL 3	246	228	186	168	108	90	(48)	0	0

TABLE 2
LATEST ACCEPTABLE IOC

Probability of success at least as great as:

	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
LEVEL 1	186	168	108	90	30	(30)	0	0	0
LEVEL 2	228	186	168	108	90	30	(30)	0	0
LEVEL 3	246	228	186	168	108	90	60	(30)	0

Figure 3 Probabilities of Success

The results of applying these criteria were that 30 strategies satisfied all six criteria. The other "close" categories were all empty (i.e., contained zero strategies). The summary of these strategies by phase is as follows:

FOR PHASE 1:	Prototype Nonindustrial	12
	Prototype Single Industrial	6
	Prototype Multiple Industrial	12
FOR PHASE 2:	Incremental - Single Source	18
	Incremental - Multiple Sources	12
FOR PHASE 3:	Single Source - No Options	5
	Single Source - Options	5
	Single Source - MYC	5
	Licensing	5
	Leader/Follower	5
	Second Sourcing	5

Relative cost comparisons of these 30 strategies are provided in Tables 2 through 4. It was decided not to eliminate any of the strategies at this point for cost considerations, primarily to discover how many strategies would be eliminated by the dominance analysis.

- Production options are mainly dependent upon estimated inventory requirements: the high estimate justifies dual source production, the low estimate does not. For the moderate estimate, there are other tradeoffs involved.

- The probability of a successful program is relatively high.

TABLE 2

TOTAL PROGRAM COST LOW QUANTITY

	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	
1.0												
0.9												
0.8				6	3		3	3				(15)
0.7					2							(2)
0.6				6	1		3	3				(13)
0.5												
0.4												
0.3												
0.2												
0.1												
0.0												
TOT)				(12)	(6)		(6)	(6)				

DEVELOPMENT COST

TABLE 3

TOTAL PROGRAM COST MED QUANTITY

	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	
1.0												
0.9				8	4							(12)
0.8				4	2		2	2				(10)
0.7							4	4				(8)
0.6												
0.5												
0.4												
0.3												
0.2												
0.1												
0.0												
(TOT)				(12)	(6)		(6)	(6)				

DEVELOPMENT COST

TABLE 4

TOTAL PROGRAM COST HIGH QUANTITY

	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	
1.0												
0.9				6	3		2	1				(11)
0.8				2	1		2	2				(7)
0.7				4	2		1	1				(8)
0.6							2	2				(4)
0.5												
0.4												
0.3												
0.2												
0.1												
0.0												
(TOT)				(12)	(6)		(6)	(6)				

DEVELOPMENT COST

There are 9 strategies remaining. The following summarizes the relative attributes of these strategies. Complicated trade-offs exist among these attributes. Trade-off analysis more detailed and more in-depth than is possible here is recommended.

1	Prototype Non-industrial	Incremental - Single Source	Single Source - MYC
2	Prototype Non-industrial	Incremental - Single Source	Leader/Follower
3	Prototype Non-industrial	Incremental - Single Source	Second Sourcing
4	Prototype Non-industrial	Incremental - Multiple Sources	Single Source - MYC
5	Prototype Non-industrial	Incremental - Multiple Sources	Leader/Follower
6	Prototype Non-industrial	Incremental - Multiple Sources	Second Sourcing
7	Prototype Single Industrial	Incremental - Single Source	Single Source - MYC
8	Prototype Single Industrial	Incremental - Single Source	Leader/Follower
9	Prototype Single Industrial	Incremental - Single Source	Second Sourcing

STR #	PROBABILITY OF SUCCESS						RELATIVE COSTS			
	EARLY IOC			LATE IOC			DEV	TOTAL		
	L1	L2	L3	L1	L2	L3		LQ	MQ	HQ
1	0.60	0.68	0.76	0.64	0.73	0.82	0.38	0.66	0.91	0.94
2	0.60	0.68	0.76	0.64	0.73	0.82	0.38	0.81	0.84	0.78
3	0.60	0.68	0.76	0.64	0.73	0.82	0.38	0.81	0.84	0.78
4	0.60	0.68	0.76	0.64	0.73	0.82	0.68	0.63	0.73	0.81
5	0.60	0.68	0.76	0.64	0.73	0.82	0.68	0.84	0.76	0.69
6	0.60	0.68	0.76	0.64	0.73	0.82	0.68	0.84	0.76	0.69
7	0.62	0.71	0.79	0.64	0.74	0.82	0.39	0.66	0.91	0.94
8	0.62	0.71	0.79	0.64	0.74	0.82	0.39	0.81	0.84	0.78
9	0.62	0.71	0.79	0.64	0.74	0.82	0.39	0.81	0.84	0.78

Please note -- The use of multiyear contracting assumes a relatively stable design for initial production. If this is not the case, single source with or without options would be the alternatives.

Figure 4 Summary of Results

A REAL-WORLD EXAMPLE

The AN/SLQ-32 Shipboard Electronic Warfare System program began in October 1971 with the objective of developing and procuring a coherent series of electronic warfare systems for near fleet-wide installation.

The AN/SLQ-32 scenario was described by its program manager as follows:

- System category -- electronic subsystem
- Concept was directed -- no concept exploration was performed
- Strategy analysis began with Phase 1
- Use of non-industrial firms was not feasible during the D&V Phase
- All alternatives during FSD and production were entered as possible, although there were political considerations which made some difficult
- Technical risk
  - Technology Advance - moderate (5) with reasonable certainty (7)
  - System Integration - total (9) with absolute certainty (9)
  - Software Dependency and Complexity - moderate (5) with absolute certainty (9)
- Inventory requirements were for 300 systems to be produced over four years with no uncertainty (i.e., low, moderate, and high estimates were identical)
- Relative production costs would be 7 (above average) with a confidence level of 7 (reasonably certain).

Given this scenario, 174 possible strategies were generated.

Urgency of need was entered as 60 months (5 years) as the time to the earliest desired IOC and 78 months (6½ years) as the time to the latest acceptable IOC. These were based upon the actual five-year time span the program office used as a goal and the achieved time to IOC of slightly over six years. Summaries of the probability of success are displayed in Figure 5. The specified minimum acceptable probabilities are circled.

TABLE 1

EARLIEST DESIRED IOC

Probability of success at least at great as:

	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
LEVEL 1	90	(30)	0	0	0	0	0	0	0
LEVEL 2	108	48	(18)	0	0	0	0	0	0
LEVEL 3	132	72	48	(18)	0	0	0	0	0

TABLE 2

LATEST ACCEPTABLE IOC

Probability of success at least as great as:

	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
LEVEL 1	144	102	(30)	0	0	0	0	0	0
LEVEL 2	144	144	102	(30)	0	0	0	0	0
LEVEL 3	168	144	144	66	(30)	0	0	0	0

Figure 5 Probabilities of Success

The results of evaluating the 174 strategies against the specified criteria are as follows:

- 0 strategies satisfy all six criteria
- 18 additional strategies satisfy five criteria and are within a probability of 0.10 on the sixth
- 12 additional strategies satisfy four criteria and are within a probability of 0.10 on the other two
- 0 additional strategies satisfy three criteria and are within a probability of 0.10 on the other three.

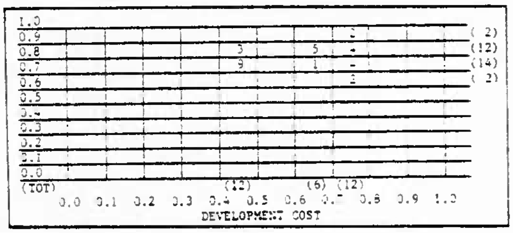
All 30 strategies accounted for were selected. The summary of these strategies by phase follows:

FOR PHASE 1:	CD Single Industrial	6
	CD Multiple Industrial	12
	Prototype Single Industrial	6
	Prototype Multiple Industrial	6
FOR PHASE 2:	Incremental - Single Source	12
	Incremental - Multiple Sources	6
	Full Concurrency - Single Source	12
FOR PHASE 3:	Single Source - No Options	5
	Single Source - Options	5
	Single Source - MYC	5
	Licensing	5
	Leader/Follower	5
	Second Sourcing	5

Since the inventory estimates were identical, one table is sufficient to display relative cost comparisons (Table 5).

TABLE 5

RELATIVE COST COMPARISON



Since no alternatives were eliminated on the basis of cost, all 30 strategies were subject to the dominance analysis. Four of the 30 strategies were determined to be "best". (See Figure 6.) Note that if more stringent comparison criteria are used, only two strategies remain, 2 and 3.*

1 CD Multiple Industrial	Incremental - Multiple Sources	Single Source - Options
2 CD Multiple Industrial	Incremental - Multiple Sources	Single Source - MYC
3 Prototype Single Industrial	Full Concurrency - Single Source	Single Source - MYC
4 Prototype Multiple Industrial	Full Concurrency - Single Source	Single Source - MYC

STR #	PROBABILITY OF SUCCESS						RELATIVE COSTS			
	EARLY IOC			LATE IOC			DEV	TOTAL		
	L1	L2	L3	L1	L2	L3		LQ	MQ	HQ
1	0.25	0.33	0.42	0.30	0.40	0.51	0.76	0.69	0.69	0.69
2	0.25	0.33	0.42	0.30	0.40	0.51	0.76	0.65	0.65	0.65
3	0.21	0.27	0.33	0.37	0.49	0.60	0.60	0.78	0.78	0.78
4	0.21	0.27	0.33	0.37	0.49	0.60	0.73	0.82	0.82	0.82

Please note -- the use of multi-year contracting assumes a relatively stable design for initial production. If this is not the case, single source with or without options would be the alternatives.

Please note -- if we apply a somewhat more stringent companion criteria, strategy(s) 1-4 are dominated by the remaining.

Figure 6 Summary of Results

*The dominance analysis portion of the model incorporates the concept of "closeness." One strategy is not allowed to dominate another if their respective attributes are relatively close. This is accomplished by comparing attributes against a pre-specified threshold. Three different thresholds are used; the smaller the threshold, the more stringent the comparison criteria. A message is printed when the use of alternative thresholds varies the results.

- Multiple source contract definition followed by multiple source incremental FSD followed by a single source multi-year production contract
- Single source prototype followed by single source FSD with full concurrency followed by a single source multi-year production contract.

The tradeoffs between the two options are as follows:

- The first option has the larger probability of success for the earliest desired IOC and the lower total program cost
- The second option has the larger probability of success for the later IOC and the lower development cost.

The actual strategy pursued for the AN/SLQ-32 was the first of the two preferred (CD + Incremental + MYC) and IOC was slightly more than six years following program inception.

The program management office for the AN/SLQ-32 manually performed a similar analysis at the start of the program: they itemized what they considered to be the candidate alternatives with the highest probability of satisfying their goals and sequentially eliminated "second-best" alternates based upon a number of criteria.

By relying principally on their experience and judgment, they spent approximately one month in the early days of the program accomplishing this analysis. Key influencing factors were as follows:

- Moderate technology advance combined with compressed schedule requirements
- Small inventory requirements
- No significant constraint on R&D money
- Ceiling on production money.

These factors were applied to the strategies identified as having potential, and rough estimates for both time and cost were generated for each. Their chosen strategy emerged from this analysis.

CONCLUSIONS

The examples provide evidence that the prototype model provides results consistent with program experience. Examples of sensitivity analyses (not included due to space limitations) illustrate the insights the model is capable of providing regarding the interrelationships among acquisition strategy alternatives and key influencing factors such as the following:

- Perception of technical risk
- Urgency of need
- Development cost
- Production cost
- Estimated inventory requirement.

The concept that acquisition strategy encompasses the entire acquisition process is emphasized. A user not experienced in program management can experience first hand why the selection of an acquisition alternative for one phase should not be made independently of other phase options. Furthermore, insight into the importance of risk identification and risk management early in the program is provided.

A computerized model will probably never duplicate the judgment and insight possessed by an experienced and intelligent program manager. However, the degree of similarity in the results for the AN/SLQ-32 example gives credence to the idea that a fully developed model, properly supported by data, might provide useful assistance. For the AN/SLQ-32 example, perhaps detailed management analyses could have been applied only to the two or three preferred strategies output by the model. In other cases, strategy alternatives overlooked by the staff may offer potential. In any case, supplementary analysis which can be provided in a short time period (no more than a few hours including sensitivity analysis) appears justified.

Finally, the data base and analytic structure provide an excellent first step toward the development of a unique and badly-needed acquisition research tool.

Collectively, these findings provide a strong indication of the potential utility of the model and the data base in three separate areas:

- A teaching aid to program management students
- A planning support tool to a program management office
- A research and analysis vehicle for the acquisition research community.

THE DSARC PROCESS "THEORY VS. PRACTICE"

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Abstract

Acquiring material for national security is a process as old as the nation itself. As new technology, missions and responsibilities have emerged, new ways of acquiring the necessary material have been designed and implemented into the defense acquisition process. Some of these changes have been at the initiative of the defense establishment. Others have been imposed by higher authority, including Congress.

What we currently recognize as the acquisition process can be traced to the early 1960's when Secretary of Defense McNamara began to centralize control over new weapon system developments through the Development Concept Paper (DCP) system. Since then, there have been numerous and significant attempts to improve (sometimes through ad hoc means) the process.

Over the years important studies and panels were commissioned to review the process and recommend improvements. A review of these reports and recommendations reveals a common intent/thread across all the reports, yet implementation has not produced the results desired.

This paper identifies that intent, tracing it from one major study to the next, through intermediate directives and ending with the current "Carlucci initiatives." A rationale for results not fulfilling the expectations of the reviewers is developed which suggests areas of emphasis for corrective action.

Background

Acquiring the implements of warfare is a process with a long history. For a humorous, tongue-in-cheek account of the frustrations, cost increases and administrative burden associated with the fundamental function of providing for the common defense read the "Free Enterprise Patriot." (1)

Before 1964 and after the formation of the Department of Defense in 1947 the acquisition process was controlled, managed, and defended by the individual Services and their hardware acquisition commands. Beginning in 1964, Secretary of Defense McNamara began to assert a larger Office of the Secretary of Defense (OSD) role in the acquisition process through the Development Concept Paper (DCP) system and the issuance of DODD 3200.9; which stated,

> "no sizable weapon should be allowed to enter the development phase until the necessary technology is demonstrably available." (2)

The commencement of development was the one major decision point for approving new program starts. DODD 3200.9 further indicated that it was necessary to preceed the development phase with a concept formulation phase where the Services were to:

- o clarify their requirements;
- o analyze alternative means of accomplishing these requirements; and
- o undertake exploratory and advanced development efforts to prove out the necessary technology.

Only then could the Services commence competitive contract definition to detail the development effort. Successful definition effort lead to the DCP, and if approved, incorporation into the Five Year Defense Program (FYDP).

Creating the DSARC

Evaluating the confusion and experiencing some of the problems associated with DODD 3200.9 and anticipating the President's Blue Ribbon Defense Panel. Deputy Secretary Defense Packard, in May 1969, issued a memorandum to the Service Secretaries establishing the Defense System Acquisition Review Council (DSARC). (3) The memorandum stated in part

> "... the primary responsibility for the acquisition and management of our major systems must rest with the individual Services. Within each Service, this responsibility is focused in the Project Manager. Recognizing the Service responsibility, I am, at the same time, most anxious of insuring before we approve transitioning through the critical milestones of the acquisition of a major system, that all facts of the acquisition process are properly considered....." (4)

Included with the May 1969 memorandum was the charter for the DSARC outlining the major questions to be answered at each milestone:

- evaluation of where the Service stood in relation to mission need, plans, and proposed procurement methodology
- analysis of risk (technical and cost);
- feasibility of production, and
- appropriateness of concurrent development and production

These are the same general questions asked by Secretary McNamara in his Directive 3200.9 in July 1965. (5)

Because of increased industry pressure and growing Congressional concern about the operation of the acquisition process within DoD two major studies were undertaken. Congress established "The Commission on Government Procurement"(6) in November 1969 to report back in 1972 and President Nixon established the Blue Ribbon Defense Panel(7) in July 1969 to report out in July 1970.

The Blue Ribbon Defense Panel Report

The results of Secretary McNamara's initiatives as implemented by the DOD and Services were not viewed as successful by the President's Blue Ribbon Panel. The report listed several reasons why:

- the necessary supporting technical work was not accomplished during the concept phase;
- the implicit assumption that technical risks can be foreseen prior to the development and can be priced accurately;
- the competitive process during contract definition lead to significant underpricing, buy-in's and over emphasis on cost;
- technical papers were developed covering detailed information concerning "how" it would work with little solid developmental hardware produced or tested;
- the appropriateness of source selection and evaluation procedures; and,
- the great inflexibility in the overall process because of the detail described in the contract of what was to be accomplished.

The Blue Ribbon Defense Panel report was a major landmark in the evolution of the DSARC process and is thus deserving of expanded discussion of the above points.

First, the criticism that necessary supporting technical work was not accomplished during or before concept formulation. Adequate front end funding was not made available in exploratory and advanced development programs to develop components independent of a final system use. Major effort in the "front end" of the process continued to be expended on system concepts, i.e., paper studies, without extending the knowledge and technology base of components necessary to build the system. The technology base was neglected with the result being a lack of solid technology developments useful to future and existing weapon systems and thus increased developmental risks.

Technical risk was implicitly conceived to be accurately predictable prior to the development. This misconception was based on two assumptions. The first being that paper studies could identify all the inherent risks the government and possible contractors would encounter during development; and second that since the areas of risk were at least catalogued (identified) they could be priced, thereby allowing the use of incentive and fixed-price contracts, with their associated detail.

Cost estimating in a competitive environment based on the foregoing assumptions during contract definition led to significant underpricing in numerous system development programs. This period of time was also marked by many contractors interested in doing defense work and with very few major development programs being started. Thus, the competitive environment was intense. In addition, the procedures used in contract definition tended to equalize the technical and management elements of contractors proposals with the result that price became the key decision element in awarding contracts. This increased the pressure to be over-optimistic in the pricing of competitive bids.

Great mounds of technical paper were developed as part of the formal process during contract definition in lieu of solid technology development. These "technical" papers included every detail of reliability, maintainability, logistics, training, personnel levels, etc. without grounding in actual scientific effort and little hardware produced or tested to verify and support concepts and informed judgments.

The techniques used in source selection and evaluation called for large volumes of data to be submitted which in turn required large source selection teams to review and evaluate the proposals. The work was of such a nature that no single group within the team understood all of any single proposal. Therefore elaborate scoring procedures were developed to evaluate and rank the proposals. The result being that many important technical areas and analysis were obscured through the numerical scoring process thus again reinforcing bid price as the primary decision variable.

Finally, the great inflexibility in program execution as a result of the detail contained in the development contracts. As a result of earlier efforts to reduce the use of cost-plus-fixed-fee contracts and move to fixed price contracts the government's management effort was directed to holding the contractor to the terms of the contract, which as noted were in considerable detail. Likewise the contractor was inclined to meet contract requirements in lieu of negotiating changes as technical difficulties or opportunities for improvement were encountered. This impasse created a lose-lose situation between the Government and the contractor rather than a negotated win-win situation to everyone's advantage.

Other problems were identified which reflected the increased demand placed on contractors for information, the increased level of risk the contractor was required to take concerning capitalization of the project and the increasing concern for additional funds to cover underpriced contracts and technical difficulties.

During this period (early 70's) there seemed to be no clear direction or policy as to how to improve the acquisition process. The basic McNamara concept seemed sound: identify and define your requirements; look for alternative ways of meeting those requirements; conduct exploratory work to prove out the technology; and, then develop the systems. The Blue Ribbon Report agreed. Those were the key considerations, but the methods and procedures employed did not produce results consistent with the intent.

To correct the situation discribed above and other broader concerns the Blue Ribbon Defense Panel produced 113 recommendations addressing areas from basic DOD reorganization to conflict of interest considerations. There were several having direct impact on the acquisition process and most of these were in various stages of implementation within DOD prior to issuance of the formal report.

Specifically the Blue Ribbon panel recommended the following acquisition improvements:

- o Discontinue total package procurement and cancel Department of Defense Directive 3200.9.
- o Increase the use of competitive prototypes, reduce paper studies.
- o Reduce concurrent development and production.
- o Be flexible in contract selection.
- o Be flexible in applying requirements for formal contract definition.
- o Increase advanced planning for T&E with separate program funding category.
- o Increase the professional development, authority and responsibility of Program Managers.
- o Increase the use of cost estimating techniques.

Operational Test and Evaluation

A major part of the Blue Ribbon Panel Report was the emphasis placed on Operational Test and Evaluation (OT&E). (8) This area was singled out as a result of pressure by Congress and GAO reports which identified the failure of operational systems to meet performance characteristics. (9) The Blue Ribbon Report identified several systems including the M-16 combat rifle, the M551 Sheridan/Shillelagh anti-tank missile, and the C-5 heavy cargo aircraft where full scale production was begun before operational testing was completed.

However, there were counter examples of systems that were successful and had no more actual OT&E than those systems considered to do poorly in operations, such as the Pershing medium range missile and the A-6 attack aircraft. However, in these cases (Pershing and A-6) highly competent project management teams, backed up with technical experience in the service, strong OSD and Service support at all levels, stable funding, and early engineering design testing were noted as contributing greatly to their success.

Somewhat indifferent to the successes and their project management attributes, the Blue Ribbon Panel concluded that OT&E was not adequately structured to insure a well tested operational system. They recommended:

- The establishment of an operational testing and evaluation group at the Secretary of Defense level; and,

- A substantial budget for OSD sponsored OT&E and a requirement for each service to budget separately for an OT&E program element.

However, the most important aspect of the panel's conclusion was their recommendation that an OT&E group within the Services and OSD be established to represent both the user and developer (10) but be organizationally independent of both. The panel also recommended that since T&E was a continuous process, it should be conducted throughout the acquisition process to assess and reduce risk and to estimate the operational effectiveness of the system being developed.

DODD 5000.1 and The Commission on Government Procurement

In July 1971, a year after the completion of the Blue Ribbon Panel Report Secretary Packard issued DODD 5000.1 "Acquisition of Major Defense Systems"; (11) thus establishing the current acquisition process.

The Directive attempted to emphasize the principles suggested by the Blue Ribbon Panel and the earlier memorandum of Packard establishing the DSARC.

The key elements of the Directive included:

- Establishing rational program priorities and clearly defined responsibilities.

- Responsibility and authority for the acquisition of major defense systems to be decentralized to the maximum practicable extent.

- Development and production shall be managed by a single individual (program manager) who shall have a charter which provides sufficient authority to accomplish recognized program objectives.

- The Development Concept Paper (DCP) and the Defense Systems Acquisition Review Council (DSARC) will support Secretary of Defense in decision-making.

- Need for a strong and usable technology base. The base to be maintained by conducting research and advanced technology effort independent of specific defense systems development.

- Program management considerations shall include:

  - Statements of need/performance requirements.

  - Cost parameters shall be established which consider cost of acquisition and ownership.

  - Logistic support considerations that have significant impact on system readiness, capability, or cost.

  - Programs structured and resources allocated to demonstrate actual achievement of program objectives as the pacing function.

  - Schedules and funding profiles structured to accommodate unforeseen problems and permit task accomplishment without unnecessary overlapping or concurrency.

  - Technical uncertainty shall be continually assessed.

  - Test and evaluation shall commence as early as possible. The results of operational testing will be evaluated and presented to the DSARC at the time of the production decision.

  - Contract type shall be consistent with all program characteristics including risk.

As Secretary Packard's new acquisition process was beginning to function, the Commission on Government Procurement Study was published in November 1972. The Commission report contained 149 recommendations of which 12 were directly related to Defense Systems Acquisition. In general, the report was critical of the lack of coordinated government wide effort for studying ways to improve the procurement process and in fact recommended the creation of the Office of Federal Procurement Policy to formulate government wide acquisition policies and regulations and to monitor acquisition practices.

The Commission report was most critical of the DSARC process in its implementation, stating:

> "The DSARC process which was intended to loosen up the acquisition system, has been administrated in an increasing inflexible manner, leading to program gaps, and increased costs due to administrative, not technical reasons." (12)

The report suggested that flexibility was needed in several areas:

- o Contracting - make the contract fit the work to be done. Do not institutionalize the contract and make the work fit the contract.
- o Management implementation - Do not adhere to the formally prescribed sequence of milestones for every program.
- o Acquisition strategy - degree of concurrency should be associated with risk.
- o Flexible testing philosophy - OT&E policy should provide for a testing process as appropriate to permit testing requirements to be tailored in such a way as to reduce development risk in light of the end product being developed. What is needed is joint testing but independent evaluation throughout the process.

The recommendations of the commission on Government Procurement were carried out through congressional establishment of the Office of Federal Procurement Policy (OFPP) within the Office of Management and Budget (OMB). Subsequently OMB issued circular A-109 which in the main established the DoD process, with a few changes, as the Federal Government acquisition process. The circular also added these embellishments to the acquisition process:

- o Each agency that acquires major systems will designate an acquisition executive to integrate and unify the process.
- o Each agency establish clear lines of authority and responsibility for the management of its major systems.
- o Develop an integrated systematic approach to the acquisition process.
- o Top level agency management attention to identify and define mission need to be fulfilled, and the relative priority assigned within the Agency.
- o Technical and program decisions normally will be made at the level of the agency component or operating activity.
- o Increased support for early research and development efforts to support mission needs. (13)

In general the recommendations of both of these efforts directed toward the DoD were consistent with the policies and direction initiated by Secretary Packard. A major difference emanating from A-109 was greater emphasis on exploring alternate systems before committing to a preferred system. This was to be accomplished by including a new milestone into the DSARC process, Milestone 0, with its associated requirements. These associated requirements were formalized by DoD into a Mission Element Need Statement (MENS) that was to provide the additional information to evaluate alternative concepts for meeting the need in the most efficient manner. (14)

<u>Other Related Studies</u>

Two additional major studies have been completed since Secretary Packard issued the initial instructions and directives establishing the DSARC process, The Defense Science Board (DSB) Study of 1977 and the Defense Resource Management Study (DRMS) of 1979. (15, 16) Both studies were critical of the acquisition process. The major criticism of the DSB Study was the growing inflexibility in the utilization of the acquisition policies, directives and procedures:

- o "The most prominent single thread that was evident throughout all the data examined by the task force was the necessity for and the absence of a high degree of flexibility in every application of the policies and practices for acquisition management".... (17)
- o "A definite tendency was observed whereby pressures for strict adherence to the letter, as well as the intent of published policies and directives are not only strong, but increasing over the past several years. The practice tends to be to take a literal or even the most stringent possible interpretation of the policies and procedures rather than to encourage a judicious interpretation of the published requirement in a manner which is appropriate to each individual case".... (18)

The inflexibilities noted by the DSB study were not the intent of policy, but the results of system implementation, and continued top-level pressures to control the process. This same general theme is reflected in the Defense Resource Management Study of 1979.

- o "There is in fact, no single, generally applicable acquisition strategy that can be applied, unreservedly, to the broad range of requirements that confront the DoD. Flexible planning, option preservation, and adaptive management are no less essential today than they were two decades ago".... (19)

The DRMS report continues by describing a set of problems arising from the institutional setting in which acquisition is managed i.e.:

- o that performance goals may have to be adjusted and that such actions by the program manager should not be construed as evidence of management failure.
- o that program managers must be given both the opportunity and the incentives to entertain and act on questions of program cancellation, slowdown or slippage as valid program alternatives;
- o that initial technical goals may not be achievable at an acceptable cost;

In March 1981, Deputy Secretary of Defense Carlucci issued his 31 initiatives (increased to 32 in July 1981) to improve the defense acquisition system and reduce system costs. (20) These were based on an in-house, in-depth look at the existing process.

Interestingly, the initiatives have the same goals and recommendations endorsed by previous Deputy Secretaries of Defense and the several major studies noted above, although in Secretary Carlucci's initiatives the range and depth is greater, given that the process the new administration inherited was now more complex and more institutionally encumbered. The Carlucci initiatives directed:

- o Decentralize responsibility, authority, and accountability to the lowest levels of the organization at which the total view of the program exists.
- o Service Program Managers should have the responsibility, authority, resources and guidelines adequate to efficiently execute the program. This includes acquisition strategy for attainment of the required operational and readiness capability, and flexibility to tailor their strategy depending on priorities and risk.
- o Evaluate alternatives which use a lower risk approach to technology.
- o Maintain program stability throughout the decision levels.
- o Provide realistic budgets for meeting economic production rates.
- o Adopt multi-year contracting.

A recent article by the Chairman of the Defense Science Board, Mr. Norman Augustine, indicates that there is more yet to be done. (21) He presents a particularly perceptive set of recommendations stressing the following:

- o Demand program stability and initiate only those programs which can be fully funded.
- o Retain qualified personnel in program management.
- o Delegate authority and responsibility to a much larger degree.
- o Realistically budget for inflation.

There were other recommendations . . . all valid, put forth by Mr. Augustine. He also pointed out that the A-109 concept of acquisition had already become ineffective as a result of encumbering and excessive implementation procedures and directives. (22)

Findings

Taking the several studies and directives and examining them side by side one is struck by:

- o The short time interval between "major studies" of the acquisition process.
- o The fact that the same problems have existed since the mid-1960's.
- o The close correlation in intent, critical findings, and recommendations for improvement.

A close examination of Table I, for example, clearly indicates the close correspondence of management intent for two Deputy Secretaries of Defense separated by over a decade.

TABLE I
Common Elements between
Secretary Packard and Secretary Carlucci

Packard (1969)	Carlucci (1981)
DOD components have primary responsibility for identifying need and defining, developing and producing systems to satisfy those needs.	Responsibility, authority and accountability for programs should be at lowest levels of the organization at which a total view of the program rests.
OSD to place minimum demands for formal reporting on the program manager.	Reduce DSARC Briefing and Data Requirements.
Conducting research and advanced technology effort independent of specific defense systems development.	Budget funds for technological risk - Preplanned Product Improvement.
Cost parameters shall be established which consider the cost of acquisition and ownership.	Budget to most likely costs.
Practical tradeoffs shall be made between system capability, cost and schedule.	Funding flexibility.
Test and evaluation shall commence as early as possible.	Front end funding for Test hardware.
Contracting shall be consistent with program characteristics including risk.	Assure appropriate contract type.

Clearly, everyone agrees that credibility and confidence in the acquisition process must be restored. What then are the impediments to progress? Where does the process keep going wrong? Or more precisely where does the administration of the process keep going wrong?

There are so many symptoms that even keen observers result to lengthy lists of corrective action. It is a situation analogous to the patient beset by such general physiological deterioration the doctors do not know where to begin. The result . . . the patient dies in the anteroom while the experts try to devise a plan of treatment.

Long lists of corrective actions implemented through new and reissued directives are not the answer. The numbers of acquisition directives enunciating policy have more than doubled since 1970 with obviously little effect.

What is needed is a quantum step toward first principles. The Carlucci initiatives provided the initial direction . . . the common concerns of Secretaries Packard, Carlucci and the other studies and commissions indicate where improvement effort should be concentrated:

- o First and foremost complete the decentralization of the process.
- o Second, but equally important, foster flexibility .
- o Third, insist on program stability.
- o Finally, establish acquisition policy consistent with the foregoing; hold the Services responsible and accountable for effective implementation.

Achieving the Objective--Restoring Confidence and Credibility in the Process

The fact that we are still examining the process and have done so with increasing frequency is indicative of general dissatisfaction with the results of the process. The Carlucci initiatives have presented an unusual and historic opportunity for improving the process. This momentum must be sustained to ensure real reform takes place.

Decentralization

Virtually all the studies and commissions recommend decentralization of the acquisition process. The DSB report of 1977 quoted earlier is particularly clear on that point. The DRMS report which followed reinforced that conclusion. Secretary Packard certainly did not envision a centralized usurpation of Service Secretary responsibility when he created the DSARC. Recall that his original memorandum stated:

> ". . . The primary responsibility for the acquisition and management of our major systems must rest with the individual Services." (23)

The micromanagement and administrative encumbourences resulting from the formation of the DSARC and providing no "value added" to the process were not envisioned by Mr. Packard. Yet those are precisely the findings of subsequent reviewers. Given the propensities of large institutions the inefficiencies and inflexibilities of over centralization will likely occur again. (In fact, there is evidence of a return to such discredited practices. (24)

Clearly, it is time to decentralize the process without equivocation, to forestall micromanagement and administrative encumbering with significant cost to acquisition programs with no discernable value added.

It is not unusual for reviewers to qualify their recommendations for decentralization. (25) Such qualifications represent a conservatism that is understandable in normal circumstances; however, with the considerable evidence that partial methods have been ineffective in improving the acquisition process . . . such conservatism lacks the decisiveness required for real progress toward improvement in the acquisition process. It is time to adopt new procedures.

Secretary Carlucci's initiative in this regard, now documented in DODD 5000.1, (26) supports decentralization but does so with an unfortunate string attached . . . "controlled decentralization." (27) What is needed is decentralization without strings attached. There is a quite simple and practical way to cut the strings.

Effecting Decentralization

The acquisition milestone concept, associated with Secretary Packard's DSARC process is fundamentally sound, well understood and institutionalized.

Necessary and sufficient acquisition policy can be directed by the Secretary of Defense, monitored and enforced by the Defense Necessary and sufficient acquisition policy Acquisition Executive through various audit procedures without a DSARC.

This vestige of a centralized OSD staff management scheme has its roots in Secretary McNamara's DCP concept . . . it and subsequent variations have been evaluated numerous times as failures. It would be tragic to retain the DSARC. It epitomizes lack of trust and confidence in the Services to carry out effectively SECDEF policy . . . and is thus demotivating.

Furthermore, the Defense Resources Board, established some three years ago, has been given new membership and functions by Carlucci intiatives. (28) The DRB has supplanted DSARC functions in two important ways . . . the addition of a long range planning scheme to look at DOD investments and a review of new program starts as part of the Program Planning and Budgeting System (PPBS) process.

Accordingly, to effect decentralization of the acquisition process and create positive motivation for the Services and acquisition program managers to accept responsibility and accountability for their programs . . . disestablish the DSARC. Use the Defense Acquisition Executive to monitor policy imple-mentation and the DRB to monitor execution.

Flexibility a Fundamental Principle

Again, it is the DSB study of 1977 which had important things to say about the inflexible implementation and administration of the milestone (or DSARC) acquisition process. And again it is the DRMS effort which reinforces the finding. Furthermore, the earlier Commission on Government Procurement report decried the adherence to a formally prescribed sequence of milestones for every program. (29) One can apply the inflexibility criticism to testing requirements, contract types, funding rules, etc. Why this inflexibility?

Inflexibility is the result of a no-risk mentality endemic in a process where unaccountable and unqualified staff entities have, without intent,effectively usurped line management authority. Further, the well documented increased length in the acquisition process stems directly from this "institutional mentality" and is exacerbated by the several review layers.

Picture a program manager who must suffer his program to an inordinate number of preliminary staff reviews before reaching the decision forum. He is subject to well meaning but often wrong advice and inappropriate, incompetent direction. Secretary Packard never envisioned such a procedure. (30) Unfortunately DODD 5000.1 can be interpreted and used to continue such practices. (31) The evidence cited earlier in this paper should convince even the most skeptical observer that there has been no value added through such proceedings . . . only exchange of information available elsewhere, through other means, if indeed needed at all.

Such reviews, in this writers experience, result in the program manager conforming to the collective wisdom which as indicated, is essentially no risk, single "acquisition model" oriented, and often lacks any practical experience applicable to the program under consideration. It usually takes high level intervention to undo misdirection caused by inappropriate or inflexible interpretation of regulations, policy and instructions. And there is an obvious limit to high level interventions.

The reduction in the number of "major programs" subject to DSARC review lessens the potential for debilitating inflexibility in the acquisition process to flourish . . . but it is not eliminated. There is nothing in DODD 5000.1 or the extant draft 5000.2" (32) which strongly encourages flexi-bility, stimulates innovation in acquisition strategy, or creates a needed sense of urgency in the acquisition process.

To ensure flexibility DOD acquisition policy must encourage it. The Carlucci initiatives to reduce acquisition directives, data requirements and administrative procedures are essential and positive steps. Implementation, while encouraging, has nevertheless been too conservative.

Flexibility is essential to an effective and efficient acquisition process therefore . . . amend DODD 5000.1 to specifically and strongly establish flexibility as a fundamental acquisition principle.

Program Stability

Program stability is a *sine qua non* for visible improvement in the acquisition of military weapons and supporting systems. It is particularly important in a period of high inflation, long material lead times and general economic instability. Analysts have determined that inflation coupled with planned or real program quantity or schedule changes account for 70% or more of so called "program cost growth."

It is unconscionable at a time when lead times for many components of weapon systems are two years or more . . . that long lead funding is held hostage to certain test results and planned acquisition strategy is frequently adjusted to conform to "budgetary rules". The financial (cost) implications of these adjustments are often over shadowed in the name of "reducing risk."

The McNamara experience, so emphatically denounced by the Blue Ribbon Defense Panel report, should be sufficient proof that risk is difficult to predict with accuracy. Weapon system acquisition is a risky business. But . . . risk reduction must not be allowed to supplant efficient and rational program progress.

Achieving Program Stability

There are two fundamental decision points in an acquisition/development program . . . first, that the development is going to be undertaken at all, and second, upon successful validation of the concept, that the system is going to be produced. An affirmative answer at the second point must also incur commitment to carrying out the acquisition strategy as presented and approved.

Barring total disaster or reversal of the original decision to proceed that commitment must be sustained.

If cost growth in programs is to be contained that commitment must be sustained at all decision levels, including Congress. Again, the Carlucci initiatives recognized this fundamental requirement with the initiation of the "Stable Program List." (33)

Another essential ingredient necessary to program stability and success is the provision of contingency funds. There is ample evidence to indicate that despite the best laid plans all eventualities cannot be foreseen . . . there must be adequate flexibility in reprogramming authority or budgeting funds (within agreed boundary conditions) to cover the unexpected, maintain program integrity and avoid the costly delays inherent in the multiple layer reviews attendent in today's procedures.

Program Managers today are more monitors than managers. Their range of authority is severely proscribed by outdated reprogramming limits and regulations regarding appropriate use of funds. Recently progress has been made as regards reprogramming and contingency funds are being budgeted in concepts similar to the Army's TRACE system originated by Norm Augustine. (34)

However, more remains to be done inorder to permit Program Managers to truly manage the program. The inhibiting rules associated with the necessity to finance a program through several appropriations should be modified to permit program managers latitude and incentive to manage. After all . . . it is the end product that's sought. Or at least I so believe: rather than deligent, slavish adherence to fiduciary rules. Or is that wrong?

Under existing rules, lines of authority, and procedures, planned program funding can be altered for enumerable reasons. None of these have anything to do with ensuring successful progress of the individual program. Quite the contrary. The incentive for budget reviewers is to reallocate funds made available to other needed purposes. Often this is sound financial management, but just as frequently it creates difficulties for the program manager from which he has a hard time recovering.

Increasing the flexibility in the use of the various appropriations would aid program stability.

Sufficient discretionary latitude and budgetary flexibility must be provided the managers of major acquisition programs if they are to manage effectively. The costs of indecision and approval delays are sizable.

The commitment to a program plan must be at all levels and sustained.
Multi-year procurement and the Stable Program List are positive steps . . . but still more flexibility in the use of funds allocated to a program must be provided the program manager.

Clearly the program manager must be held accountable . . . but he should not be hogtied by budgetary rules that have more to do with Congressional committee organization than sound financial management practices. The checks far outweigh the balances . . . and inefficiency, costly delays are the result.

Acquisition Policy

As noted earlier the milestone (DSARC) acquisition process is understood, logical and well institutionalized. It needs limited embellishment in the way of additional instructions or directives. There are far too many embellishments already . . . and they have accomplished little. What is needed is sound application of basic principles and common sense . . . and that comes from the program management team.

The recent issue of DODD 5000.1 is an adequate document in and of itself. Some changes in emphasis and deletions have been suggested above. The force and effect of DODD 5000.1 can be enhanced if one additional suggestion is adopted.

An essential requirement for successful policy that will stand the test of time is . . . KEEP IT SIMPLE . The original Packard 5000.1 was six pages; the current issue is eleven. Most of the addition has to do with internal OSD staff responsibilities and unnecessary embellishments. The original directive is quite good . . . it could be tightened to four pages without loss of clarity or force.

The next issue of 5000.1 should succincly establish principles for the Services to follow and implement . . . without further enunciation in additional clarifying directives. The OSD staff should ensure the Services carry out the spirit and intent in their implementing directives and in the execution of the programs.

The Defense Acquisition Executive has the requisite cognizance and authority to look out for the interests of the Secretary of Defense as regards material acquisition matters. (35) The Service Secretaries are the line authorities for executing his policies. Ensure that acquisition policy recognizes this fundamental organizational relationship.

In the last 20 years the world has changed significantly. Procedures and concepts must be improved to react to new situations. Management must adjust to new concerns. Time honored schemes of centralized management with large staffs and time consuming coordination cannot function in a rapid changing world of today. They must rely on information flow, exception management, and delegation of responsibility and authority.

The centralized management trend started by Secretary McNamara has clearly not worked. The positive changes initiated by Secretary Carlucci are refreshing. Basic concepts of good management still apply. Lets get on with their implementation.

Summary

This paper has focuses deliberately on the fundamental problems discovered by the several sources cited above. Unfortunately our human tendency is to try and grapple with all the symptoms at once. This has been the major flaw in the several "revisions" made in the acquisition process over the past two decades.

What is really needed is a process with a fundamental characteristic that motivates people. Responsibility, authority and challenge motivate people . . . the acquisition process should give it to them.

Centralization is the fundamental characteristic of todays acquisition procedures. The major flaw in centralization . . . it demotivates people. Program managers and their staffs run the acquisition process . . . they are people. They really want to do a good job . . . and they generally do. But it is in spite of . . . not because of current acquisition and budgetary procedures. The trend toward decentralization has been started . . . it should be completed.

The other aspect of motivation is to provide flexibility in the process and procedures to allow for managers to manage . . . and for innovators to innovate. The results of such an enlightened approach will astound us. There are ample examples in the commercial world . . . why should we think the acquisition enterprise in government will respond differently? Flexibility must be encouraged and tied to a sense of urgency in getting good usable weapons and systems fielded.

If we overlook the "motivation factor" in reforms and improvements in the acquisition process progress will be small. It is time to take a bolder course . . . the Carlucci Initiatives opened the door and paved the way. Lets press on!

Acknowledgement

This paper would not have been possible without the considerable research, suggestions, organizational ability and painstaking editing by Dr. Thomas Varley of the Office of Naval Research. I am greatly in his debt. However, the theme, thrusts, tenor, recommendations and conclusions are solely the authors. They are based on experience gleaned from participation in some of the efforts cited in the paper, authoring acquisition policy and participating in hundreds of reviews of scores of programs, mostly Navy, at the CNO, SECNAV and DSARC levels over the last decade.

REFERENCES

(1) "The Free Enterprise Patroit" by John Rickey, The Book Tree, St. Louis, MO, 1975.

(2) Department of Defense Directive 3200.9 Initiation of Engineering and System Development, 1 July 1965.

(3) Memorandum for the Secretaries of the Military Departments: Establishment of a Defense Systems Acquisition Review Council, 30 May 1969.

(4) ibid.

(5) op. cit. DODD 3200.9.

(6) Report of the Commission on Government Procurement Vol II, Part C, Acquisition of Major Systems, December 1972.

(7) Report to the President and the Secretary of Defense on the Department of Defense Blue Ribbon Defense Panel July 1970.

(8) Appendix F: Staff Report on Operational Test & Evaluation, Blue Ribbon Defense Panel, July 1970.

(9) GAO Report; "Adverse Effects of Large-Scale Production of Major Weapons Before Completion of Development and Testing", 19 November 1970.

(10) Staff Report OT&E, op. cit. page 7.

(11) Department of Defense Directive DODD 5000.1 "Acquisition of Major Defense Systems" 13 July 1971.

(12) op. cit. Commission Report.

(13) Office of Management and Budget Circular No. A-109 "Major Systems Acquisition" 5 April 1976.

(14) For a fuller discussion of this and early history of the acquisition process, see "Maturing of the DOD Acquisition Process" by David Acker; Defense System Management Review, Summer 1980

(15) Defense Science Board 1977 Summer Study - Report of the Acquisition Cycle Task Force, 15 March 1978.

(16) Defense Resource Management Study: A Report Requested by the President and Submitted to the Secretary of Defense, February 1979.

(17) op. cit. Defense Science Board, page 39.

(18) op. cit. Defense Science Board, page 40.

(19) op. cit. Defense Research Management Study, page 31.

(20) Office of the Secretary of Defense: "Improving the Defense Acquisition System and Reducing System Costs." 30 March 1981.

(21) "Just How Good/Bad is the Defense Acquisition Process" by Norman Augustine February 1982 Government Executive.

(22) op. cit. OMB A-109.

(23) Secretary Packard's 30 May 1969 Memo.

(24) Draft Department of Defense Instruction 5000.2 Major System Acquisition Procedures, 5 March 1982.

(25) See Augustine page 27 Government Executive, February 1982.

(26) New DODD 5000.1 issued 29 March 1982.

(27) See para c, Policy, DODD 5000.1.

(28) Deputy Secretary of Defense Memorandum: Management of DoD Planning, Programming and Budgeting System, March 27, 1981.

(29) Report of the Commission on Government Procurement also OMB Circular No. A-109.

(30) Secretary Packard Statement before Military Operations Subcommittee, Committee on Government Operations, House of Representatives, September 22, 1970, pgs. 16-17.

(31) See Section E. Subparagraph (d) OSD Staff Information Requirements.

(32) op. cit. DODI 5000.2 Draft.

(33) Deputy Secretary Carlucci Initiative 4, Increase Program Stability

(34) Total Risk Assessing Cost Estimate (TRACE) Guide, 1 March 1979, Department of the Army Contract # DAAK40-79-C-0034, J. M. Cockerham and Associates.

(34) Department of Defense Instruction. Subject: Defense Acquisition Executive Summary, 18 March 1982.

PRE-PLANNED PRODUCT IMPROVEMENT (P^3I)

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ABSTRACT

This paper is a summary of a Masters Thesis undertaken by the author from June 1980 through September 1981 at the Air Force Institute of Technology, School of Systems and Logistics. The thesis, titled Pre-Planned Product Improvement (P^3I) was an effort to develop policy that might be used by the services as they formally implement P^3I. To accomplish this objective the thesis research focused on three questions that are basic to an understanding of P^3I: (1) What is the nature of the P^3I process in itself? (2) What is the role of P^3I in actual program examples: and (3) How can the inherent uncertainty that accompanies long range improvement planning be successfully managed? Although the answers to these research questions lead to conclusions and recommendations for P^3I policy, P^3I is still in its infancy and only by actual implementation can these policies be verified.

SCOPE

The concept of P^3I could be applied to a broad range of system types since few systems remain unchanged throughout their useful life. Most often modification and change are a necessity if a system is to respond and remain effective to changing user needs. With such a broad range of potential applications, a limited study must narrow focus to a particular category of P^3I. This thesis focused on air-vehicle P^3I applications, choosing as examples the Boeing 727, the Air Launch Cruise Missile (ALCM), and the Air Force F-16. The rationale for choosing air-vehicles lies in the complexity of air-vehicle design. Typically such systems have a very high degree of internal component interaction as well as rigid design constraints. A change in one system component often has a ripple effect to force changes in neighboring components. Pre-planning air-vehicle improvements becomes a difficult task and a test of the effectiveness of P^3I in a worst case environment.

RESEARCH METHODOLOGY

The research was a data gathering activity through document reviews and interviews, structured to answer the three research questions in order. Initial reviews and interviews focused to gain a broad understanding of the P^3I process. Key in this effort was a thorough review of the American Defense Preparedness Association (ADPA) P^3I Seminar & Workshop Proceedings and extensive interviews with seminar attendees. Program managers were also interviewed for their understanding of the P^3I process. Next the research focused on specific P^3I applications: the Boeing 727, which is typical of the P^3I process on-going in the entire family of Boeing commercial aircraft; the ALCM, which presented an example of P^3I in a very constrained system; and the F-16, which introduced a P^3I-type effort after the production go-ahead. Data describing the role of P^3I in these examples was obtained from program documentation and interviews with program managers responsible for the P^3I effort. Once research questions (1) and (2) were answered, the data was again reviewed to understand how long range improvement planning might be successfully managed. For reference, a complete description of documents and interviews used to gather data is presented in the thesis.

FINDINGS - THE NATURE OF P^3I

The ADPA P^3I Seminar & Workshop Proceedings defined P^3I in three parts.

> P^3I is a systematic and orderly acquisition strategy beginning at the systems concept phase to facilitate evolutionary cost effective upgrading of a system throughout the life cycle to enhance readiness, availability, and capability.
>
> The modular baseline configuration design shall permit growth to meet the changing threat and/or take advantage of significant technological and/or operational opportunities through future modifications or product improvements at appropriate time intervals.
>
> The baseline technological risk will be minimized and provide early availability by utilizing well known and established technology to the maximum extent feasible, limiting advanced technology to the subsys-

tem(s) offering substantial operational or cost benefits.

This definition was condensed by Deputy Secretary of Defense Carlucci in his 6 July 81 Memorandum to the Service Secretaries titled, "Improving the Acquisition Process Through Pre-Planned Product Improvements".

> P^3I is an acquisition concept which programs resources to accomplish the orderly and cost effective phased growth or evolution of a system's capability, utility, and operational readiness.

Dr. Hylan B. Lyon, Chairman of the ADPA P^3I Seminar and Workshop described the concept of P^3I within the boundaries of implementation.

> A threat-technical response - a basis for planning the evolution of system requirements.
>
> System partitioning via structured programming - a basis for system design to minimize modification costs.
>
> A program manager's plan for improvements - to be supported by the acquisition system as a basis to direct P^3I.
>
> A funding basis for development and modification - a necessary prerequisite for weapon system improvement.

ADPA, in its P^3I Summary Briefing to the DOD emphasized that P^3I requires three fundamental design features.

> Modular Systems.
>
> Reserve Capacity.
>
> Tight Interface Control.

Finally, the 6 July Carlucci Memo defined objectives of P^3I.

> Shorten the acquisition and deployment time for a new system or an incremental capability.
>
> Reduce overall acquisition and operating and support costs.
>
> Extend useful life of equipment.
>
> Combat military obsolescence.
>
> Reduce technical, cost, and schedule risk.
>
> Accomplish orderly growth from initial to mature system reliability.
>
> Reduce logistics and support problems entailed with new material introduction.

In summary, the thesis of P^3I is that improvements can be incorporated more quickly and efficiently when planned into an initial system design. Further, the average level of technology will be higher throughout the system lifetime if the system is first developed with off-the-shelf technology and then modified with an orderly schedule of planned improvements; rather than, as is now the case, developed with advanced technology and then modified to correct system deficiencies as theyarise. These definitions, descriptions, design features, and objectives provide an overview of the nature of the P^3I process. This nature will become clearer by examining actual P^3I program examples.

THE BOEING 727

The motivation for using a P^3I approach for aircraft design at Boeing began in the Boeing 707 program. To remain competitive Boeing found it necessary to continually improve aircraft capability and performance. However, the cost of improvement quickly outpaced Boeing's profit margins, forcing sales of the improved versions at a loss. Boeing realized that profit margins could be increased to cover improvement costs in the following ways.

> Making large capital investments for modernizing production.
>
> Ordering materials and parts in optimum quantities.
>
> Improving productivity.
>
> Reducing improvement costs by pre-planning later improvements into their production line and aircraft.

Pre-planning improvements permitted the production learning curve to continue downward even though the production line was changed to manufacture an improved model. When Boeing began to design the 727, the P^3I lessons from the 707 were incorporated into the 727 such that provisions for growth were an integral part of the initial 727 design. As a result of this front-end P^3I effort, Boeing could manufacture the 727 on a tailor-to-order basis and satisfy specific customer needs and remain competitive with newer aircraft models. Using the P^3I strategy, not only were 727 improvement costs reduced, but customer demand continued strong in later out years of production because the aircraft remained competitive. Thus, Boeing was able to extract a lengthened return on its initial 727 investment.

DOLLAR SIGN TOOLING - A P^3I EXAMPLE

The concept of dollar sign tooling is an example of P^3I. Dollar sign tooling requires a formal contract between engineering and manufacturing that guarantees that certain surfaces will be maintained for tooling while other specified surfaces will be available for the engineer to change. This permits strength changes with essentially no manufacturing cost impact. As an example, dollar sign tooling specifies that wing chords, webs, and spars can be changed on the manufacturing line without changing their interface with the upper inspar skin of the wing (Figure 1). In other words, these structures can be redesigned and made stronger so that an aircraft can carry higher gross weights, with little change to the wing itself, thereby keeping increases in manufacturing costs low when the wing is strengthened.

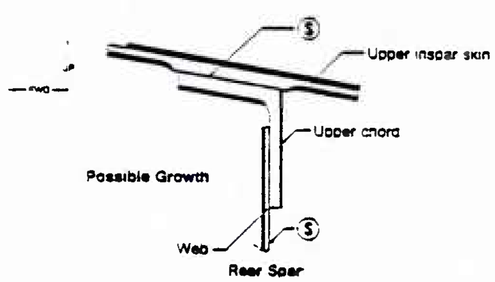

Figure 1

Dollar Sign Tooling

MANAGING IMPROVEMENT UNCERTAINTY

The most significant factor reducing improvement uncertainty in Boeing aircraft programs is recognition that improvements must be preplanned to ensure a long program life. The two are mutually supportive: pre-planned improvement leads to a long program life; a long program life provides the opportunity for continued improvement. However, without pre-planning in both the aircraft and production lines, improvement can be so costly that program cancellation is warranted.

Once it is recognized that improvements must be pre-planned, forecasts of sales, technology, and customer requirements give direction to pre-planning to select improvement candidates. There is naturally a degree of uncertainty in forecasting, but that uncertainty can be reduced by continuously updating future forecasts. Boeing updates sales forecasts as a basis for production planning and remains aware of potential developments of competing aircraft manufacturers that could reduce their sales. Boeing not only updates technology forecasts, but develops and applies technology in their labs. Technical uncertainty is reduced as Boeing labs work closely with design engineers to develop pre-planned improvements. Finally, uncertainty in customer requirements is reduced as Boeing works closely with a world-wide base of customers to evaluate their needs.

The P^3I process must begin early in the conceptual phase of an aircraft program, when these forecasts are evaluated to formulate an improvement plan and select prerequisites to support that plan. Prerequisites are incorporated into the intial aircraft configuration and also the production line so that massive retrofits are not required when older aircraft are improved or a new derivative is manufactured. Since prerequisites are based upon forecasts that are somewhat uncertain, prerequisites that allow for flexibility are emphasized to reduce improvement uncertainty. The concept of dollar sign ($) tooling, for instance, allows for structural strength changes within a wing. Those changes are not restricted to one particular strength, but a range of strengths so that a range of wing improvements can be made. As a similar example, the Boeing 747 was designed with the structural prerequisites to allow the aircraft to be stretched. As it turned out, the 747 was shortened rather than stretched, but those same prerequisites provided the flexibility to either stretch or shorten the aircraft with reduced cost. Thus, prerequisites flexible to allow for a range of improvements reduce improvement uncertainty.

If a prerequisite for improvement is incorporated into an aircraft configuration or production line, there is still the small possibility that a particular prerequisite will never be used. By considering the prerequisite reward/cost comparison, one can further manage improvement uncertainty. For pre-planning with very high uncertainties, it would seem logical to select only those prerequisites with very high reward/cost comparisons. Again using the concept of dollar sign ($) tooling as an example, there is basically little cost associated with holding the dollar sign surfaces constant. Yet there is potential for significant savings in strengthening the wing without changing the production line. Thus, by selecting prerequisites with very high reward/cost comparisons there is potential for large improvement savings with little extra cost, even when improvement is very uncertain. Further, Boeing has found that in the long range the aggregate that a prerequisite will reduce improvement costs increases significantly.

Finally, improvement uncertainty can be reduced if the P^3I process itself can be made more efficient, reducing the extra cost associated with pre-planning and thereby increasing the reward/cost comparison. Boeing's P^3I process is made more efficient because: (1) P^3I receives the support of Boeing's development/production system; (2) P^3I is an in-place and on-going process; and (3) Boeing has a continuity of 25 years of aircraft P^3I experience. Their current emphasis, CAD/CAM, has the potential to markedly increase pre-planning efficiency by allowing improvement design and testing via computer before improvements are incorporated in the aircraft.

In summary, the Boeing 727 program illustrates how Boeing used the P^3I strategy to manage long range improvement uncertainty. By continuously updating future sales, technology, and customer requirement forecasts; by selecting prerequisites that offer wide flexibility and a high reward/cost comparison, and by achieving efficiency in the P^3I process, there is reduced chance that prerequisites for improvement will not contribute to a long program life and reduce improvement costs.

THE AIR LAUNCH CRUISE MISSILE

The ALCM was designed within a strict set of engineering and performance specifications. The missile presented a major challenge to integrate a variety of components i.e., the guidance system, engine, fuel, and ordnance, into a very compact body. Provisions for growth, such as empty space, extra electronics, or extra fuel capacity was very limited. These conditions appeared to make ALCM a poor P^3I candidate. Further, if Boeing had overtly planned for growth in ALCM with extra hardware that did not directly contribute to ALCM's immediate mission, USAF would have rejected such hardware as "gold plating", diminishing Boeing's chance for contract award.

Even with such strict engineering and performmance constraints, Boeing wanted to design ALCM to increase its chances for a long program life, thereby giving Boeing a greater return on its ALCM investment. Boeing reasoned if ALCM was designed to accommodate a variety of possible missions then USAF, other services, and perhaps even NATO countries might purchase ALCM and ALCM derivatives for many years to come. A P^3I design was needed to give ALCM that mission flexibility.

In the original ALCM proposal, USAF requested a missile with a 1000 nautical mile range. ALCM managers at Boeing reasoned that if the missile was to be deployed for rough terrain following and evasive side maneuvers, the 1000 nautical mile range would need to be extended by at least 30%. Also, another missile, the Tomahawk, already had a longer range and if ALCM was to be used for other missions its range should be extended to compete with the Tomahawk. Finally, new aircraft have historically been improved by extending range, and Boeing believed that ALCM would evolve similarly. Boeing reasoned that the only way to extend range (holding other mission parameters constant) would be to increase fuel capacity, which would require lengthening ALCM. Boeing could not simply attach an additional six or eight feet to the back of the missile; the basic structure would require redeisgn with possibly different strengths, support, and a different internal configuration. Using the P^3I strategy, Boeing designed the original ALCM as if it was to be later stretched into a longer version with increased fuel capacity for extended range. Thus, when the go-ahead was given to manufacture ALCM in a stretched version, redesign would be minimized.

Boeing correctly perceived the requirement to lengthen ALCM. USAF changed its ALCM proposal to extend range, which resulted in a definite advantage for Boeing, who was able to minimize cost and schedule impact for the change in design. The ALCM contract was eventually awarded to Boeing.

Another P^3I example concerns the ALCM nose cone. If a missile is to have a good change to reach its target, it must avoid detection by enemy radar. Radar avoidance can be increased if the missile nose has a very low radar reflectivity. A traditional method to achieve low radar reflectivity is to design a soft nose that will absorb radar waves rather than reflect them. However, a soft nose is very expensive to manufacture. To keep costs down, Boeing wanted to put a hard nose on ALCM. Also, a hard nose is less vulnerable to any debris in the air, especially at very high speeds. A hard nose could be used only if it could be shaped to minimize radar reflectivity; Boeing set out to shape such a hard nose. Boeing found that the shape of the nose dictated the circumference of the missile, which in turn constrained the internal configuration of the missile. Using the P^3I strategy, Boeing pre-planned the shape of the missile and its internal configuration to interface with the shape of a hard nose, confident that one day the hard nose would be fully developed, tested, and attached to ALCM. To win the contract award, Boeing placed a soft nose on ALCM in order to demonstrate that ALCM can be produced now, using a soft nose with low reflectivity. Thus, by using the P^3I strategy, Boeing will not have to redesign ALCM's shape and internal configuration when the hard nose is attached.

Another P^3I example is illustrated by the small wings on ALCM, called elevons. Current elevons are shaped to give ALCM specific flight characteristics at current mission speeds and altitudes. If the ALCM mission changes, the elevons will likely be redesigned to fit each particular mission. For example, an extended range and low speed mission would require larger elevons with more lift, and a high speed mission would require smaller, tapered elevons with less drag. To give ALCM this flexibility in terms of elevons, Boeing fastened the elevons to ALCM using eight accessible bolts, rather than permanently bonding the elevons so that they could never be changed. This elevon design will help to minimize production line change when manufacturing ALCM derivatives.

As another example of P^3I, Boeing considered that if ALCM was used in a mission requiring a higher speed, the air intake for the engine would require a lower throat mach number to prevent compressor stalls. Historically, as other jet engines have improved and evolved, their speed has increased and their air intakes modified to allow for higher speeds. Boeing designed the ALCM air intake with a low throat mach number, so that when ALCM is employed in higher speed missions, the air intake will not require modification.

As a continued improvement effort, Boeing developed an engine replacement for ALCM which increases thrust 57% over the present engine. The new engine is designed to simply "drop in" the present ALCM engine compartment, with no other changes to the missile.

Other P^3I examples include the fact that ALCM was required to be carried on the B-52, but Boeing also designed ALCM to be carried on the B-1. Finally, Boeing was able to reserve a small amount of free space for incorporation of future electronic countermeasure components.

MANAGING IMPROVEMENT UNCERTAINTY

Boeing's experience with ALCM, P^3I, and improvement uncertainty is similar to the 727 example, but there are differences. As in the 727, Boeing recognized that pre-planning in the initial ALCM design was required to give ALCM the potential for a long program life. Yet Boeing had very little knowledge of DOD threat and mission forecasts to pre-plan improvements; instead, they relied upon historical aircraft trends and their best estimates of potential ALCM missions. Boeing was well aware of technology forecasts, and planned ALCM derivatives by developing and applying new technology, thus even with limited opportunity for P^3I, Boeing was still able to design ALCM with some flexibility and reduce improvement uncertainty.

The risk of any improvement cancellation, as in other aircraft programs, is not significant when viewed in the long term and not justification to neglect pre-planning. There is more risk of program failure if pre-planning is neglected. The potential reward of reduced improvement cost and a long program life make P^3I a perceived necessity for Boeing's profitability. The cost of ALCM pre-planning was low, in part, because pre-planning was limited. Thus, the reward/cost ratio for improvement pre-planning is potentially very high, which further justifies pre-planning when there is great uncertainty. Other factors, such as Boeing's development/production system, the in-place and on-going P^3I process, and Boeing's continuity of P^3I experience help to make P^3I more efficient and reduce the cost of pre-planning, thereby increasing the potential reward/cost comparison. Finally, CAD was used to shape the nose of ALCM, which also contributed to design efficiency. These findings, taken together, illustrate how Boeing used the P^3I strategy to manage long range uncertainty in a program with a very limited potential for P^3I and with a limited knowledge of future requirements.

THE AIR FORCE F-16

The F-16 was originally developed as a simple, lightweight, fighter aircraft with air-to-air and air-to-surface weapon delivery capability for the Air Forces of the United States, Belgium, Denmark, The Netherlands, and Norway. The F-16 offers good performance, reliability, and maintainability at a cost that is less, compared with other USAF fighter aircraft. Performance advantages are made possible, in part, because the aircraft is simple and lightweight. Extra provisions for aircraft growth to meet new mission requirements were not deemed compatible with the initial F-16 concept.

The F-16 was developed to play a major role in tactical warfare in a NATO-Warsaw Pact confrontation. As the Soviets continue to increase the sophistication of their weapons, the Warsaw Pact threat has become reason to upgrade the capabilities of the F-16. In response, tactical force planners have identified key mission needs as: (1) Day Precision Strike; (2) Night and In-Weather Attack; (3) Low-Level In-Weather Penetration; and (4) Beyond-Visual-Range Air-to-Air Intercept.

In response to these mission needs, TAC and NATO decided that avionics and other system improvements now in development might have a potential home in the F-16. These improvements would not be fully developed and operational until the late 1980s and would be added to the aircraft as modifications. These improvements are:

Advanced Medium Range Air-to-Air Missile (AMRAAM) - a beyond visual range radar guided missile.

Airborne Self Protection Jammer (ASPJ) - an active internal electronic countermeasures system.

Global Positioning System (GPS) - a satellite based navigation system used to determine vehicle position and velocity with extreme accuracy.

Joint Tactical Information Distribution System (JTIDS) - a battlefield information display network.

Low Altitude Navigation and Targeting Infrared for Night (LANTIRN) System - an all weather laser-augmented navigation, target acquisition, and weapons delivery system.

SEEK TALK Radio System - a jam resistant and secure UHF radio system.

30MM Gun Pod - an anti-armor capability for TAC aircraft.

It will be no simple task to integrate one or more of these improvements into the F-16 when they are finally developed. The cost of the after-the-fact modification is extremely high, and in fact prohibitive, because the aircraft would be dismantled and retrofitted to accommodate each improvement.

Early in the production program the F-16 System Program Office (SPO) recognized the magnitude of problems that would result if these F-16 improvements were managed according to standard USAF modification procedures; they would create an engineering and financial nightmare. Therefore, the F-16 SPO broke with standard modification management procedures and directed a group of SPO officers to plan and provide for an orderly approach to accommodate growth into the total weapon system. The SPO received USAF support in this effort, as the Vice Commanders of AFLC, AFSC, and TAC had urged the SPO to develop and implement a master modification plan. The basis of the plan was to first incorporate improvement prerequisites and later improvement subsystems into the aircraft on the production line so that the F-16 could accommodate final improvements without massive retrofit. The plan was formulated as the F-16 Multinational Stated Improvement Plan (MSIP). It was multinational, since it would accommodate major mission improvements for all countries buying the aircraft. It was staged to reflect efficient weapon system evolution and management of improvement uncertainty. To understand how MSIP proposed to accomplish these tasks, it is instructive to review the three stages of MSIP.

Stage I began in November 1981 adding early structure and wiring. The decision to incorporate early structure and wiring provisions for MSIP improvements was made with the greatest amount of uncertainty in Stage I, since this stage was furthest removed in time from incorporating the ultimate improvements. MSIP managers attempted to solve this uncertainty in Stage I by pre-planning for flexibility. Prerequisites chosen to reduce the cost of modification had to be applicable to the widest range of possible improvements. Also, since no extra funding was available, prerequisites had to have a very high reward/cost comparison to justify freeing dollars from other funds. Stage I prerequisites are very basic, adding no extra performance capability to the aircraft, but making it possible to add improvements without massive retrofitting. For example, to add AMRAAM without Stage I prerequisites, aircraft wings would need to be removed from the aircraft and completely retrofitted. Five to seven wing spars would be replaced, the slats and flaps removed, and the wing reskinned. The cost of this retrofit for one wing is more than the cost of Stage I prerequisites for the entire aircraft, which is comparatively low, adding about $130,000 to each aircraft's pricetag for an increase of only 1.25% of total aircraft cost. Stage I prerequisites are summarized as follows:

Wing structure and wiring provisions for beyond visual range air-to-air missiles.

Engine inlet structure and wiring provisions for various electro-optical and target acquisition pod systems.

Cockpit structure and wiring provisions for a wide field of view raster head up display, multifunction display set, data transfer unit and Up Front Communications/Navigation/Identification.

Wiring provisions for an expanded capacity fire control computer, advanced weapons central interface unit, radar altimeter.

Early structure and wiring provisions for internal ECM systems.

Increased capacity environmental control system.

Stage I is further defined by ECP 0425, which increases the size of the horizontal tail for increased maneuverability when pods or other armament are attached to the aircraft.

Stage II builds upon Stage I by adding subsystems that support final MSIP improvements. Stage II begins in July 1984, but the prerequisites of Stage I will continue to be added along with these subsystems. Since Stage II is closer in time to the final improvements, there is more certainty of actual improvements. Also, these subsystems will contribute to improve aircraft capability in themselves, ensuring changes necessary to maintain single pilot operability in high task/threat situations through up front controls and displays. Stage II subsystem changes are as follows:

Increased capacity Fire Control Computer (FCC).

Advanced Central Interface Unit (ACIU) for multiple weapons handling and launch.

Multifunction Display set (MFD) and software programmable display generator to replace the current stores control panel and radar symbol generator.

Programmable Signal Processor (PSP) for improving the APG-66 radar.

Dual Mode Transmitter (DMT) for improving the APG-66 radar.

Radar Altimeter (RA).

Data Transfer Unit (DTU).

Up Front Communications/Navigation/Identification (UFCNI).

Wide angle Heads Up Display (HUD) for LANTIRN.

Improved Environmental Cooling System (ECS) turbine assembly to provide added cooling capability.

Many of these subsystems are prerequisites for more than one improvement.

Like Stage I, Stage II will continue for the production life of the aircraft. Aircraft delivered between November 1981 and July 1984, without Stage II subsystems, will need to be retrofitted for these subsystems. However, the cost of retrofit will not be high since prerequisites for these subsystems were included in Stage I.

Stage III begins as actual growth system improvements are incorporated on the production line to meet new mission requirements i.e., AMRAAM, GPS, LANTIRM, etc. Operational aircraft can be improved usually with only a few changes in switches and plugs.

MANAGING IMPROVEMENT UNCERTAINTY

The SPO selected for Stage I those prerequisites that offered the most substantial savings for improvement, and were relatively inexpensive i.e., with a high reward/cost comparison. If the targeted improvements are never incorporated, little will be lost. However, Stage I prerequisites offer tremendous flexibility because they are so basic to any future F-16 improvement effort. General Alton Slay briefed the ADPA P^3I Seminar & Workshops that after 10 years of service the F-16 will likely have more derivatives than the F-4, which has 19. Thus, there is little change that Stage I prerequisites will not contribute towards reducing MSIP improvement costs, even if some planned improvements are cancelled, because there is a great chance that other improvements will use these same prerequisites. In this respect, prerequisites that are very basic to future improvements have an inherent flexibility that allows for a range of improvement candidates, and reduces improvement uncertainty.

Stage II subsystems will be incorporated nearer to the time when actual improvements are fully developed and funded for modification, therefore, by MSIP design, there is a much higher degree of certainty that Stage II subsystems will be useful. Also, since many subsystems support more than one improvement, there is little chance that a subsystem by itself will never be used.

The F-16 Program Office emphasized that an important thought process occurred in formulating MSIP. As improvements were conceptually added to the F-16 one-by-one, General Dynamics engineers and SPO managers had to continually question what aircraft interfaces were affected. Anticipating problems as each improvement was conceptually added was an on-going effort behind MSIP. In this way, subsystem interaction problems were recognized, and those prerequisites and subsystems fundamental to a variety of improvements identified. Prerequisite flexibility, as applicable to a variety of improvements, prerequisite reward/cost comparison, and time phasing of prerequisites and subsystems in Stage I and II were the key tools used to manage improvement uncertainty.

CONCLUSIONS ON THE NATURE OF P^3I

P^3I has already been applied, in varying degrees, to commercial and military programs. These applications were not always integrated into a formal plan but do carry many of the seeds of a P^3I appraoch.

Complex P^3I applications require a structured program architecture.

The sum of all P^3I application to complex systems is, de facto, evolving a discipline and structure to the P^3I process.

CONCLUSIONS ON MANAGING IMPROVEMENT UNCERTAINTY

Threat, technology, and mission requirements forecasts are the basic means to manage improvement uncertainty.

Appropriate use of P^3I prerequisites in initial design can actually serve to decrease improvement uncertainty.

Long range improvement uncertainty is manageable and not fatal to P^3I.

GENERAL CONCLUSIONS

P^3I is a strategy which improves a contractors probability of making a profit. It is not a necessary requirement that P^3I be subsidized by the government.

Even more important than government development and control of a sophisticated P^3I system is the requirement for government to not inhibit P^3I use by contractors. Several government perspectives and policies currently inhibit P^3I.

The potential pay-offs in P^3I for manufacturing, tooling, processing, and facilities savings are great and should not be ignored.

RECOMMENDATIONS

Link industry planning with DOD forecasts of threat, technology, and mission requirements.

Link government/industry labs with P^3I programs to develop planned improvements.

Expand life cycle cost evaluations to include the savings from reduced improvement costs.

Educate acquisition managers to the P^3I process.

Conclusions and recommendations are discussed in detail in the thesis. A copy may be obtained from the Defense Technical Information Center, reference #ADA 110971 or by writing the author.

PANEL E

NEW PROCUREMENT TECHNIQUES

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AUTOMATION AND IMPROVEMENTS IN CONTRACTING TECHNIQUES

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Increasing Productivity and Professionalism in Government Contracting

The Directorate of Contracting and Manufacturing at Hill AFB, Ut is an Air Logistics Center. We process over 48,000 contractual documents a year for both Central and Base Contracting. Central Contracting supports weapon systems such as the Minute Man and MX missiles, the F-4 Aircraft and the F-16 Aircraft among others. The Directorate employs approximately 500 people and processes purchases of $1.6 billion.

Productivity increase, in the professional field of Government Contracting has, at times, been a slippery and elusive goal. Capital investment in the white collar area has been negligible. In the recent past, however, new techniques have caused a dramatic increase in productivity in Contracting at Hill AFB. New Techniques, equipment or processes may be partially successful. They will be wholly successful only if they are designed from the functional user or Buyer/PCO viewpoint. Some of the successful steps taken in the Directorate of Contracting and Manufacturing at Hill AFB, Utah are:

AUTOMATED CONTRACT PREPARATION SYSTEM (ACPS):

Before we talk about ACPS, I'd like to distinguish between a classic administrative word processing system and an ACPS: Word Processing is used, in the classic sense, to create office requirements such as reports, letters, regulations and other office correspondence. The ACPS produces contracts and contractually related products only. Although ACPS is capable of functioning as a word processor, it is much more streamlined. The ACPS produces 40 to 50 page contractual documents with less operator involvement than would be required for a short one-page letter. Some major documents can be produced with as little as ten key strokes.

The ACPS is composed of two distinct and necessary concepts: First is the equipment and related software. The ACPS equipment is highly sophisticated and capable of modular expansion. The software, of course, is the main driving force and is at the latest state-of-theart. Our software maintenance contract requires the contractor to update the ACPS software quarterly. The second aspect of ACPS is the system. By System, I mean the forms, procedures and techniques employed to enhance the production of contracts. The equipment and software would work without the system as the system would work without the equipment and software. Together, they produce a sophisticated and streamlined method of producing contracts, solicitations, and contractually related documents.

Until the ACPS was implemented, we expended a major portion of our efforts first in creating our documents. The Buyer/PCO had over 200 pages of forms and rough drafts that had to be completed to obtain the many types of documents issued. These forms were for Firm-Fixed-Priced documents only. A cost reimbursement or time and material contract had to be constructed from scratch. The buyer individually selected each clause. For example there are over 150 possible General Provisions which could be in a contractual FFP document. If the buyer had Data in a document, each of the 20 possible Data clauses had to be individually selected or rejected. The clerk that physically prepared the document had to type a major portion of the document, use cut sheets wherever possible, and tape and paste the document together. A standard Request for Proposal (RFP) took a buyer sixty to ninety minutes to draft and involved three and a half to four hours to prepare. Ten to fifteen days was an average turnaround time.

As previously stated, the software must be compatible. If a solicitation is numbered "82-R-9999", that is the title or name it should have in machine storage. Or a clause numbered "H-1" on documents should be stored as H-1 in the machine as well as in the documents.

Some software on the market will not allow this flexibility. The software assigns predetermined alpha-/numeric designations to anything created. This works well for letters and miscellaneous documents, but destroys flexibility and would cause a complex manual tracking system in an ACPS operation.

The system, again, was designed from the users viewpoint. The Buyer now has a one-page form which replaces the 200 plus forms previously used. The Buyers can obtain an IFB, RFP, Basic Ordering Agreement Order, Letter Contract, Bilateral Contract, Award, etc. all on this one-page form. Any type of pricing arrangement from Firm-Fixed-Price to Cost-PlusAward-Fee can be obtained. The key to the form is that the Buyer is asked to describe his acquisition rather than select individual clauses.

To accomplish this, clauses are arranged in logical decision groupings rather than strict DAR sequence. For example, all negotiated documents require certain clauses. If the Buyer is accomplishing a negotiated document, necessary clauses are given automatically. If the Buyer checks that work on a Government installation is required as part of the acquisition, all clauses required by that circumstance are included.

The system includes a dictionary and math program. All documents are checked for spelling or typographical errors before release. Also, the system accomplishes all math functions for the buyer.

All data on the system is kept under strict and orderly control. New clauses proposed by a Buyer or Contractor are reviewed by legal and the Contracts Committee before being added to the system. This effectively adds quality assurance to the system and review processes. It also stops duplicative document creation because of clause problems. All clauses are identified to their origin (e.g. "IAW AFLC DAR Sup 2-501.3(a)").

The user is kept apprised of all new or changed requirements. A "Buyer-Gram" is issued immediately after a change and the buyer receives a quarterly update to the Basic Clause Book (or Buyers Guide) showing all changes which have occurred during the quarter.

Although the system is designed for ease of use by the buyer, who is the ultimate user; it also focuses on ease of use by the clerk who prepares the document. The clerks are trained in document requirements and make minor administrative decisions. The clerks (or operators) become very expert at document construction. All documents are pre-reviewed for quality input before being put on the system.

The ACPS has given many benefits, among which are:

(1) Buyer Preparation time for contractual document has been reduced to an average of ten to thirty minutes.

(2) Turnaround time for documents is an average of 1.3 days

(3) Document preparation personnel have been reduced by six despite a 90% increase in workload.

(4) Documents are more concise, professional and reliable than ever before.

(5) Only information or clauses which pertain are in the document (self-deletion is not used).

(6) Spelling, typographical and math errors have almost been eliminated.

(7) Reviewer's (PCO/Legal/-Contracts Committee) time necessary to review documents has been reduced.

(8) We are more responsive to changes. We can guarantee the Buyers that the documents will be current and complete as of the time processed. This warranty can be made because the system is updated within one-half hour after receipt of a change.

(9) The cost of each document has been dramatically cut in postage, reproduction, storage and other areas.

(10) New trainees are more productive more quickly as the system is easier to understand.

It is estimated that the ACPS and associated techniques save from one and one-half to two million dollars per year at Ogden ALC and we are just in the infancy of what we can do.

BASE CONTRACTING ON ACPS

Base Contracting was put on the ACPS in October 1980. Prior to being added, many documents were considered too complex, too specialized or too cumbersome to automate.

However, research of the Regulations indicated that any document created in Base Contracting could be automated in much the same way as Central Contracting. For example, a construction document took the Buyer three to four hours to draft and eight to ten hours to prepare. Using logical decision grouping it was discovered that there were very few choices a buyer had to make concerning the creation of the construction document.

The Buyer now uses a 5" x 8" form for all construction documents. The document takes two to three minutes to complete and eight minutes to prepare and print. The same rationale also applies to other areas of Base Contracting (e.g. Mortuary Services, Packing & Crating, Food Services, etc).

The same benefits attributable to the ACPS operation, above, have been realized by Base Contracting. Additionally, Base Contractual documents are now standardized and compatible with Central documents and do not require any special research or handling.

MICROFICHE TECHNIQUE

The Microfiche technique was instituted as a test to assess possible benefits. The benefits were to be derived with the least possible disruption to the contracting process and inconvenience to contractors and field activities.

The benefits we were seeking, for the contractors and Government were lowered costs, reduced handling and review of documents, and an easily understood format. Additionally, we wanted to provide the full-text of Defense Acquisition Regulation (DAR) clauses which by regulation are incorporated in our documents by reference. Although many DOD contractors subscribe to the Regulation and therefore have access to the text of these referenced clauses, many more do not. The microfiche technique was designed to give all contractors equal access to the full-text of the DAR.

MICROFICHE PROCEDURE

Documents utilizing the Microfiche technique incorporate clauses by a one or two line reference. The reference contains the provision number (e.g. H-1); the clause title; any regulatory reference number (e.g. 7-104.13) and the frame number on which the full-text of the clause can be found. This system is used for those clauses which normally are set forth in fulltext in contractual documents and for those which normally are set forth by reference.

Provisions which require a completion or a "blank" fill-in by the Government are set forth as stated above with the following added language: "The (blanks or information) required by the above provision are as follows:" The fill-ins are identified, if more than one, as to paragraph or other specific identification.

Provisions which require contractor completion are also set forth as above and contractor required fill-ins are stated beneath the clause. For example, the small business certification appears as follows:

"K-1. SMALL BUSINESS

HE IS (___) HE IS NOT (___)
WILL (___) WILL NOT (___)
(FRAME #558)"

Any clauses which were specific to certain programs or contractors (e.g. controverted cost clauses) were not put on microfiche. Clauses of this nature are printed out in full-text on the individual document.

Document preparation by the Automated Contract Preparation System (ACPS) was altered very little. All provisions and files used for document preparation in the "normal" or full--text mode were left untouched. Each was duplicated and altered to the Microfiche technique. Each file or clause used for microfiche documents was named the same as the "normal" clause except an "F" (for fiche) was added to the name. This allowed minimal adjustment by the ACPS operators. Documents were created exactly as in normal mode with only the "F" addition. For example, if provision H-1 was needed in "normal" mode the operator typed "H1." In fiche mode, the operator typed "FH1." Any updates were and are made to both sets of files, thus ensuring currency in each mode of operation.

MICROFILM PROCEDURES

The Microfiche Was prepared from actual pages of the Defense Acquisition Regulation, AF DAR Supplement, and AFLC DAR Supplement. Other regulatory clauses, the AFLC Model Contract clauses, and selected local clauses (photographed from print-outs from the ACPS).

Because the Ogden ALC Microfilm Section (DARM) does not have photographic capabilities, the actual creation of a "silver master" was contracted to a local firm. The cost was $29.94 for 582 pages of "hard-copy" to be put on the silver master. This process was repeated one time during the test period due to the loss of an original silver master. Average turn around by the contractor was seven days.

After the silver master was received, it was turned over to DARM for copying. Because of the high volume, the copying process was used to fill any slack periods in the DARM workload. The fiche copies were created on all three shifts and mailed to contract distribution (PMDAD) on a weekly basis.

The 582 pages or frames were first copied at a 48X reduction on three fiche. This size caused the most contractor complaints. Therefore, two months into the test, we doubled the size to 24X. Although this size increased the number of fiche to six and doubled the costs from $.09 per set to $.18 per set, it effectively stopped most complaints as to readability and legibility. The 24X size is large enough to be read by an aperture card reader. Once received in PMDAD, one set of fiche was attached to each copy of the RFP, IFB and all contracts, including letter contracts.

UPDATING

During the test period many provisions were changed, deleted updated, or added. The Microfiche was not changed. Updates to documents were accomplished in two fashions: If the change resulted from a DAR update or change, the provision was incorporated directly from the DAR, by reference, without reference to the Microfiche. If the change resulted from some other source, the provision was printed in full-text in the hard-copy contractual document.

Because of the gradual "creep" of full-text provisions into written documents, the average size also increased, but still stayed in the cost effective range. For example, the average size of a solicitation document at the beginning of the test was 46 pages without Microfiche and 11 pages with Microfiche. At the end of the test period, these figures had increased by six pages to 52 and 17 respectively.

All changes accomplished during the year were "instantaneous." That is, within one-half hour after a change was received by receipt of a DAC, AFAC or other means, the updated material was on ACPS and being incorporated in our documents. The buyers were notified of all changes within one day by use of a "BuyerGram." In this manner, our documents, whether utilizing Microfiche or a Basic Ordering Agreement (BOA) order, were and are always current as of the date and time the document is processed through ACPS. This, again, is a guarantee that we make to our buyers.

RESPONSES TO TEST

All the documents issued using the Microfiche have a prominent notice in bold type explaining the test and asking for opinions on the test be forwarded to the OPR of the test.

FIELD ACTIVITIES

Response from field activities were minimal and none in writing. We received three phone calls from three different DCASMAs. All three requested we stop sending a copy of the fiche with each document. The consensus was that after an initial distribution was made, they had all the fiche necessary and additional copies were unnecessary. An ACO from DCASMA Los Angeles, stated that the fiche was very helpful to the small businesses whose contracts he administered.

CONTRACTOR RESPONSES:

Contractor's letters were varied. From the thousands of copies of documents issued we received 126 responses. Because of the small response, we sent a questionnaire seeking additional input. We issued 500 questionnaires at random and received 92 answers. The majority of contractor's letters received prior to the questionnaire were negative. The questionnaire, however, revealed opinions which were strongly positive. The results of each are categorized below:

Letters
- No Fiche Readers-41
- Disapprove of Technique-26
- Strongly oppose technique-20
- Fiche ok but prefer "Master Solicitation"-14
- Approve of the Technique-15
- Strongly favor Technique-6
- Neutral (already subscribe to DAR)-4

Questionnaires
Microfiche was:
- Acceptable-30
- Acceptable & usable-11
- Usable-2
- Acceptable & usable but not preferred-8
- Prefer the Master Solicitation-28
- Unacceptable-9
- Other comments-4

It should be noted that the technique was used in both Central and Base Contracting. Therefore it covered a broad spectrum, from very large to very small concerns.

From our sampling of the letters it appears that the large contractors already had the DAR and felt the technique was unnecessary. The major complaint by small contractors appeared to be the lack of a reader or the inconvenience of using one.

We believe that the very small number of letters received from contractors using microfiche documents plus the majority of questionnaire respondents who found the technique acceptable and/or usable, proves that it can be used and causes few problems for most contractors.

PROBLEMS ENCOUNTERED

The problems which occurred during the test were minor in nature. We had no protests nor cases of contractors being found non-responsive as a result of the Microfiche Test.

The other minor problems we had were:

(1) Four months into the test, a Microfilm Operator inadvertently damaged one of the silver masters. We had to contract out for another set, but then ordered extra to assure we had backup.

(2) Some contractors told us they could not function without the full-text of some of our local clauses. In those cases, because of the contractor's viewer problems, we sent a hard copy of local clauses.

(3) As previously stated, the test was started with a fiche reduction of 48X. It wasn't long before we discovered that this was too small for most viewers owned by contractors. Within two months, we doubled the size to 24X.

BENEFITS

We have found benefits over and above those anticipated when we started the test. The tangible cost avoidance we experienced was approximately $535,000. Reproduction represents $260,811 of the total and postage the remaining $274,075. Many benefits not easily reduced to dollar savings were:

(1) Documents utilizing the fiche technique process through ACPS machine preparation over 50% faster.

(2) We can hold up to 1,000 more documents "on-line" due to the smaller size. On-line, in this case, means we can hold documents in current magnetic storage longer.

(3) We can go up to 45 days longer before creating history tapes of our documents. The history tapes will hold approximately 1200 documents, whereas with full-text documents 500 to 600 documents are the limit.

(4) Buyers, Legal, the PCO and Contracts Committee review are shortened and more streamlined due to the compact size of the document.

(5) We have found in talking to various contractors, that having the fiche is a definite advantage for those contractors who do not subscribe to the regulation. They can read <u>all</u> provisions of the contractual document.

(6) Future problems or questions which arise may be more readily handled. For example, should a contractor submit a Value Engineering Change Proposal two or three years after a contract is issued, there is no necessity to search the old regulations for the full-text clause that applied to that contract. The clause that applied is attached to all copies of the contract on the Microfiche.

RECOMMENDATIONS

The test has been completed and the Microfiche Technique is being continued. A technique such as the Microfiche is essential to reduce costs and increase the productivity of our people. When the fiche is adopted commandwide, we have made the following recommendations to Headquarters AFLC:

(1) Issue one set of fiche once per year. The updates do not cause such growth that they cannot be made in the hard-copy document. Also, tracking is better and the fiche can have the calendar or fiscal year to which they apply printed at the top of each one.

(2) After initial distribution of fiche to field activities, do not send more unless they are requested. Otherwise we add to the cost, and burden the field with more fiche than they can use.

(3) The fiche should be no smaller than 24X. This appears to be the optimum size for readability and cost savings.

(4) State in the written document the exact identification of the attached fiche, the importance of the fiche and explanation as to how the fiche and clause provisions are cross referenced.

CONTRACT QUALITY REVIEW

The contracting process requires that contractual instruments issued by the Government be of the highest possible accuracy and quality. The Government cannot afford to issue inaccurate, sloppy, or ambiguous contracts. To do so would weaken the support of the weapon system, cause unnecessary litigation, and raise the cost of the contracting process.

To assure that Air Force contracts are legal, clear, and concise and that fair and reasonable prices are obtained, the Contracts Committee at Ogden Air Logistics Center reviews all contractual documents over $500,000 prior to award and samples documents under $500,000 on a post award basis. The contracts committee is composed of highly skilled and experienced people. They have a broad base of knowledge and expertise in the Contracting & Logistics field.

When Committee members reviewed contractual documents, a great deal of their time was spent recording and preparing their comments for the buyer. In addition, the comments made by different members of the Committee on the same subject matter often differed in content and context based upon their various backgrounds. Some comments were made without giving regulatory references causing the buyer to believe that they were simply recommendations. Finally, an inordinate amount of time was spent each month manually compiling the review comments for statistical reporting to the Directorate.

To solve some of these areas of concern, the repetitive comments were standardized (so that each member of the Committee made the same comments about the same subject matter) and loaded into the Administrative Word Processing Center (WPC) (so that the analysts could phone their review in and recall a specific comment by a single alpha/numeric character). One of the Committee members created a reference book of standard repetitive comments covering all areas of contracting (e.g., clauses, levels of approval, determinations and findings, etc.) and giving the regulatory requirement of each comment. A one-page worksheet was developed for the analyst to "record" the comments.
A great many benefits have been and are expected to be derived from this procedure:

(1) All comments are standardized without "flavoring" by the individual analyst.

(2) The analyst's and WPC operator's time is more effectively utilized because they are not writing out and typing repetitive comments over and over, but simply recalling them from machine memory by use of a single character.

(3) All comments made by the Committee give a regulatory reference.

(4) The WPC equipment compiles on demand a statistical report which formerly took two to three days to assemble.

(5) Transferring the recording of comments from the Contracts Committee clerk to the WPC assures that there is always an operator available, whereas formerly, recording of comments could be delayed by the absence of the Committee clerk.

(6) Time formerly devoted to recording and compiling comments and reports can now be devoted to giving more in-depth analysis and identification of trends.

(7) The use of the procedure has allowed the development of contract quality standards to measure the Directorate performance.

AUTOMATED ADMINISTRATIVE COMMITMENT DOCUMENTS (ACDs):

When buyers requested commitment of funds for a contract, they copied (by hand) the fund citations from the purchase request onto a draft AFLC Form 49. The form was then typed (or in some cases the hand--written form was used) and forwarded to Accounting and Finance for Commitment. Besides being a time consuming task; many errors were encountered due to the detail of Fund Citations.

To counter this situation, the buyer has been offered two other ways to obtain an ACD, through the use of the ACPS or the Word Processing Center. In both cases, all fund citations were loaded in the systems and verified by accounting.

Using the ACPS, the buyer has three choices: (1) He/she can obtain an ACD with the solicitation; (2) he/she can obtain an ACD with the contract or (3) he/she can obtain an ACD only. In the first two instances the ACPS is programmed to copy all ACD information from the contractual document. In the latter instance, the ACPS operator obtains the necessary information from a copy of the Purchase Request and the programmed fund cites. If an ACD is created with the solicitation, the contract number, contractor and dollar amount are left blank for later fill-in by the buyer before forwarding. In the case of an ACD created with the contract or an ACD only, the ACPS verifies all mathematical computations automatically. The only action required by the buyer is to check that an ACD is required.

Using the Word Processing Center, the buyer refers to a list of all of all possible fund citations segregated by type (e.g. FMS, Missiles, Aircraft, etc). To create an ACD, the buyer dictates one character alpha/numeric codes to a recording device in the WPC. This dictation will obtain complete ACD's including entire fund citations for fund commitment.

Whether using the ACPS or the WPC to create the ACD, although the ACPS is the easier of the two, the buyer is relieved of tedious, time consuming and mundane effort. In return he or she receives an error free document which increases the productivity of the buyer, the clerk and the funds certification officer.

BOA REVIEW PROGRAM

Basic Ordering Agreement (BOAs) are documents used to facilitate the Government Contracting process. The BOA is an agreement on clauses, terms and conditions pre positioned with a contractor. Orders incorporating such terms, conditions and clauses may then be issued without specific negotiations on matter covered by the BOA.

Unfortunately, the rapid changes in laws, regulations and executive orders soon rend a BOA out-ofdate. Therefore, each time an order is issued, the buyer is required to review the BOA and include in the order necessary updates, deletions, incorporations or additions required by Public Law, Executive Orders or by action of the BOA itself. This review process is heightened because the PCO, legal and contracts committee have review responsibility in addition to the buyer.

To counter this repetitive review process, the BOA review program was established. The BOA is reviewed one-time, by a member of the Contracts Committee. A one-page review sheet is issued to all buying sections and to the BOA file. The review sheet contains all pertinent information on the BOA in capsule form. For example the sheet shows clauses which must be updated, deleted, incorporated or added and the circumstances when such action must occur. It also relates basic information such as how long the contractor has to issue a priced modification to an unpriced order.

The Committee member creates the review sheet by dictating single character alpha/numeric codes to the Word Processing Center (WPC). Part of the prepositioned information in WPC is an ACPS file designation (e.g. L-6-A). A line from the review sheet might be "L-6-A - 7-104-.33-- A. MIL-I- Inspection - Delete if MIL-I not required." The buyer would then designate "L6A on his document request form. ACPS then automatically does the necessary deletion/updating/incorporation/or addition) to the order.

It is estimated that this technique alone (as one of many ACPS techniques) saves over $50,000 per year. It eliminates repetitive reviews and frees contracting personnel for other matters.

CONCLUSION

All of the above innovations and techniques have greatly increased the productivity of Contracting personnel as well as given tangible cost reduction in paper, reproduction, postage and other areas. They have increased the pride and professionalism in work created and give people time to do the good job they want to do. Even with these improvements, we are just at the threshold of what we can do to increase productivity in the Contracting Field.

1982 FEDERAL ACQUISITION RESEARCH SYMPOSIUM

6 MAY 1982

PRODUCTIVITY AND NEW PROCUREMENT TECHNOLOGY

SPONSOR: THE DEPARTMENT OF THE ARMY

AUTOMATION AND THE FEDERAL PROCUREMENT SYSTEM

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ABSTRACT

AUTOMATION AND THE FEDERAL PROCUREMENT SYSTEM

The "Automation and the Federal Procurement System" topic is addressed through an evaluative dissertation of automated procurement support potentials with existing state-of-the-art computer technologies and applications. This presentation is highlighted by case studies of the present users of SUPPLIERS (Sources of Uniform Procurement Planning, LIbrary Evaluation / Retrieval System), a program developed for and being implemented by the Acquisition Institute (AI) of Washington, D.C. AI is a publicly supported research and educational foundation specializing in the study and development of modern (automated) procurement decision support methodologies, procurement law and contracts, and curriculum training and education programs to support public administration, acquisition and current procurement discipline requirements.

As a pilot program of the Federal Library Committee (FLC), Library of Congress, FLC-SUPPLIERS is providing a new procurement data base as a service to Library users. FLC-SUPPLIERS is an automated procurement decision support system to index, file, evaluate and retrieve information pertaining to private sector contractors to assure competition for the materials, products and services to support the needs of government agencies. The FLC-SUPPLIERS data bank and programs are special tools that have been developed to meet procurement requirements of executive agencies, which are common to federal, state and local levels of government.

The in-put and maintenance of company information in FLC-SUPPLIERS is based on standard Federal Government Procurement information gathering formats and Federal Coding systems, including: Standard Form 129 (Bidders Mailing List Application); Standard Form 254 (Architect-Engineer and Related Services Questionnaire); and encompasses the following coding formats: Standard Industrial Classification of Establishments (SIC); Standard Occupation Classification (SOC); Federal Procurement Data System (FPDS) product and service codes; and other code sources. The FLC-SUPPLIERS data base is very versatile in that it will support the full range of common procurement actions including; planning and resource identification, solicitation, procurement advertisement, contractor qualification and bid evaluation, award activities, contract management functions, audit requieements, contract tracing and scheduling, contractor performance and contract close-out. FLC-SUPPLIERS manages first the technical, then the qualitative, before it addresses the social-economic and set aside provisions contained in verious public laws which encourage; small business, veterans, women, minorities, and other groups deserving besiness opportunities with government.

Extensive FLC-SUPPLIERS field testing by technical and procurement managers have demonstrated that <u>procurement schedules may be reduced 40% to 60% and operating Costs by 75%</u>. More effective Industry competition, the full ability to reconstruct documentation and the reduction in facility requierments make this procurement method ideal for supporting mission supply and service needs. AI's Corperate and individual experiences with automated procurement systems including the: U.S. Postal Service; Department of Transportation, Federal Railroad Admenistration, U.S. Coast Guard demonstrate the potential cost-efectiveness of FLC-SUPPLIERS.

In March 1982 AI initiated an FLC-SUPPLIERS data management and maintenance training program for disabeled War Veterans. Employing Disabeled Veterans in meningful work while they are hospital patients or confined to homes may help reduce the sixty percent (60%) unemployment rate imposed on our American war disabeled.

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SUPPLIERS

The Acquisition Institute (AI) has made available to the Federal Library Committee (FLC) the "Sources for Uniform Procurement Planning, Library Evaluation/Retrieval System" (SUPPLIERS). FLC-SUPPLIERS is an automated data base and document support system to index, file, evaluate, document and retrieve information pertaining to private sector companies with the resources and capacity to insure competition for the materials, products and services required to meet the operating needs of Government.

Users of FLC-SUPPLIERS are the managers, planners, technologists, attorneys, librarians and those acquisition professionals, e.g.; procurement executives, contracting officers, contract and grant administrators, purchasing agents and buyers employed in or supporting uniform procurement.

FLC-SUPPLIERS conforms to required Federal Procurement Regulations (FPR) and/or Defense Acquisition Regulations (DAR/ASPR) and may support any number of planning or procurement decisions, e.g.; Uniform procurement planning, mission requirement or development planning, sources for determination of purchase costs, sources for support of make or buy decisions, Supply-side availability and lead times or logistic considerations. In addition, the system supports government mandated programs designed to generate business opportunities for:

- Small business participation (including new business);
- Socially/economically disadvantaged individuals/businesses;
- Labor Surplus Area (LSA) company participation;
- Women-owned businesses, et al, and other relevant public law and/or policy.

Input and maintenance of information on FLC-SUPPLIERS is largely based on standard Federal procurement information gathering formats and Federal coding systems, e.g.; Standard Form 129, Bidders Mailing List Application; Standard Form 254, Architect-Engineer and Related Services Questionnaire and encompasses coding from: Standard Industrial Classification of Establishments (SIC), Standard Occupation Classification (SOC) and the Federal Procurement Data System (FPDS) product and service codes, et al.

Output from FLC-SUPPLIERS provides contract and document preparation, resource files, RFQ/IFB/RFP bidders list, mailing labels, RFQ/IFB/RFP acknowledgements, notice to short listed contractors, contract or purchase award notice, bid response evaluation, other standard or custom procurement support and management information.

Users may access FLC-SUPPLIERS data off-line as well as on-line through the Government-wide Federal Library Committee. Off-line data access is accomplished by completing and mailing the FLC-SUPPLIERS Quick Inquiry Program (QIP) form to the Federal Library Committee, Library of Congress, Washington, D.C. 20540. Schedule five (5) working days for first class mail turnaround, or allow three (3) working days for QIP form telecommunication via TELEWRITER to the Federal Library Committee at (202) 287-6000. On-line FLC-SUPPLIERS data access is via International Telecommunication by local-dial-up from any computer terminal located at a user site or a user library facility.

Users or user libraries may subscribe to the "SUPPLIERS Digest" on Automation and the Federal Procurement System, edited by AI as a companion service. This monthly newsletter provides procurement professionals a comprehensive, terse overview of relevant new laws, regulations, administrative decisions, advances in procurement automation and other news concerning Government and the Supply-side of procurement.

The FLC has arranged for user training for the FLC-SUPPLIERS service at the facilities of the Federal Library Committee; Library of Congress, Washington, D.C. 20540 or at a user library site. For information, call: (202) 287-6055.

THE ACQUISITION INSTITUTE'S "SUPPLIERS" DATA BASE SERVICE

I. RESEARCH AND DEVELOPMENT OF SUPPLIERS

SUPPLIERS is a concept and system that has evolved since 1974, when the firm JGM Consultants and Engineers, Ltd. (JGM), designed for the U.S. Postal Service an early form of today's SUPPLIERS, creating a system which currently indexes 15,000-25,000 "supplier sources" active firms which have, within the last seven years, sought work from the Postal Service. Following this experience, JGM created another iteration of SUPPLIERS (indexing 15,000-30,000 sources for the Federal Railroad Administration's Northeast Corridor Project) under a subcontract with the DeLeuw, Cather Company and the Ralph M. Parsons Company, a joint venture to manage the five-year $2.7-billion program to rehabilitate the Amtrak passenger rail system between Washington, D.C. and Boston, MA. A "spinoff" of SUPPLIERS was subsequently developed for the construction of the Alaska Natural Gas Pipeline (10,000-15,000 sources), and, most recently, JGM created a "freestanding" system for the Acquisitation Institute in support of the U.S. Coast Guard Headquaters (5,000-10,000). These seven years' experience with various versions of SUPPLIERS--in design, test, and operation--is reflected in the SUPPLIERS system today marketed by the Acquisition Institute Foundation through the expanding 600 member Federal Library Committee, Library of Congress. This arrangement allows ultimate access to 3000 libraries internationally.

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II. THE FEDERAL LIBRARY COMMITTEE (FLC) SUPPLIERS CONCEPT

FLC-SUPPLIERS is a procurement operations decision-support and data base management system created (and used effectively) to serve a specific set of government needs. At the same time, it is a technique for exposing new business opportunities to the private sector.

Essentially, FLC-SUPPLIERS operates:

- to stimulate and expand private-sector competition in selling the goods and services purchased by government/s;
- to support government efforts to comply with the complex policies, laws, and regulations (more than 1,600 of them) on the methods and procedures through which these goods and services must be purchased;
- to provide, for the government-as-buyer, a more efficient buying system (cutting down paperwork and both direct and indirect labor costs) and an accounting trail that can withstand public scrutiny.

More specifically, FLC-SUPPLIERS supports the full range of requirement, planning and procurement decisions that are generic and universal to federal, state, and local governments (counties or municipalities) including:

- mission technical requirements/development planning/scheduling
- commercial market/cost research, including
  - support of "make" or "buy" decisions
  - determinations of supply-side availability
  - logistic considerations
  - determinations lead times
- scoping the procurement/contract
- advertising the procurement
- assuring compliance with government-mandated programs for generating business opportunities for, e.g.;
  - small business or new business enterprise
  - Veteran / Vietnam-ERA Veteran
  - the socially / economically disadvantaged
  - labor surplus area (LSA) companies
  - women-owned business enterprises
  - and other enterprises identified by public law as deserving special opportunities, i.e.; the handicapped, the blind, etc.

In addition:

- FLC-SUPPLIERS supports these government functions;
  - bid document production and control
  - contract production
  - bid-response evaluations
  - documentation/support of bidder selection
  - contract administration and tracking
  - contract compliance and enforcement
  - contract evaluation and closeout
  - individual/personal information management
  - interpersonal communicating/teleconferencing

FLC-SUPPLIERS works to automate, to the fullest practical extent, each of these decisions or procedures, with the aim of improving the government-as-buyer's cost efficiency neutrality, and objectivity in performing its purchasing functions within prescribed legal parameters.

At the same time, a government-as-buyer relies on the FLC-SUPPLIERS system to support one of its purchasing functions, the private-sector, benefits too -- because its qualifying credentials, bid responses, and contract performance are surfaced and evaluated in a more objective and timely fashion.

CONTINUED

Thus, FLC-SUPPLIERS is designed and operated as an integrated technical/procurement/contracting operation to benefit government personnel by lending greater efficiency to procedural and clerical tasks; reducing political pressures on their buying decisions; freeing valuable time and talent for concentration on long-range planning and the subjective complexities of bidding and of negotiated procurement; and providing a complete accounting and scheduling record of an individual transaction from budget authorization to contract closeout. In the process, FLC-SUPPLIERS benefits the supply side by automatically exposing a greater number of qualified business enterprises to a fuller range of business opportunities than could be discovered through independent research; by assuring a more timely and objective evaluation of responses to these opportunities; and by depoliticizing, clarifying, and streamlining the reporting responsibilities and contract-performance expectations monitored by government management and procurement executives.

....

III. FEDERAL LIBRARY COMMITTEE-SUPPLIERS' POLITICAL POSITION

The FLC-SUPPLIERS concept would be hard to fault (and, conversely, easy to endorse) from a political standpoint -- such has long been the case. Today's difference is that the "sentiments" supporting this concept are now assuming the force of the law and executive order, for example, President Reagan's Executive Order dated March 18, 1982 on "Federal Procurement Reforms."

Efforts to ensure effective and efficient spending of public funds through fundamental procurement reforms are gaining rapid momentum, through legislative and administrative channels at all levels of government, to improve the methods used in acquiring goods and services from the commercial sector, with the objectives of insuring honesty, eliminating wasteful practices, broadening the spectrum of goods and services purchased, stimulating and expanding opportunities for effective competition, limiting noncompetitive actions, with latitude for innovation, and improving efficiency in the purchasing process. These objectives are thoroughly endorsed by the Acquisition Institute -- they are, in fact, AI's raison d'etre -- but the point to emphasize is: All the elements needed are now in place to accomplish these objectives and are now being codified.

At the Federal level, this initiative began in earnest with the passage of P.L. 93-400, (August 1974) the Federal Procurement Policy Act. This act created, at the Office of Management and Budget, the new Office of Federal Procurement Policy (OFPP), headed by its own Administrator, nominated by the President and confirmed by the Senate. OFPP Policy Letter 80-5 (July 10, 1980) established the requirement for a single Federal Acquisition Regulation (FAR), which has to pass through its draft stages on the way to replacing the nearly 40-year-old Defense Acquisition Regulations (DARs) and the (civilian) Federal Procurement Regulations (FPRs). P.L. 96-83, the Office of Federal Procurement Policy Act Amendments of 1979, mandated OFPP's development of an innovative, comprehensive, and uniform procurement system for use by federal agencies.

Under its new Administrator, The Honorable Donald E. Sowle, the OFPP has published, (October 29, 1981), a Draft-Proposal for a uniform Federal Procurement System (FPS). Public hearings were held on December 1, 1981, to receive comments which have been incorporated and the documents were delivered to Congress on February 26, 1982 completing OFPP's systems design mandate. Finally, on April 30, 1982, OFPP sent proposed legislative changes to existing procurement statutes. This action completes OFPP's key obligations under Public Law 96-83. OFPP is now implementing the FPS system proposal through Executive Order 12352 on procurement reforms.

FLC-SUPPLIERS is completely on track with the development of the FPS/FAR. In fact, the current FLC-SUPPLIERS Data Base Management Service fulfills at the pilot operational level the two procurement computer support considerations stated as paramount in the draft FPS, only now being articulated at the conceptual level:

- FLC-SUPPLIERS Data Base Management Service is user oriented, facilitating day-to-day procurement operations that insure advance planning productivity and cost efficiency; and

- FLC-SUPPLIERS is employed as a tool by procurement managers to accomplish decision support, accountability, scheduling, and effective procurement competition. (See Proposal for a uniform Federal Procurement System, SECTION 3: A SIMPLIFIED SYSTEM; INCREASING THE USE OF AUTOMATION, and Appendix L: AUTOMATING THE PROCUREMENT PROCESS.)

In sum, FLC-SUPPLIERS operating specifications support the following:

- public laws on acquisition / procurement
- Federal Acquisition Regulations, subsuming
  - Defense Acquisition Regulations (DARs)
  - Federal Procurement Regulations (FPRs)

CONTINUED

- Executive Office of the President
  - Executive Orders
  - Executive policy letters
  - Office of Management and Budget, circulars
  - Office of Federal Procurement Policy, directives

FLC-SUPPLIERS adheres to the following Executive Office of Management and Budget guidelines for awarding contracts:

- Hire contractors with the experience, financial capability and demonstrated ability to deliver the property or service needed.

- Obtain property and / or services of quality and value.

- Stimulate the economics of Labor Surplus Area (LSA) companies.

- Stimulate the economics of Small Business enterprise.

- Stimulate and train the socially and / or economically disadvantaged.

- Achieve effective competition with an absence of bias or favoritism in the solicitation for bids, evaluation, and for the contract award of public acquisition dollars.

These trends are replicated at the state and local levels, where procurement systems are being overhauled and modernized in response to voter / taxpayer demands for improved economies, efficiency and accountability in government purchasing. The recently completed revision of Maryland's procurement regulations, (Maryland Register: Title 21), which are now virtually identical to the FARs, except for architectural / engineering services procurement, and the adoption by a growing number of states of the American Bar Association's Model Procurement Code are examples of state and local government procurement reform.

Because the basic internal modeling of FLC-SUPPLIERS is universal to procurement, the fine tuning required to make the system responsive to any particular legal / regulatory requirements of individual federal agencies, states and municipalities is minimal -- and can be easily effected at the FLC-SUPPLIERS operating level.

....

IV. THE FLC-SUPPLIERS DATABASE: GENERAL DESCRIPTION

The FLC-SUPPLIERS database contains computerized data on companies in the following professions, fields and / or industries (See Exhibit B Page 6)

- Architect-Engineer (A-E)
- Construction contractors
- Expert consultants
- Vendors
- Small administrative purchases

Created to accommodate a total of 2.4 million company records/units, the FLC-SUPPLIERS database expands primarily through the continuing addition of "shared resources," thus: Each time a Federal agency issues an interagency Purchase Order to the the Federal Library Committee (usually on an annual basis) for the use of FLC-SUPPLIERS, that agency accepts, as the first transaction, the conversion / contribution of its existing active company-record files to the FLC-SUPPLIERS database. In general, the term "active" identifies companies which have sought work from that agency within the last three years. It is a given (understood by the new agency) that once these records are "up" on the FLC-SUPPLIERS, they become part of a dynamic database that other FLC-SUPPLIERS users may access. The advantage of this "tradeoff" is that the new contributor now automatically enjoys the similar benefit of an expanded pool of vendor / contractor information from which it can, (via FLC-SUPPLIERS, again), satisfy its mission needs.

A government agency will derive several other important advantages using FLC-SUPPLIERS. Each new agency joining the users of FLC-SUPPLIERS reduces its need for hard-copy file cabinets, frees up floor space and cuts utility requirements. Direct and indirect labor demands are also reduced, and the data system makes it possible to level peak workloads, thus lowering the probability of overtime and its corresponding premium pay.

The other major beneficiary of this system is, of course, the private sector. Now a business may automatically receive, for example, an RFP, IFB, or RFQ in the mail, gaining an opportunity to bid with an agency with which it has never done business -- all without having to expend any effort in searching out the opportunity or filing yet another form. All this is made possible because its business record was freely shared via FLC-SUPPLIERS distributed database by another agency / user.

CONTINUED

EXHIBIT B

THE SUPPLIERS DATABASE:
SIX INTERACTIVE, SHARED-RESOURCES FILES

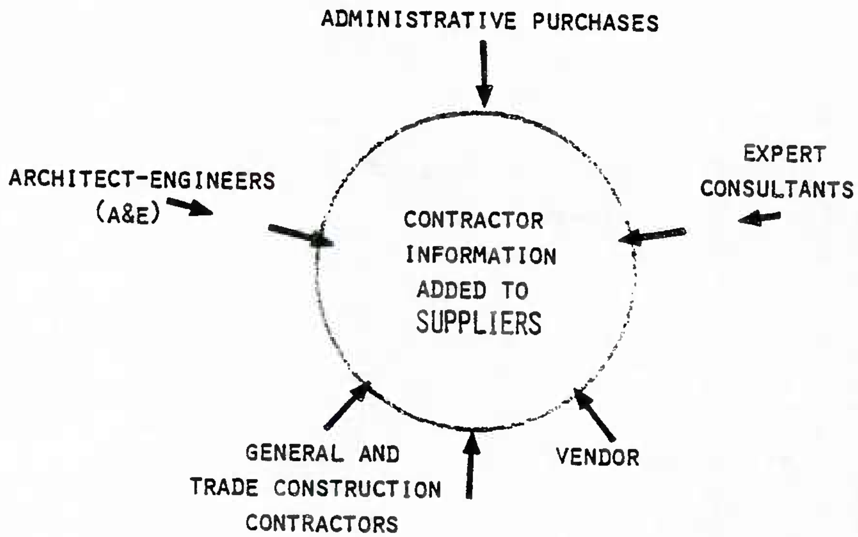

EXHIBIT B

The business records contributed by each company / agency participating in the FLC-SUPPLIERS Data Base are by distributed processing synchronized in the master file — these records becoming the input to the data base —are primarily (1) based on standard Federal Government Procurement (FPR and DAR) information-gathering formats, e.g., Standard Form 129, Bidders Mailing List Application, and Standard Form 254, Architect-Engineers and Related Services Questionnaire, and (2) encompass federal coding systems such as Standard Industrial Classification of Establishments (SIC), Standard Occupational Classification (SOC), and the Federal Procurement Data System (FPDS) product and service codes. The cost for creating a company business record is quite inexpensive in the FLC-SUPPLIERS data base. FLC-SUPPLIERS currently creates the most cumbersome and lengthy of these records — the 7-page SF 254 — at a cost of $13; other company business record costs are as low as $2 / record.

Most of these forms are to be updated periodically by those businesses filing them. Because the filing date is a key record identifier, FLC-SUPPLIERS can be "searched" for a list of "Dated Records," with FLC-SUPPLIERS using direct-mail contact and/or local-media advertising to inform businesses that updates are needed. AI's historic labor costs for maintaining FLC-SUPPLIERS records is at the rate of 10,000 records per one-person-year; revisions are entered off-line from hard copy forms, as an economy measure, before being synchronized by and entered on FLC-SUPPLIERS via distributed processing.

While the primary build of the FLC-SUPPLIERS database comes from marketing successes (signing new purchase orders), AI also employs other techniques to expand the system. It will, for example, undertake the "creation" of a source list for an agency's special needs, on request, culling these sources from a variety of lists that are either commercially available or on public record. In this regard, it is important to appreciate the public right in accessing Federal data through the Freedom of Information Act.

Not yet fully tested within AI is the expansion of FLC-SUPPLIERS' through direct-mail campaigns. The technique to be applied is / would be the mere solicitation of new records identified / worked through selected lists. Estimates of requisite capitalization for significant expansion under this methodology would include not only traditional direct-mail costs, but also the costs of creating new records.

V. USER ACCESS OF FLC-SUPPLIERS: OUTPUT

While FLC-SUPPLIERS serves the information needs of a variety of managers, planners, designers, contractors, technologists, attorneys, and librarians, it is a system designed primarily to aid acquisition professionals: procurement executives, contracting officers, contract administrators, purchasing agents and buyers. Designed to respond to the broadest level of procurement and contract operations, FLC-SUPPLIERS supports and assists contracting officers in achieving and reporting acquisition goals. Management and technical contributions to contractor selection, contract documentation, and clerical activities are combined by FLC-SUPPLIERS in order to improve technical packaging and contracts preparation, to document and track contract award schedules, and to reduce the cost of processing each contract or contract transaction.

VI. FLC-SUPPLIERS OUTPUT TO AGENCY USERS

FLC-SUPPLIERS output to a government user falls into five basic generic categories, as displayed in Exhibit.

Resource files indexing contractor information are drawn from five interactive, shared-resources databases: architectural / engineering services, construction contractors and trade construction contractors, expert consultants, vendors, small administrative purchases.

A. RESOURCE FILES: INDEX CONTRACTOR INFORMATION;

- eligible bidders (general qualifications)
- qualified bidders (experience profiles)
- bidders meeting special requirements, e.g.,
  - small business
  - Veteran or Vietnam-ERA Veteran business
  - Disabled veterans
  - socially/economically disadvantaged business
  - Labor Surplus Area (LSA) companies
  - SBA 8a certified subcontractor

B. PRIVATE-SECTOR COMMUNICATIONS

- quarterly project announcements
- public advertisements
- RFQ/IFB/RFP mailing labels and packets
- RFQ/IFB/RFP acknowledgements
- award announcements
  - short lists
  - apparent low bids
  - final awards

CONTINUED

C. BIDDER EVALUATION SUPPORT

- contractor response evaluation
- apparent qualified low bid

D. MANAGEMENT REPORTS
(standard & semi-custom)

- technical and procurement support
- management information services
- federal procurement data system information

E. DOCUMENT AND CONTRACT PREPARATION
(See FLC-SUPPLIERS-AUGMENT manual)

An agency-as-buyer may access FLC-SUPPLIERS for its choice / need of any or all of the decision-support, tracking, communications, or accounting aids that are needed to facilitate any of the following procurement transactions — whether they be negotiated procurements for architectural / engineering services or advertised bidding for materials or equipment; each of which is subject to different formalized methods and procedures, as established by law.

The agency-as-buyer accesses the FLC-SUPPLIERS system in one of two ways:

Off-line access is accomplished by completing and mailing a simple, one-page Quick Inquiry Program (QIP) form Exhibit . For this method, a user is advised to schedule five (5) days for first-class turnaround for receipt of hard-copy response. (See Exhibit C page 9)

On-line access is accomplished via International Telecommunication by local telephone dial-up from any standard terminal located at a user site. The database search is in this case prompted by the user's responses to a set of questions paralleling the hard-copy QIP checklist.

Whether obtained on- or off-line, each unit of FLC-SUPPLIERS information delivered directly to, or dispatched on behalf of, a user is billed according to the estimating form. This schedule also details, in the "ITEM" column, the specific pieces of information FLC-SUPPLIERS can generate, the specific searches or evaluations that can be performed through the system, and the formats in which FLC-SUPPLIERS information can be delivered.

(See Exhibit D page 10)

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VII. COAST GUARD FLC-SUPPLIERS FILE ACTIVITIES CASE STUDY

THE ARCHITECT-ENGINEER FILE (A-E)

The Coast Guard currently communicates annually with over 3,000 A-E firms that have expressed interest in competing for government contracts. These firms have been entered into the FLC-SUPPLIERS data bank as a result of general publicity and specific Commerce Business Daily announcements.

Good agency practices require that each contracting office publish a quarterly announcement containing a general list of projects for Commerce Business Daily (CBD) advertisements to be released over the next three months. This activity is routinely handled by FLC-SUPPLIERS to establish a CBD "Window" date for both large and small firms to target marketing efforts. A-E firms use this time to develop a creative project interest and prepare qualification documents. In practice, small A-E firms use this found lead time to establish joint venture or sub-contract associations.

An A-E firm expresses interest by submitting a completed SF 254, Architect-Engineer and Related Services Questionnaire to the agency. When an SF 254 is received by FLC-SUPPLIERS, the data is coded and entered into the database. This is a continuing operation which will accommodate new entries or update information already contained in the database.

To initiate the contractor selection process, the user agency 's procurement and contract office must receive an approved request for procurement, accompanied by a definitive work package from the technical project development office. Typically, this package contains the project design requirements, a government cost estimate, a preliminary scope of work, a draft CBD announcement, and a FLC-SUPPLIERS QIP form and the Contractor Evaluation Board Qualification Criteria in draft form.

A. Advance Project Notice to Individual Contactors

The FLC-SUPPLIERS QIP form sets the criteria for a database search of SF 254's for potential A-E contractors that have indicated interest and experience in the type of work to be performed (Exhibit E). The "found" contractors are saved in a project file and each is mailed an advance project notice in the form of the Commerce Business Daily Announcement and appropriate notes. Included in this package is a blank SF 255, Architect-Engineer and Related Services Questionnaire for Specific Project, which the found contractors may use in preparing their firm's qualifications submittal.

CONTINUED

FEDERAL LIBRARY COMMITTEE (FLC)

SOURCES FOR UNIFORM PROCUREMENT PLANNING, LIBRARY EVALUATION/RETRIEVAL SYSTEM (SUPPLIERS)

Agency ______________________ QUICK INQUIRY PROGRAM

Office ______________ Authorization No. ________ Date ________ 19 ____

Contact ______________________ FTS No. ____________

Address ______________ City ________ State Code ________ Zip ________

PLEASE USE CHECKS ☒/(X), DESCRIPTIVE WORDS OR APPROPRIATE CODES TO RETRIEVE COMPANY DATA

CHECK APPROPRIATE STANDARD INDUSTRIAL CLASSIFICATION (SIC) DIVISIONS:

( ) A. Agriculture, Forestry/Fishing
( ) B. Mining
( ) C. Construction
( ) D. Manufacturing
( ) E. Transportation/Public Utilities
( ) F. Wholesale Trade
( ) H. Finance, Insurance/Real Estate
( ) I. Services

☐ OR USE SF-254 ARCHITECT-ENGINEER AND RELATED SERVICES FILES.

☐ OR ENTER FEDERAL PROCUREMENT DATA SYSTEM (FPDS) CODE(S): ________ ( ) AND ________

☐ AND SUPPLIERS OFFERING ( ) PRODUCT(S) ( ) COMMODITIES ( ) EXPERIENCE PROFILE CODES

________ CODE ____ ________ CODE ____
________ CODE ____ ( ) AND ________ CODE ____
________ CODE ____ ( ) OR ________ CODE ____

☐ AND SUPPLIERS OFFERING REQUIRED ( ) OCCUPATION(S) OR ( ) DISCIPLINE(S):

________ CODE ____ ________ CODE ____
________ CODE ____ ( ) AND ________ CODE ____
________ CODE ____ ( ) OR ________ CODE ____

☐ AND SUPPLIERS LOCATED IN THE FOLLOWING ( ) COUNTRY(S) OR ( ) STATE (S):

________ OR ________ OR ________ OR ________

☐ AND SUPPLIERS LOCATED IN THE FOLLOWING ZIP CODE(S):

______ OR ______ OR ______ OR ______ OR ______ OR ______ OR ______

☐ AND RESTRICT TO: ( ) REGULAR DEALER ( ) WHOLESALE DISTRIBUTOR ( ) ACTIVE EXPORTER ( ) SURPLUS DEALER

☐ AND RESTRICT OWNERSHIP TO: ( ) SMALL BUSINESS ( ) VETERAN OR ( ) VIETNAM VETERAN (1964-75)
( ) SOCIALLY/ECONOMICALLY DISADVANTAGED ( ) WOMAN/WOMEN ( ) LABOR SURPLUS AREA (LSA) ( ) SBA 8a CERTIFIED SUBCONTRACTOR

☐ AND INCLUDE THE NAMES AND ADDRESSES OF APPROPRIATE INDUSTRY/TRADE ASSOCIATIONS.

☒ SUMMARIZE QUICK INQUIRY PROGRAM (QIP) REQUIREMENT:
( ) ADD FILE(S) ( ) RETRIEVE FILES ( ) IFB LIST ( ) RFQ LIST ( ) RFP LIST ( ) BID LIST
( ) MAILING LABELS ( ) ACKNOWLEDGEMENT POSTCARDS ( ) AWARD NOTICE
( ) TO QIP A SUPPLIERS COMPANY FILE, ENTER TELEPHONE NO. (____) ____–________
( ) TO QIP AN AGENCY FILE, ENTER PROJECT NO. ____________ AND STATE REQUEST.

REQUESTS:

☐ DEFER RUN TO COMPUTER CENTER FOR SUPPLIERS PROCESSING AND/OR:
( ) HIGHSPEED PRINTING ( ) PHOTOCOMPOSITION ( ) MICROFILM ( ) MICROFICHE

FLC/SUPPLIERS QIP FORM

EXHIBIT C

FEDERAL LIBRARY COMMITTEE (FLC)

SOURCES FOR UNIFORM PROCUREMENT PLANNING, LIBRARY EVALUATION/RETRIEVAL SYSTEM (SUPPLIERS)

SCHEDULE

ITEMS	The FLC, SUPPLIERS Estimating Form (1)	UNIT (2)	QUANTITY X	UNIT PRICE (3)	AMOUNT
I	INDEX CONTRACTOR INFORMATION				
	a. Standard Form 129, Bidder's Mailing List Application	Ea		2.00	
	b. Standard Forms 254/255, Architect-Engineer And Related Services Questionnaire				
	1. SF-254	Ea		25.00	
	2. SF-255	Ea		18.50	
	c. FLC-Construction Industries Forms				
	1. General Contractors/Operative Builders	Ea		12.00	
	2. Special Trade Contractors	Ea		12.00	
	d. FLC-Vendor Forms				
	1. Manufacturer/Producer	Ea		12.00	
	2. Regular Dealer (Type 1)	Ea		12.00	
	3. Regular Dealer (Type 2)	Ea		12.00	
	4. Service Establishment	Ea		12.00	
	e. FLC-Business Supplement Forms				
	1. Small Business Act, 1958	Ea		1.00	
	f. 2. P.L. 95-507, Socially/Economically Disadvantaged	Ea		6.00	
	3. P.L. 95-89, Labor Surplus Area (LSA)	Ea		1.00	
	4. Women-Owned Businesses	Ea		6.00	
	5. Active Exporter	Ea		12.00	
	6. Surplus Dealer	Ea		12.00	
II	MARKET RESEARCH FOR UNIFORM PROCUREMENT				
	a. Qualified Contractor Listing with specific experience	Ea		2.455	
	b. Qualified Contractor Information, Multi-Criterion	Ea		3.50	
	c. P.L. 95-89 LSA Contractors Listing	Ea		1.26	
	d. IFB/RFQ/RFP Bidders Mailing Labels	Ea		.231	
	e. Award Mailing Labels (Zip Coded)	Ea		.231	
	f. Small Business Contractors Listing	Ea		2.455	
	g. P.L. 95-507 Contractors Listing	Ea		2.455	
	h. Women-Owned Business Listing	Ea		2.455	
	i. Veteran Owned Business Listing	Ea		2.455	
	j. Vietnam Veteran (1964-75) Owned Business Listing	Ea		2.455	
III	INDUSTRY/TRADE ASSOCIATIONS:	Ea		1.26	
IV	IFB, RFQ or RFP ACKNOWLEDGEMENT POSTCARDS	Ea		1.26	
	• Individually addressed, unique message	Ea		.85	
V	RFQ/RFP SELECTION CRITERION EVALUATION				
	a. SF-129/FLC Forms, Bidder Criterion Summary	Ea		26.50	
	b. SF-255 Architect-Engineer and Related Services Questionnaire for Specific Project, Qualifications Summary	Ea		32.00	
VI	STANDARD REPORTS/SEMI-CUSTOM REPORTS				
	a. Technical and Procurement Support	N/A		On Request (1)	
	b. Management Information Services	N/A		On Request (1)	
VII	FLC HAS ARRANGED FOR USER TRAINING FOR THE SUPPLIERS SERVICE	N/A		On Request (1)	
VIII	TOTAL ESTIMATE				$

NOTES. (1) For information about SUPPLIERS or budget Cost Estimates:
Address: Federal Library Committee, The Library of Congress, Washington, DC 20540 Telephone numbers: (202) 287-6055, FTS 287-6055.
(2) Ea = Each Firm or Company Name N/A = Not Applicable
(3) Unit prices are for Off-Line Requests and include the cost of Data Center Terminal Operators.

FLC, SUPPLIERS FORM NO. 0002

EXHIBIT D

Advance project notices are the second benefit a contractor may derive from being included in FLC-SUPPLIERS. These notices will call timely attention to the projects for which the firm has qualifications. Advance project notices are mailed to the found A-E firm with the CBD publication mailing. The CBD is located in Chicago, IL.

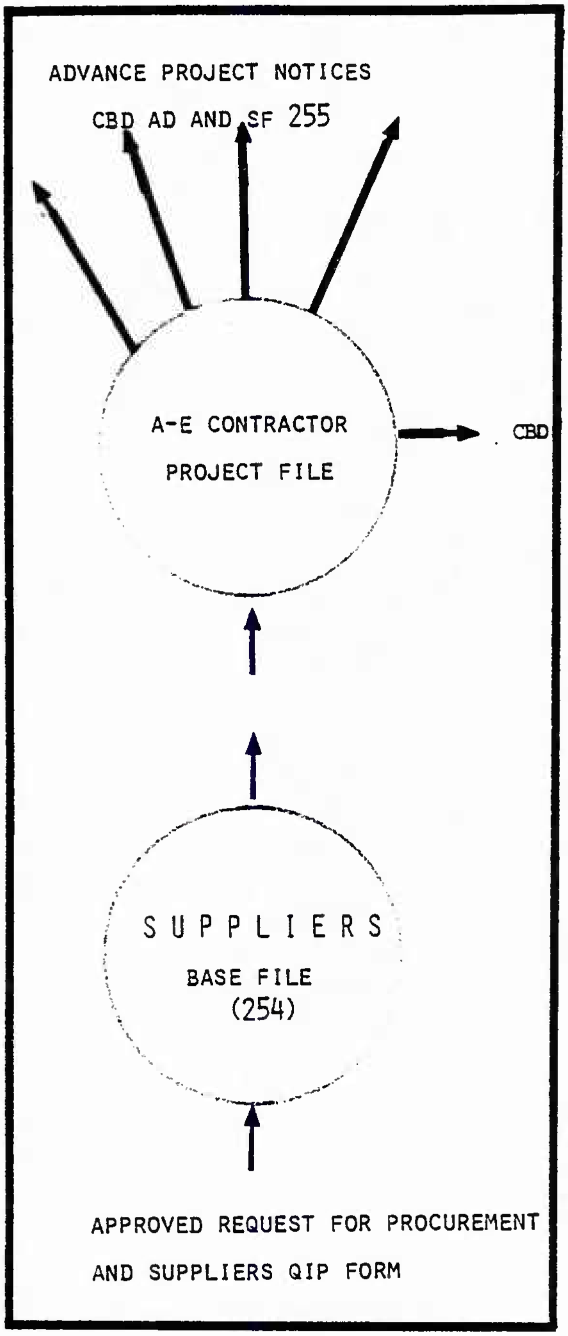

EXHIBIT E

For example, the U.S. Coast Guard policy is to identify on FLC-SUPPLIERS all A-E firms with the specific qualifications required to perform the work plus "socially and/or economically disadvantaged" firms with the general capabilities and qualifications; these firms are sent advance project notices and the SF-255 form. Most likely, these advance notices will reach a firm officer 15-20 days before the announcement is published in the Commerce Business Daily, because the CBD advertisement copy is sent to Chicago for typesetting at the same time the advance project notices are mailed to the found A-E firms. The date the ad appears in the CBD establishes the closing date for the SF254/255 project qualification submittals--usually 15 days after publication.

B. Assistance for Special Firm Capabilities (Joint Ventures or Consultants' Associations)

Using FLC-SUPPLIERS, several agencies have, upon request, provided a contractor with a resource list to aid in forming complementary associations with other firms, thereby enhancing that joint venture or consulting association's total capabilities. A Quick Inquiry Program (QIP) provides for this service by customized sorting of the information maintained in FLC-SUPPLIERS. It allows the user to sort by any combination: by disciplines; experience profile codes; geographic location, by states or ZIP code; by work-experience ZIP code; small business; and/or firms qualifying for socially or economically disadvantaged status.

C. Contractor Evaluation Board

A week or two before the advertised closing date of a project, a uniquely constituted agency A-E Contractor Evaluation Board (CEB) meets to review the technical project information and adopt final contractor qualification and selection criteria, which are assigned score values.

(See Exhibit F page 12)

D. CEB Criteria Modeling

Using the criteria adopted by the CEB, FLC-SUPPLIERS enters an evaluation program creating a mathematical model of an "ideal" firm to accomplish the A-E design. It may be noted that this step is typical of the planning inherent to FLC-SUPPLIERS, in that work is accomplished during a normal slack period and does not impact the critical work path.

E. RFQ / Qualification Documents

After the closing date, contractor response will have come from two sources :

- Those responding to FLC-SUPPLIERS advance project notice, or
- Those responding to the published CBD announcement.

(See Exhibit G page 13)

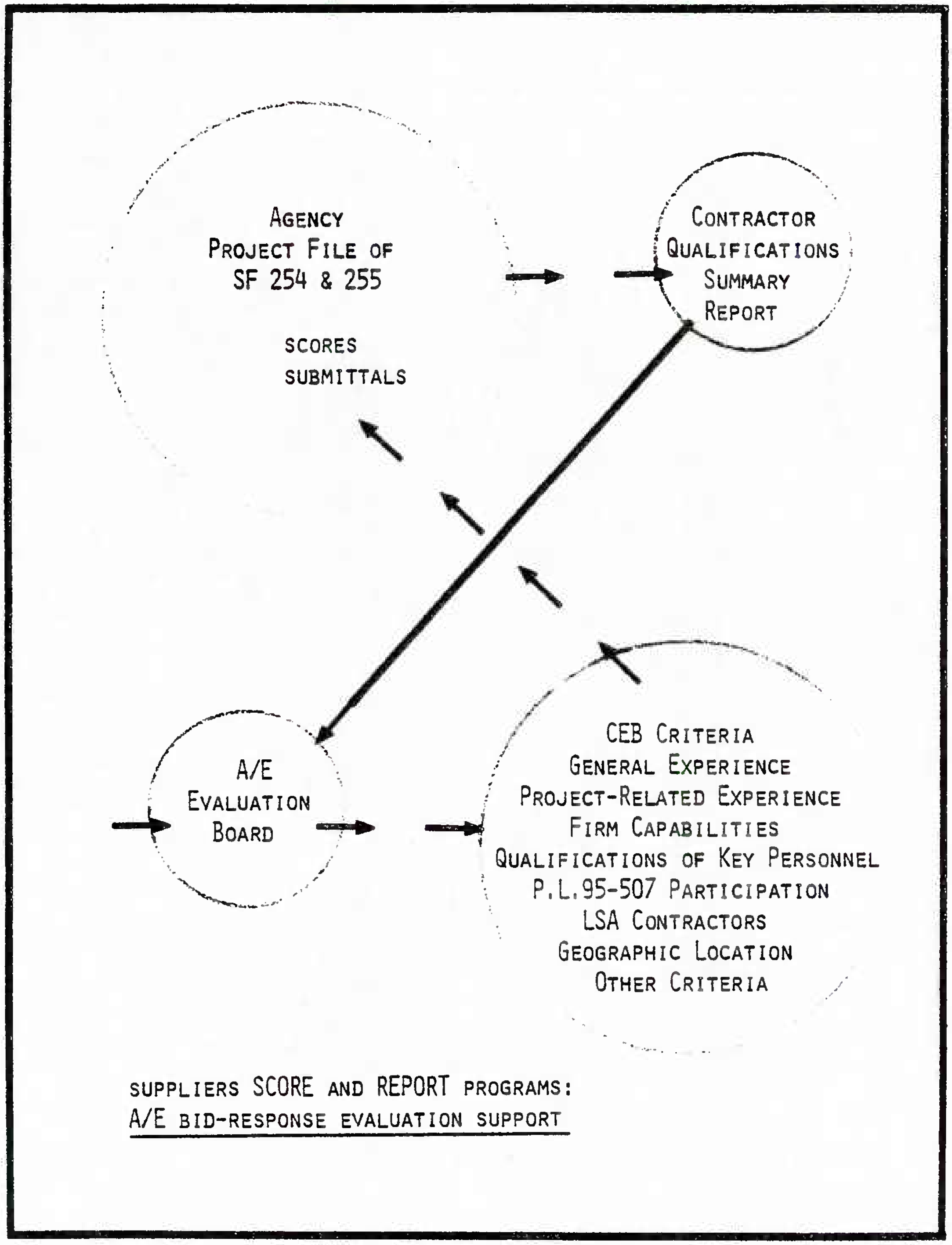
AGENCY
PROJECT FILE OF
SF 254 & 255
SCORES
SUBMITTALS
CONTRACTOR
QUALIFICATIONS
SUMMARY
REPORT
A/E
EVALUATION
BOARD
CEB CRITERIA
GENERAL EXPERIENCE
PROJECT-RELATED EXPERIENCE
FIRM CAPABILITIES
QUALIFICATIONS OF KEY PERSONNEL
P.L.95-507 PARTICIPATION
LSA CONTRACTORS
GEOGRAPHIC LOCATION
OTHER CRITERIA
SUPPLIERS SCORE AND REPORT PROGRAMS:
A/E BID-RESPONSE EVALUATION SUPPORT

EXHIBIT F

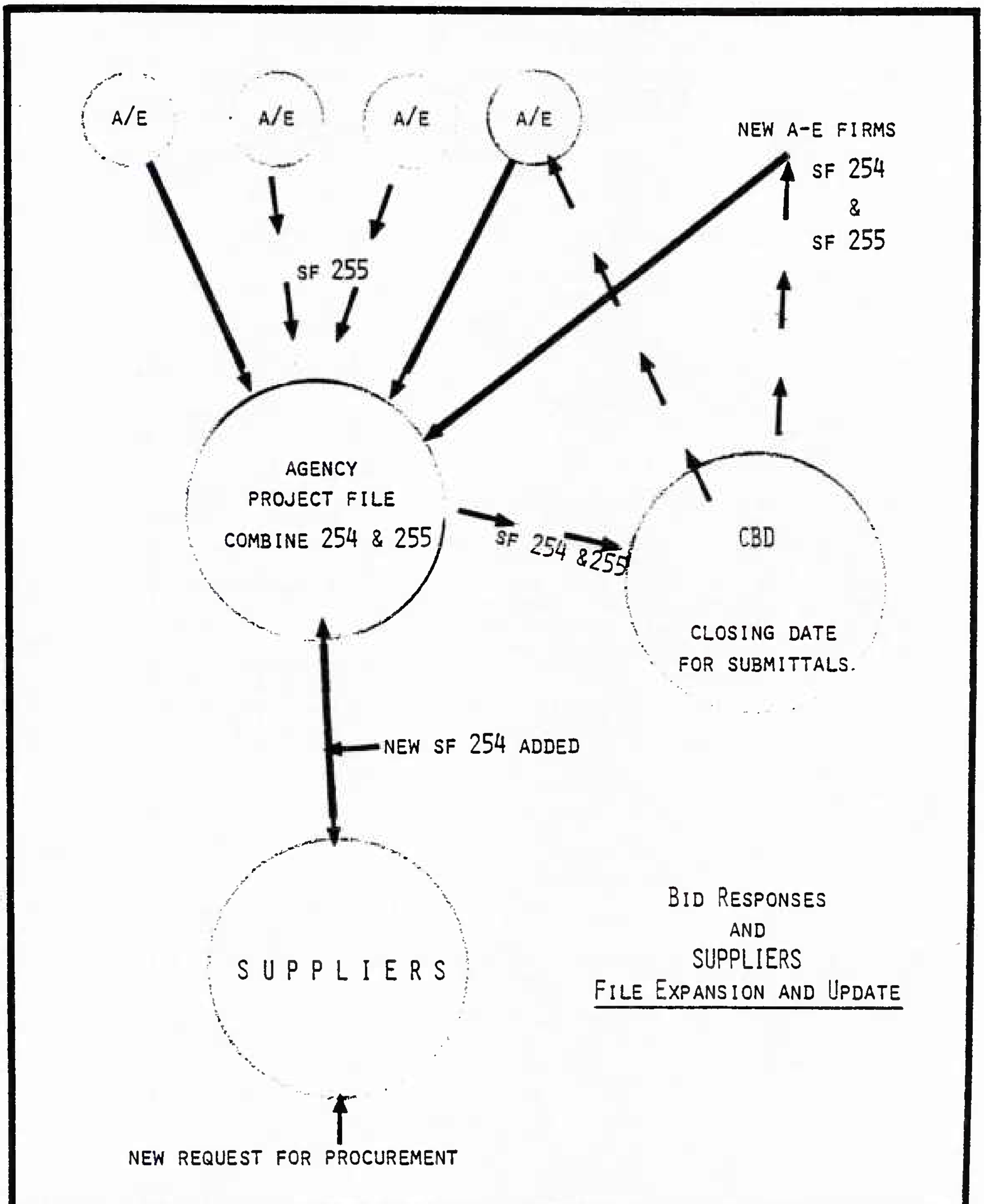
A/E
A/E
A/E
A/E
NEW A-E FIRMS
SF 254
&
SF 255
SF 255
AGENCY
PROJECT FILE
COMBINE 254 & 255
SF 254 &255
CBD
CLOSING DATE
FOR SUBMITTALS.
NEW SF 254 ADDED
SUPPLIERS
BID RESPONSES
AND
SUPPLIERS
FILE EXPANSION AND UPDATE
NEW REQUEST FOR PROCUREMENT

EXHIBIT G

E. RFQ / Qualification Documents (Continued)

From these responses, the SF 254 data is entered on FLC-SUPPLIERS for those firms not on file or updated for those already in the system. The SF 255's for specific projects are forwarded to the A-E technical project group for subjective evaluation of the management plan, management experience and key personnel. The SF 255 submittals are returned to FLC-SUPPLIERS, coded and entered into the project file. Joint-venture firms and/or consulting (sub-contract) firm records are linked with prime contractors in the project file.

F. By-Product Communications / Reports

FLC-SUPPLIERS prepares computerized acknowledgement postcards addressed to each submitting contractor. Management reports are also prepared delineating categorical information about contractors responding to project notification. An alphabetical list of firms is prepared for the record. All files are updated and activity dates noted.

G. Qualification Evaluation

The technical project office's subjective evaluation of the A-E firm's key personnel, management plan and management experience is combined with the objective information submitted by a contractor on the SF 254/255 and entered into FLC-SUPPLIERS. Prime contractor, joint-venture and consulting associations are established by the link program, and CEB report processing is ordered for off-peak computer operating hours .

Overnight, all contractor submittals are evaluated against the model criteria and against all contractors and/or associated contractors. The results are stratified and printed out in the contractor Qualifications Summary Report for CEB review. This report, together with the SF 255 documents and all pictorial submittals, are furnished to the CEB to aid and document the contractor selection and short-listing process.

H. Short List Firms

The Contracting Officer, upon the advice of the CEB, notifies FLC-SUPPLIERS of firms short-listed, and the data is posted. This trigger activates FLC-SUPPLIERS updating and notifies those firms selected for interview.

I. Award Tracking

Contractor activity is collected as a byproduct for each agency, for example, RFQ received, RFQ submitted, times short listed, contracts in negotiation and the number of awards and contract dollar amount is logged for each firm and on each agency's files .

(See Exhibit H page 15).

J. Automated Information And Notification

Congressional delegation award notices are prepared for all contracts over $1,000,000, or some other pre-agreed amount.

Computerized award information is prepared for all appropriate agency departments or systems as follows:

- Contract Information Management Systems
- Program Management
- Logistics
- Scheduling
- Cost Control/Accounting

Computerized award data may be prepared for the new Federal Procurement Data System (FPDS) as a by product of FLC-SUPPLIERS.

Project Award labels are prepared for dissemination to interested organizations:

- CBD Publication
- Legislative Offices
- RFQ Contractors
- Professional and Trade Associations

K. Cost Experiance

FLC-SUPPLIERS operatting costs of .0015 to .002 percent per $1,000,000.00 of contracts awarded may be used as a rule of thumb for all catigories of contracts. Negotiated Architect and / or Engineering contract decision support costs using this Library resource are estimated at $2,000 / million awarded.

....

CONSTRUCTION CONTRACTORS

A separate FLC-SUPPLIERS database file has been created for construction contractors. General contractors and specialty trade contractors (subcontractors) are invited to submit their company qualifications on a FLC-SUPPLIERS questionnaire. This questionnaire incorporates SF 129 information and the Standard Industrial Classification codes. Information from contractor-completed forms is recorded into FLC-SUPPLIERS. Listed contractors will then receive quarterly project schedules and a pre-invitation notice for bid, each time their companies' specific areas of interest are identified. A contract bid document request card is included in the pre-IFB for contractors to return to the agency Contracting Officer. Contract bid document costs are included as well as information on plan-room locations.

....

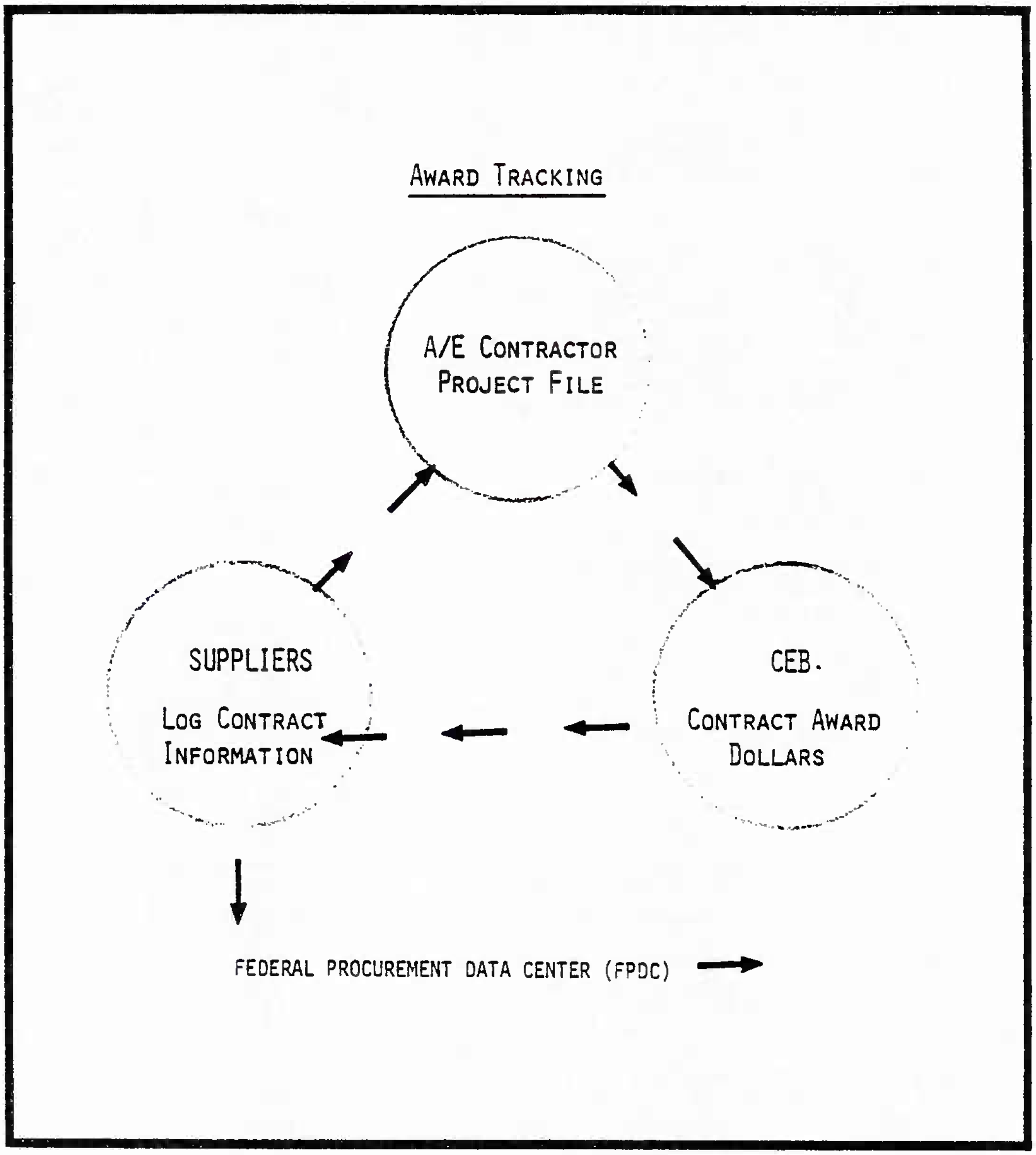
AWARD TRACKING
A/E CONTRACTOR PROJECT FILE
SUPPLIERS
LOG CONTRACT INFORMATION
CEB.
CONTRACT AWARD DOLLARS
FEDERAL PROCUREMENT DATA CENTER (FPDC)

EXHIBIT H

VENDORS

Vendor and service companies are maintained in FLC-SUPPLIERS. Data is entered from a Standard Form 129, bidders mailing list application. Vendors may be classified by Standard Industrial Classification Code numbers (SIC Code); Federal Data System Code numbers, (FDS Code); Federal Supply and Commodity Code numbers, (FSC Code); and Research and Development Code numbers, (R & D Code).

Department of Defense data maybe entered from DD Form 1630, Research and Development Capabiity Indexing for Scientific and Technological Vendors, both by fields and areas of company interest. Small business contractors and small business concerns controlled by socially and economically disadvantaged individuals (P.L. 95-507) are maintained within the FLC-SUPPLIERS vendor file.

Vendor and service company price data may be accessed by use of the vendor telephone Quick Inquiry Programs (Phone QIP).

The price data format sets forth the date of quotation, the code, the model / item number, ordering unit and bid price.

Bid award data is also available with approved security access.

VIII. SPECIALIZED CAPABILITIES--"OFF-LINE"

QUICK INQUIRY PROGRAM (QIP)

FLC-SUPPLIERS maintains a large amount of data about potential contractors and vendors interested in government procurement programs. A Quick Inquiry Program (QIP) has been developed as a means of custom-sorting through all the data maintained in FLC-SUPPLIERS. It allows the off-line user to access the system and sort by any data combination eg: disciplines; experience profile codes; geographic location by states or zip codes; work experience ZIP codes; labor surplus area (LSA) ZIP codes; small business status or socially and/or economically disadvantaged business status; number and dollars of project awards. Agency award data may also be made available.

The QIP program is used to provide contractors with resource lists. FLC-SUPPLIERS provides these lists to aid firms in making associations with other firms to complement capabilities and improve competition.

The off-line QIP is also the means of creating mailing lists and labels for quarterly advance notices for specific projects.

It has also been used to answer congressional inquiries about private-sector participation within a congressional district.

IX. A SUMMARY TO EMPHASIZE WHY FLC-SUPPLIERS IS TIMELY NOW?

The United States Congress, in response to public and business pressure (and findings by the Commission on Government Procurement, P.L. 91-129 and the GAO), has recognized the necessity for establishing government-wide policies and procedures for the management of federal procurement. An effort was made to centralize and strengthen policy through the passage of the Office of Federal Procurement Policy Act (P.L. 93-400, amended by P.L. 96-83), creating the Office of Federal Procurement Policy (OFPP) at the Office of Management and Budget (OMB).

The new administrator of OFPP is Donald E. Sowle, confirmed by the Senate as President Reagan's choice for this post. Mr. Sowle, a former procurement expert consultant, understands that the present system is laborious and needs to be improved.

Today there are 131,000 General Service (GS) personal plus a like number of uniform and contractor personel employed in approximately 3,000 Federal procurement offices laboring to conform to over 800 different sets of contracting-related regulations currently used by Executive agencies, departments and bureaus. The new Federal Acquisition Regulation (FAR) system is being designed to consolidate, rewrite and replace present Defense Acquisition Regulations (DARs), the Federal Procurement Regulations (FPRs), and other regulatory instruments. The FAR is being published for comment through December 1982 and is scheduled for publication in the Code of Federal Regulations by July 1,1983 under a new Title 48. The issuance of the FAR, in conjunction with the Uniform Federal Procurement System, will culminate a nine (9) year government-wide effort to establish standard procurement policies and procedures.

FLC-SUPPLIERS has been developed and successfully pilot-tested over a seven-year period and accepted for operation by various elements of the government; namely the U.S. Postal Service, Federal Railroad Administration, and the U.S. Coast Guard. Today FLC-SUPPLIERS is available to all federal agencies through the Library of Congress, Federal Library Committee.

END

BASIC ORDERING AGREEMENTS: AN INNOVATIVE ACQUISITION TOOL

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ABSTRACT

Within the research community there is a continuing need for research centers such as the Defense Systems Management College to conduct fact finding and analytical studies in an expeditious manner. Frequently, the scope of these studies requires resources and capabilities which are not resident in the research centers. Nevertheless, the urgency and time-sensitive need remain, as well as the need to maintain competition for as long as possible to obtain the benefits for the Government from competition.

The DMSC has approached the problem of being responsive to this need by issuing multiple basic ordering agreements (BOAs) to qualified firms through a competitive process. A BOA sets forth the contract clauses applicable to procurements entered into between the parties during the term of agreement. The formal contract for a specific task order is executed at a later date and incorporates the terms and conditions contained in the BOA. Task orders are competed among those firms qualified in the relevant research areas. The BOA has provided DSMC a powerful acquisition tool to expeditiously award task orders in a competitive environment.

This paper will focus on the mechanics and use of the BOA, observations and conclusion pertaining to the BOA as an effective acquisition management research tool, and the lessons learned. The latter is based on the two years of experience by the DSMC in using the BOA for issuing task orders in its contractual research program.

INTRODUCTION

An important part of the Defense Systems Management College's directed mission is to conduct research or special studies in defense program management and defense systems acquisition management concepts and methods.

The need for acquisition research is more apparent than ever. New basic policy direction, including legislation, and the constant search within the Department of Defense to improve management capability and credibility, mandates the need for a vigorous acquisition research program. Indeed, such a program is necessary to adequately assess the impact of current DOD practices.

Today's acquisition research program at the College has three major thrusts:

- Correct and refine acquisition procedures on a continuing basis and cope with acquisition problems as they surface;
- Design the optimum method of giving effect to new acquisition initiatives and policies and expose them to test and evaluation experiences; and
- Achieve innovative improvements, develop training materials, and participate in research on a DOD-wide and government-wide basis.

Acquisition continues to expand. It daily becomes more complex, resulting in efforts to resolve problems by a patchwork of laws, methods, regulations, procedures and administrative requirements. Old problems remain unresolved as new ones continue to arise. This severely impacts upon the acquisition cycle by lengthening the time required to procure weapons systems; simultaneously, the United States requires that the most modern weapons be available for the nation's defense.

RESEARCH METHODOLOGY

In the latter part of 1978 and early 1979, the DSMC found itself attempting to implement a contractual research program.

The College had had several research efforts accomplished by contractors. These were as a result of unsolicited proposals and adding effort to other research contracts. As the efforts were expanding a contractual instrument that allowed quick response was desired. The College anticipated that $350,000 would be available to fund five projects over the next 12 months and this would expand in later years.

The search for this contractual research vehicle considered such instruments as Task Order Agreements, Indefinite Quantities Contracts, and Basic Ordering Agreements. Each had its pros and cons and allowed for a quick response, but tied DSMC to one contractor for the length of the contract. This consideration was especially critical because it was felt that no one contractor had the full breadth and depth required to fully support the DSMC research effort nor did any one contractor stand above the rest in ability to structure research efforts. DSMC was having to "train" contractors in acquisition issues and research methodologies.

The "research and studies" community is one of continually changing personnel and ideas. People, not companies, maintain the expertise. Companies staff up to accomplish what contracts they have been awarded, rather than maintain a work force based upon steady workload. Moreover, these "research and studies" companies are continually hiring and laying off personnel based upon what expertise is required for the next contractual effort. Recognizing this environment, DSMC and its contracting officers at the Defense Supply Service-Washington (DSS-W) worked on a new contractual instrument, contemplating the most effective means of meeting DSMC's needs. The challenge was to ensure that the College received quality products in an expeditious manner, while enhancing technical and cost competition to the maximum extent possible among potential offerors. The solution proposed was to issue multiple basic ordering agreements.

The "source sought" notice, published in the Aug. 14, 1979, edition of the Commerce Business Daily (see Figure 1) was the first step. It presented a detailed listing of the kind of support required by DSMC, to be obtained through award of task orders pursuant to a BOA. The specific areas of knowledge necessary to accomplish the research projects were delineated. The notice alerted potential respondents to the probable needs for a multidisciplinary team approach to the assigned tasks. Qualification statements were solicited, to be evaluated in the following areas: technical approach, problem perception, technical experience, personnel background, and organizational management.

The notice attracted small and large businesses from around the country. Within 30 days, responses were received from 33 firms. Qualification statements ranged from cover letter stapled to a contractor's standard, all-purpose brochure, to in-depth presentations geared to DSMC's specific areas of concern. All submissions were forwarded to DSMC for evaluation. DSMC technical review ranked the respondents by area of expertise as determined by the evaluation process. Eleven firms, including eight small business concerns, were rated superior and qualified for award of a BOA. Three to six contractors were designated in each of the five research areas, with seven qualifying in more than one area. Figure 2 illustrates the evaluation matrix of the five evaluation areas and five research areas. Debriefings were conducted for five unsuccessful participants, all of whom seemed impressed with the fairness of the operation. On Feb. 29, 1980, DSS-W, after 7 months, delivered the 11 BOAs.

SPECIAL FEATURES OF THE MULTIPLE BASIC ORDERING AGREEMENTS

Task orders issued under the BOA include those areas as listed in the Commerce Business Daily (CBD) announcement, Figure 1. The task orders are either in the form of Cost-Plus-Award-Fee (CPAF) or Cost-Plus-Fixed-Fee (CPFF) contracts. Full and complete criteria for the award fee portion of a CPAF contract are included as follows:

(1) Technical Accuracy

(a) Development of the study data base, including source materials, interviews, surveys and maintenance of a current data base throughout the study effort.

(b) Use of expert consultants, as appropriate, as research sources including, at no cost to the contract, Government personnel.

(c) Logical development of issues related to topic.

(d) Completeness of analyses.

(e) Timeliness of issues.

(f) Credibility of study tools, procedures and techniques.

(2) Technical Innovation

(a) Develops all alternatives with

FACT FINDING AND ANALYTICAL STUDIES RELATING TO ACQUISITION MANAGEMENT INCLUDING FINANCIAL, MANPOWER AND POLICY. Support as required by task orders issued pursuant to a basic ordering agreement to the Defense Systems Management College, to include: (1) studies, analyses, reports, fact-finding and/or training programs on methods and procedures to (a) reduce costs and increase effectiveness of military procurement and acquisition management, support activities to acquisition management process and relate areas, (b) appraise ability of Services to accomplish assigned acquisition management missions and the effects of Public Law, Presidential Orders, Federal regulations. DOD Directives and Circulars on this ability; (c) appraise ability of acquisition mamagement system to meet foreign policy, NATO and ABCA Interoperability and international commitments; (2) development of mathematical models, ADP programs, etc. to evaluate system acquisiton management requirements, policies and procedures; (3) development of case studies to utilize results of (1) and (2) above for teaching aids. It is expected that a multidusciplianry team approach will normally be required to accomplish assigned tasks. Teams should contain personnel knowledgeable and experienced in the Defense environment, especially the OSD/Service interfaces, Congressional overviews, OMB interface with OSD, and Presidential/Presidental Staff interfaces. Specific subject areas of knowledge required to accomplish research tasks include: (1) data and data rights in Government contracting, (2) acquisition strategy and modeling, (3) subcontractor management, (4) competition in Government contracting, (5) Personnel resource requirements in acquisition, (6) risk assessment, (7) DSARC process and (8) issues relating to GFE v. CFE, independent operational testing, prototyping, second source effectiveness and effective front end management. Those firms wishing to be considered for qualification shall furnish information in accordance with Note 68 (first paragraph). Evaluation will focus on technical approach, problem perception, technical experience, personnel background and organization management. Five copies of the qualification statement are requested. Closing date for submission of qualification statement is 30 days from publication of this notice. Pefer to BOA-9016. (222)

Figure 1. Commerce Business Daily Announcement (14 Aug 79)

RESEARCH AREAS / EVALUATION CRITERIA	Business/Financial Management	Acquisition/Program Management	International Management	Technical Management	Logistics/Support
Technical Approach					
Problem Perception					
Technical Experience					
Personnel Background					
Organizational Management					
Total Scores in Each Research Area					

- Business/Financial Management - DAR, PPBS, Economic Analysis, Competition, Second Source, CS^2, etc.
- Acquisition/Program Management Strategy, Resource allocation, Risk, Assessment Decision Making, Planning, Organizing, Control etc.
- International Management - Multinational Programs, NATO/RSI, FMS, etc.
- Technical Management - Design, Data, Analyses, DTC, Testing, Production, Research, etc.
- Logistics/Support - Training, Manpower, Spares, Support Equipment, O&S Cost, LCC, Depot Management, etc.

Figure 2. Matrix of Research Areas and Evaluation Criteria.

workable, practical recommendations and implementation instructions.

(b) Comments on the study illustrate the understanding of the task.

(c) Shows new processes, procedures and methods for making constructive changes.

(d) Credibility of the assumptions/conclusions.

(3) Management of the Study Effort

(a) Cost performance on task (cost reductions, improvements, economics and eliminating nonessential work).

(b) Timeliness of required reports and deliverables.

(c) Assures sound schedules and assures schedules are followed.

(d) Briefings and associated training aids are presented in a professional manner.

(e) Capability/reputation of study team/team members.

(f) Study makes a real contribution to the field.

(g) The quality of the report (errors, typos, etc.).

(h) Initiatives in accomplishing the tasks.

(i) Coordination of the report with principals.

(j) Adherence to overall staffing plan.

The Fee Determination Offical (FDO) is the Commandant of the Defense Systems Management College. Fee determination on a CPAF task is a unilateral determination of the FDO and is not subject to the Disputes Clause of the Contract. The fee determination is made quarterly. Upon reviewing contractor appeals, if any, the FDO makes a final determination of award fee to be allocated the contractor. The FDO decision of final determination of the amount of award fee earned by the contractor is binding on both parties.

The task orders are issued for a completed effort as defined in the BOA, task order RFP and contractors response. A level of professional staff effort is designated on each task order for purposes of estimating costs and scoping the effort. Two types of orders may be issued, both priced and unpriced.

Deliverables include:

(1) User's handbooks, reports, point papers and summarization of research efforts in written form.

(2) Computer tapes in the proper format for a specified automatic data processing system.

(3) Training programs and presentations at DOD facilities to include films, written case studies, oral presentations and other training aids.

(4) Briefings at DOD facilities to include films, viewgraphs, slides, other briefing aids and oral presentations by contractor personnel.

DSMC has 30 days after delivery of the final deliverable product for inspection and acceptance.

The BOA is written for a one- year term and is renewable, at the option of the Government for three additional years. Because of the business environment as discussed earlier, DSMC has chosen to recompete the BOAs after only two years to have a chance to look at new contractors as well as other contractors that may now possess the requisite skills.

Any software delivered under the contract is subject to DAR 7-2003.76. The "Rights in Technical Data and Computer Software" clause requires that the contractor inform the government concerning use or disclosure of computer software which was developed at private expense and is to be delivered under the contract. The offeror is required to identify in his proposal to the extent feasible any such computer software which was developed at private expense and upon the use of which he desires to negotiate restrictions, and to state the nature of the proposed restrictions. If no such computer software is identified, it will be assumed that all deliverable computer software will be subject to unlimited rights.

Approval of key personnel assigned to the tasks issued under this Basic Ordering Agreement is reserved by the Contracting Officer's Technical Representative (COTR). The Contractor is required to notify the Contracting Officer prior to making any change in the personnel identified in the proposal as key individuals to be assigned for participation in the performance of the individual task order. The contractor must demonstrate that the qualifications of the prospective personnel are equal to or better than the qualifications of the personnel being replaced. The Contracting Officer's Technical Representative (COTR) must also approve any consultant involved in any or an aggregrate of task orders involving payment of salary and expenses over $25,000 per annum.

Dissemination or publication, except within and between the contractors, of information under the tasks or in the reports is barred without prior written approval of the COTR or Contracting Office.

PROCEDURES FOR ESTABLISHING MULTIPLE BOA AND TASK ORDERS

The procedures for establishing multiple BOAs are relatively simple yet time consuming. Approximately four months are required for establishment of multiple BOAs. The seven basic steps in establishing a basic ordering agreement are shown below:

STEP 1 - User develops "sources sought" notice which describes supplies or services to be procured under the provision of DAR 3-410.2, and forwards it to contracting office.

STEP 2 - Contracting office publishes "sources sought" notice in Commerce Business Daily soliciting qualification statements from potential respondents.

STEP 3 - Potential respondents have 30 days to submit qualification statements.

STEP 4 - The user evaluates the qualification statements based on criteria established prior to solicitation.

STEP 5 - User ranks respondents by expertise as determined by the evaluation process. The user as referred to here is the party desiring the supplies or services.

STEP 6 - Contracting office notifies both qualified and non-qualified respondents of the results of the evaluations.

STEP 7 - Contracting office issues basic ordering agreements(s) to qualified respondents.

Upon completion of STEP 6 unsuccessful respondents may desire debriefings as to why they were considered not qualified. When this is the case, the debriefings should be coordinated among parties and the contracting office should require a formal written request for debriefing from the respondent.

Once the basic ordering agreements are issued to the qualified respondents, task orders may be issued under the basic ordering agreement on DD Form 1155 or Standard Form 26. In the case of multiple basic ordering agreements, task orders are issued through a competitive process.

The task orders are issued as Request for Quotation (RFQ). The task order contains the proposed length of the effort, scope of work, background, objectives of the research, a listing of applicable documents and the various tasks to be performed. In research, a literature survey is normally conducted initially to identify issues and previous work. Tasks may also include investigation, interviews, and other fact-finding techniques; documentation of the issues, findings and recommendations; investigation of related/affected areas and other aspects of the impact of recommended solutions; and integration of the documentation into a complete report. Review meetings, financial progress reports and a final deliverable report are called out. A schedule for conduct of the tasks is provided.

The technical proposals submitted by the contractors are required to address the following areas with a 5- to 10-page limitation on the proposal:

(a) Statement of personnel who will be assigned for direct participation in the project. Resumes that clearly present the qualifications relative to this particular work should be provided. Special mention should be made of the relevant experience of key personnel.

(b) Statement and discussion of the requirements of the scope of work as understood by the offeror. This section should contain as a minimum: A detailed description of how each task will be carried out, to include a sequence of activities (steps) to be undertaken; a description of the type of data and information (including sources) which will be collected in each task and how these data or information will be used to provide input to other tasks; and anticipated results related to the objectives.

(c) A detailed outline of the proposed technical approach for executing the requirements specified in the task order.

(d) Statement and discussion of any anticipated major difficulties and problem areas, together with potential or recommended approaches for their resolution.

(e) Statement of any interpretation, qualifications, or assumptions made by the offeror concerning the project to be performed.

(f) Explanation of the study management plan and how the offeror's staff will be organized. Provide an overview of the measures to be taken to ensure a quality product, and the approach to be used to deliver the required product based on the schedule provided.

(g) Schedule describing task accomplishments.

(h) Table showing the number of man-hours to be spent on each task by each person to be assigned to the project.

(i) A table of travel, including number of travelers, destination, and duration of each trip.

The standard procedure used by OSMC for issuing task orders is shown below:

STEP 1 - DSMC forwards task order to DSS-W, accompanied by a commitment to fund the research effort.

STEP 2 - OSS-W incorporates task order into a request for quotation (RFQ) issued to those firms qualified in the relevant research area(s). The RFQ also contains a list of deliverables required, a delivery schedule, and the evaluation factors for award.

STEP 3 - Contractors have 14 days to submit a technical and cost proposal.

STEP 4 - DSMC evaluates technical proposal.

STEP 5 - DSS-W combines results of technical and cost evaluations and issues task order to the successful contractor.

The technical evaluation of the contractors proposal is based solely on his responses to the RFQ. Technical evaluation factors vary form one task to another tailored to the individual procurement but can be represented as shown below:

(1) Contractor's Technical Approach

(a) Well-organized, clear, concise proposal

(b) Understanding of the problem, tasks, and study apporach

(c) Responsiveness to scope, concept, conditions, and time for performance.

(d) Study approach and methodology

(2) Program Management Personnel

(a) Availability

(b) Educational Background

(c) Exerience in Program Management

(3) Background and Experience

(a) Experience in Financial, Technical, International and Logistics/Support related areas

(b) Familiarity with Army/Navy/Air Force/Marine Corps organizations and missions

(c) Acquisition Research Experience in related areas

(4) Past Performance and Cost Realism

(a) Job understanding as reflected by allocation of time and resources

(b) Past Performance under the BOA

Evaluation of technical proposals received from the RFQ's are in accordance with 10 U. S. C. 2304(a). Proposals are reviewed and evaluated by at least five DSMC personnel who are familiar with the task to be performed. Evaluation procedures are documented by the project officer in the form of evaluation criteria to assure that each evaluator is using the same ground rules. The evaluation criteria are grounded on the analysis of each proposal based upon:

(1) Evidence of understanding of the scope and objectives of the proposed contract

(2) Other evidence of knowledge and understanding of the job to be done, such as anticipation of problems which may be encountered in performance;

(3) Originality of thought and grasp of objectives as indicated by samples, technical approaches, or other ideas presented which indicate understanding of the problem;

(4) Managerial ability indicated by work-flow charts, proposed organization for contract performance, statements of intended approach, or other data submitted.

After each evaluator has completely analyzed all proposals in the manner described thus far, each proposal is given a relative standing in the group. At this point, a proven method is to consolidate all ratings into a single rating for each offeror by averaging-out the ratings of the various evaluators. After this has been done, the evaluators can usually agree on the elimination of those proposals which obviously do not merit further consideration because of their inadequacy, and, thus, recommend further evaluation only of those proposals which have been rated high enough to deserve further attention. These scores are forwarded to the contracting officer, who adds in the score for the cost proposals. Cost is normally weighted anywhere from one-third to one-half of the total score Proposed prices or costs are assigned numerical weights and added to the numerical weights assigned to the technical evaluation. The lowest proposed price or cost is assigned the maximum numerical weight. Award is made to that responsible and responsive offeror whose proposal is considered to be most advantageous to the Government, price and other factors considered.

LIMITATIONS: DAR 3-410.2

The user of multiple BOAs should be familiar with the limitations placed on the use of this method of procurement by the Defense Acquisition Regulation. Basic ordering agreements shall not obligate the Government to place future orders or contracts with qualified participants in the agreements, nor shall the agreements be used in any manner to restrict competition. Supplies or services may be ordered under BOAs under either of the following circumstances:

(1) It is determined that it is impractical to obtain competition by formal advertising or negotiation for such supplies or services: or

(2) After a competitive solicitation of quotations on proposals from the maximum number of qualified sources, other than a solicitation accomplished by using SF33, it is determined that the successful responsive offeror holds a basic ordering agreement, the terms of which are identical to those of the solicitation or so similiar as to have no impact on price, quality or delivery, and if a determination is made that issuance of a task order against the basic ordering agreement would not be prejudical to the other offerors. However, the choice of firms to be solicited shall be made in accordance with normal procedures. Firms not holding a basic ordering agreement shall not be precluded by the solicitation from submitting a proposal or quote. The existence of a basic ordering agreement shall not be a consideration in source solution.

The Government shall not make any final commitment nor authorize any work by the contractor pursuant to an order under the basic ordering agreement until prices have been established, unless the order establishes a monetary limitation on the obligation of the Government and either:

(1) The order is subject to the pricing procedures contained in the basic ordering agreement, or

(2) There is a compelling need of unusual urgency for the supplies or services, as when the Government would be seriously injured, financially or otherwise, if the supplies or services were not furnished by a certain date, and delay for establishment of process would preclude the contractor from achieving the required delivery date.

The basic ordering agreement shall cite the applicable negotiation authority and shall be subject to such reviews, approvals, determinations and findings, and other requirements, including synopses of the proposed procurement and contract awards, as specified in the DAR. Modification to the basic ordering agreement shall be by review and not by individual orders issued thereunder.

In a recompetition of the BOAs conducted this fiscal year using the same "sources sought" procedure, 33 firms submitted qualification statements. A source selection panel evaluated all oualification statements based on predetermined criteria in the following areas, technical approach, problem perception, technical experience, personnel background, and organization management. The results of this evaluation process were that 11 firms were selected as being qualified superior in the relevant acquisition management areas of business/financial management, international management, technical management, acquisition/program management, and logistics/support management. Interestingly, six of the eleven were firms that had not previously been qualified. Those BOAs previously awarded were terminated prior to the competition. Five firms requalified and were awarded new BOAs. This confirmed our perception of the migrating expertise in the "research and studies" business environment. The BOA source selection criteria remained unchanged from the previous 1979 competition.

OBSERVATIONS

As of Sept. 30, 1981, DSS-W had issued task orders encompassing all five research areas to five different firms, including four small business concerns. At least three offerors have been in the competitive range for each solicitation. The time elapsed from step one through step five for issuing a task order has averaged 84 days. This indicates that many delays inherent in the competitive process are still present with the multiple BOAs. However, the award of one competitive task order in 37 days encourages us regarding the benefits of this process.

Based on two years of experience in using multiple basic ordering agreements the following are the observations and lessons learned by the DSMC:

o By having the contractor propose a refinement of the statement of work and plan his technical approach under competition, DSMC no longer has to pay to get the contractor smart, and when the tasking contract is awarded, the contractor is ready and well prepared to start out on the issues.

o Contractor's qualifications do change as personnel with differing expertise and background move around in the research community.

o Contractors qualified under the BOA are responsive and highly motivated due to the competitive environment and pride most firms have in producing a quality product.

o The use of the multiple BOAs involves a substantial investment in time on the part of government and contractor. However, the reduction in time to award a contract for a research effort more than offsets this investment.

o The limitation of the size (5 to 10 pages) of proposals submitted by contractors simplifies the source selection. Contractors can't generalize but must be very specific in their proposals.

o Increasing the weight assigned technical cost aspects of proposal evaluation increases the quality of the product.

o In evaluating proposals the background and experience of contractor personnel assigned to perform the task should be a weighted criteria.

CONCLUSIONS

The multiple BOAs established for the contracted research program at DSMC uses competition to the maximum extent. Contractors compete for the BOAs and task orders. They are aware that past performance is an evaluation criterion for future taskings. In the event of consistently poor performance, their standing under the BOA would terminate at the annual review of the BOA. Based upon two years of experience on seven task orders, DSMC has experienced no cost overruns and has had quality products delivered in a timely manner.

REFERENCES

John S. W. Fargher, Jr., "Acquistion Research: A Management Tool, " Program Managers Newsletter, Vol VIII, No 3, May-Jun 1979, pp 4-5

Douglas M. Pollock, "Multiple BOAs: An Acquisition Tool", Program Manager Newsletter, Vol IX, No 6, Nov-Dec 1980, pp 15-16

USING CONTRACTOR MOTIVATION DATA IN ACQUISITION PLANNING: DECISION SUPPORT SYSTEM OPTIONS

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ABSTRACT

This paper outlines the need for better use of contractor intelligence and data on contractor motivation by government contracting personnel and program managers to increase the probability of contractor performance to government objectives. A blueprint for a decision support system is presented that includes relevant databases on specific contractors and industry outlooks, as well as analytical and simulation modules that provide users the ability to view contractor status and motivation from the contractor's perspective.

THE PROBLEM

In April 1981, Deputy Secretary of Defense Frank Carlucci highlighted 31 primary DoD acquisition goals. Several of these objectives focused on the interdependence between the nation's defense needs and industry. Among these are achievement of more economical rates of production, reduced costs, shorter delivery times, improved maintainability and supportability of systems, increased private capital investment, improved use of contractor incentives, and a stronger industrial base prepared, able and willing to support vital defense requirements.

Since the government has only limited means of persuasion to ensure a contractor's performance toward these goals <u>once a contract is awarded</u>, it is to the government's advantage to expend adequate time and resources <u>in the pre-award period</u> for planning and designing contracts that increase the probability of contractor performance to government objectives.

What is involved in this planning and design process? In addition to the basic evaluation of acquisition factors from the government's viewpoint, it must include analysis of the whole range of acquisition factors <u>from the contractor's perspective</u>, identifying what terms are likely to motivate successful performance at the same time as meeting DoD acquisition objectives. This must include analyses of current business conditions in the industry and future outlooks, the overall financial status of the contractor as well as segment-by-segment analyses, the contractor's market position in the industry and future opportunities, and the contractor's strategic business goals by segment. This information can help government contracting personnel be sensitive to contractor needs in developing contract terms and incentives, and thereby motivate contractor performance.

Two recent papers (Williams and Carr, 1981 and Blakely, Cohen, Lewin and Morey, 1982) develop exchange models of the contracting relationship that emphasize the behavioral interdependence between the government and contractor. These models suggest that the actions taken by each party are determined by the prioritized objectives of each, but these actions are constrained by the internal and external environments in which the parties operate. For the Government, these factors include appropriations, regulations, and political requirements. For the contractor, they include information about the market, financial status of the corporation, technological breakthroughs, and corporate style. Negotiations to achieve a positive-sum outcome for both sides dictates that it is in the best interests of the government <u>and</u> contractor to understand the other's objectives and circumstances under which these goals will be pursued. However, the authors point out that information about the contractor's objectives and environmental constraints is often limited and uncertain. Efforts toward improving government access to this information and increasing certainty about the contractor's motives will facilitate the efficient negotiation of contracts considered mutually beneficial.

OBJECTIVES

The objective of this paper is to recommend the blueprint of a decision support system for government contracting personnel and program managers that fills the information and analytical gaps concerning contractor motivation, constraints, and potential actions. The results of such a system will help minimize information uncertainty for the government in pre-awarded planning and hopefully, yield mutually beneficial contract terms.

BLUEPRINT OF THE SYSTEM

Management information systems (MIS) are currently being used to automate and track various aspects of the procurement process. They produce documents automatically, monitor procurement activities, transmit information, maintain audit data, and retrieve DARs (Varley and Spagnola, 1980). Decision support systems generally go beyond these database and retrieval operations to perform analytical and evaluative tasks as well. These systems are often developed to assist on complex problems that are semi-structured or where there is uncertainty. They usually include a model or algorithm that is based on evidence, expert methods, and judgment. The output of decision support systems are often a narrowed set of feasible options, the impact of alternate decisions, or the payoff of different courses of action. The ultimate decision is still left to the human analyst.

The decision support system proposed here combines several databases on company-specific and industry information relevant to the contracting environment, as well as several analytical models that assess the current status and future opportunities and problems of particular contractors as they would analyze them. In addition, a simulation model -- driven by contractor motivation factors -- is recommended that would enable program managers to assess likely contractor responses to alternative government incentive and contracting strategies. Overall, the system is intended to enhance the capability of program managers to tailor contracts to the special needs of a contractor while maximizing DoD acquisition goals.

DATABASES

The following types of databases would provide government contracting personnel and program managers with basic contractor and industry profiles to understand corporate financial status, business outlooks, and contractor motivation:

- Financial time series by contractor (for example, earnings, sales, share, ROI)
- Corporate/segment business objectives and priorities
- Executive incentive programs and targets by contractor
- Previous DoD contract performance by contractor, including special contract terms, negotiation strategies used, cost overruns, delivery history, and quality performance
- Corporate characteristics by contractor, including number of employees, organization structure, product and customer diversity, technological skills, capacity utilization, personnel turnover, R&D expenditures, capital investment, and balance sheet idiosyncracies
- Industry characteristics by segment, including competition, market size, growth potential, diversity, seasonality, price sensitivity, and technological change.

These types of data are available through public sources and government contracting records.

ANALYTICAL MODULES

The purpose of these modules is to provide program managers with a view of contractor motivation from the contractor's likely perspective. A sensitivity to contractor financial status, objectives, and targets can aid the government in designing an effective contract strategy that has a high probability of ensuring successful contractor performance, because contractor needs are satisfied by the terms of the contract.

1. Portfolio Analysis. A widely used technique for strategic business planning is portfolio analysis. This approach assigns a strategic role for each product based on market growth rates and market share relative to competition. By comparing the roles of different products offered by the same company, the entire "portfolio" of products can be analyzed in terms of where investment opportunities lie, where the cash for investment is likely to arise, and which products should be eliminated. Figure 1 presents a typical portfolio matrix.

How can this type of information be used by program managers? Many of the larger defense contractors today are conglomerates, producing multiple products that support the requirements of different military services as well as commercial clients. An Air Force program manager, for instance, might be dealing with a corporation to purchase aircraft engines, but that same firm might also have divisions that produce systems for Naval vessels and components for spacecraft. A portfolio analysis could indicate that the firm has a dominant market share in aircraft engines, but the market is growing slowly (a "cash cow"). In comparison, the firm's Naval systems may have high market growth potential but low share ("problem children"). Corporate planners are likely to analyze the long-term implications of this situation and reduce investments in engines and use available cash derived from that division to underwrite R&D, capital expenditures and marketing of the Naval systems.

Under these circumstances, the Air Force program manager attempting to purchase engines may find it difficult to gain corporate commitments to invest in new engine designs that mean high expenditures in R&D and facilities. However, a Navy product manager might receive just the opposite reception. By conducting a portfolio analysis during the pre-award phase and planning contract strategy, the Air Force project manager might decide to emphasize multi-year funding options, foreign sales possibilities, and commercial product offshoots to indicate future market growth in a previously sluggish industry segment.

2. Environmental Assessments. This strategic planning technique evaluates the opportunities and problems of a firm's business segments relative to market factors, competition, financial and economic factors, technological factors, and socio-political factors. The "attractiveness" of a market to the company can be quantified in a composite weighted index that takes into account a variety of environmental factors. This index is then contrasted with an index of business segment position relative to the competition.

The results of the analysis for the corporate planner is an assessment of investment opportunities and strategies.

For the program manager, this analysis will assess the strengths, weaknesses, opportunities and constraints of each business segment in a company relative to the environment. Where the environment is causing hardship for a particular business segment, contract terms such as improved cash flow provisions and risk sharing to modernize the industrial base might improve contractor performance once a contract is underway.

3. Contractor Motivation Simulation Model. This proposed simulation tool would enable program managers to ask "what if" questions about the impact of various contract terms and incentives on likely contractor-specific reactions, given the economic and industry environments and contractor motivation. The purpose of this simulation is to provide program managers with a systematic device to evaluate and select contract terms that are tailored to the situation and likely to be effective in maximizing DoD acquisition goals. Such a tool could be used appropriately by program managers in charge of major acquisitions to assess the likely acceptability of alternate contract terms and plan for contingencies, as well as by personnel who are in training to be program managers to provide them with realistic scenarios and immediate feedback of results.

In a recently completed study by this author for the Air Force Business Research Management Center (Spector, 1981), data on contractor goals and motivation for 50 large defense corporations were collected and analyzed. The intent of the study was to determine how this type of information could be used by Air Force acquisition personnel to achieve its objectives through contracting, basically by providing contracting personnel with additional leverage in tailoring contract terms and incentives.

Current data on contractor motivation were gathered on each company that included executive incentive programs (types of plans in force, rewards available, eligibility, and most importantly, award criteria and targets that must be achieved to obtain the rewards), corporate and divisional strategic business goals, and management climate. These data were collected from public sources and through direct communication with the firms. Several generalizations concerning contractor motivation were developed from this exercise:

- A general hierarchy of industry goals can be postulated (see Figure 2).
- Corporations have several "basic" goals in common that are short-term, tactical and highly quantitative in nature. Most common among these is growth in net earnings.
- Corporations also have "second-order" goals that motivate longer-term strategic actions. They tend to be more qualitative in nature and are open to negotiation and tradeoff.
- Corporations do not pursue only one goal at a time. They often strive to achieve a mixture of basic and second-order objectives simultaneously, thereby making tradeoffs among goals almost inevitable. The growing emphasis in corporations on setting long-term objectives for managers has produced a phenomenon where even the "basic" short-term goals may be compromised to achieve more critical long-term survival goals such as customer diversification and productivity.
- These corporate goals are translated into personal targets for managers and executives through internal corporate incentive programs. Many bonus and stock option plans motivate managers to short-term financial goals. Most companies also have long-term performance incentives that reward achievement of long term growth, diversification, and productivity goals.

How can these detailed data and generalizations on contractor motivation be used by program managers to customize contract terms? Figure 3 conceptualizes a simple exchange model. To achieve their objectives, each party designs and pursues specific strategies. Contractors attempt to maximize their hierarchy of corporate and personal goals and determine their willingness to take risks or make tradeoffs among these goals. The government attempts to maximize its acquisition goals by designing and offering contract terms and incentives that are likely to motivate and assure successful contractor performance on the job. The more information each party can amass of the other's priorities and goals, the less uncertainty and greater efficiency there will be in achieving a mutually beneficial outcome to contract negotiations. For example, a favorable contractor response can be anticipated <u>if</u>:

- <u>The government knows that</u> ...
  a company is committed to promoting the use of quality circles and employee participation in decisions

  <u>and offers terms that</u> ...
  allow for flexibility in production approaches, product quality, and reliability assurance.

- The government knows that ...
  a company seeks diversification and commercial product spinoffs

  and offers terms that ...
  enable product ownership.

- The government knows that ...
  a company requires modernization of its industrial base to improve productivity, lower costs, and remain competitive

  and offers terms that ...
  provide for risk sharing with the government.

- The government knows that ...
  a company has serious cash flow problems

  and offers terms that ...
  provide for advance or progress payments or identify program continuity.

The proposed simulation tool would enable users to establish various contracting scenarios that include government acquisition targets, the contractor, the type of procurement, and the economic environment. The system would simulate the impact of various contract terms and incentives on probable contractor reactions and calculate the likely benefits and payoffs to both parties of using specific terms. The linkages and parameters of the underlying model could be established by analyzing data on previous acquisition cases, evaluating surveys on contractor motivation, and eliciting probabilities and utilities from a sample of relevant contractor and government personnel.

As with most simulations, the program manager would benefit from using such a system by testing various contract strategies <u>before</u> implementing them in the real world. For example, one program manager could test the likely effectiveness of different combinations of contract terms, test innovative terms, identify potential tradeoffs that contractors might find acceptable, test the sensitivity of timing on negotiations, and observe the differences in contractor reaction under various scenarios.

CONCLUSIONS

This paper has provided several recommendations on how data on contractor motivation and contractor intelligence can be used to achieve DoD acquisition goals. The use of decision support systems by government contracting personnel and program managers appears to be the most appropriate vehicle for planning contract strategies in the pre-award period, given the uncertainty of information on contractor motivation, the multiple factors that simultaneously impact on contractor motives and actions, the wide range of contracting scenarios that can exist, and the need to test a variety of contracting options under these scenarios.

REFERENCES

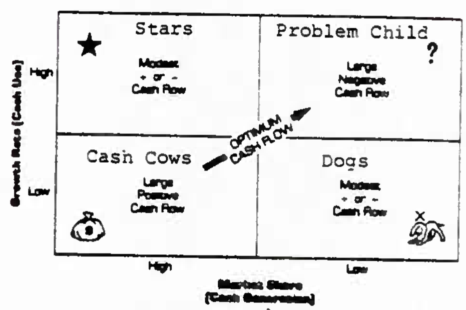
Blakley, D., K. Cohen, A. Lewin, and R. Morey (1982), "Assessing Defense Procurement Policies" <u>Simulation</u>, March.

Spector, B. (1981), <u>Study of Contractor Internal Reward Structures</u>. Final Report under Contract No. F33600-81-0603, December.

Varley, T., and J. Spagnola (1980), <u>Results of the Ninth Annual DoD/FAI Acquisition Research Symposium</u>. USGPO, October.

Williams, R., and D. Carr (1981), <u>Contractor Motivation Theory and Applications</u>. Fort Lee, VA: U.S. Army Procurement Research Office, March.

FIGURE 1
Portfolio Analysis Matrix



Source: D. Abell and J. Hammond (1979) <u>Strategic Market Planning</u>. Englewood Cliffs, NJ: <u>Prentice-Hall, Inc.</u>, P. 178

FIGURE 2
Hierarchy of Industry Goals

Basic Goals

1a. Growth in:

- Net earnings
- Earnings per share
- Return on equity, assets and capital
- Volume sales
- New contract bookings.

1b. Company Survival (at a minimum)

Second-Order Goals

2. Financial Management Goals

- Tighten financial controls
- Strengthen cash flow
- Be low cost producer
- Utilize capacity.

3. Investment Goals

- Pursue acquisitions and diversity
- Increase R&D and capital spending.

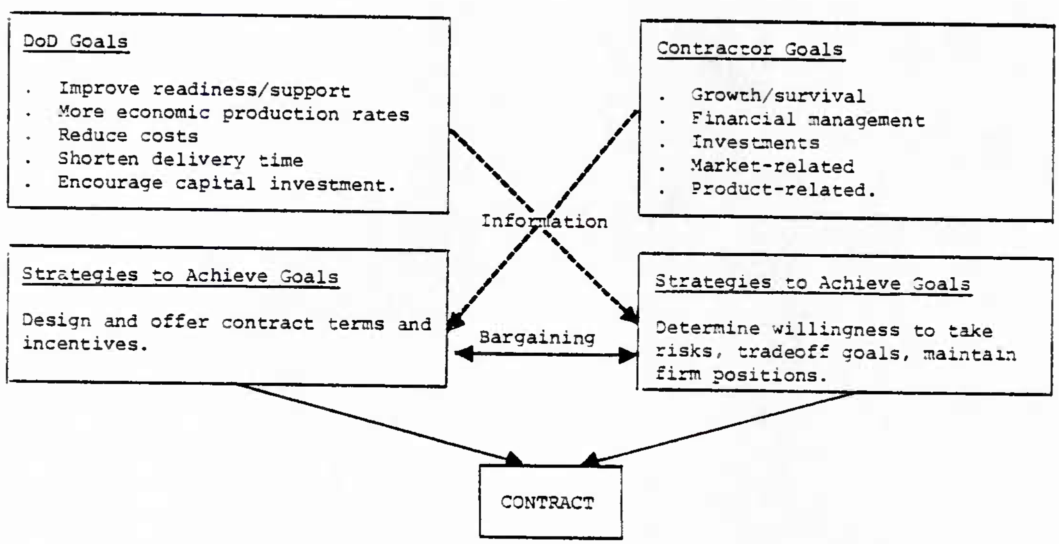
4. Market Goals

- Diversify customer base
- Develop long-term relationships with current customers
- Develop dominant position in field
- Improve public image.

5. Product Goals

- Be technical innovator
- Spinoff commercial products
- Develop company service and reliability reputation
- Develop capabilities and workforce.

FIGURE 3
Exchange Model



PANEL F

NEW DEVELOPMENTS IN OMB CIRCULAR A-76

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Deputy Associate Administrator for Major
Acquisitions and Procurement Strategies
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LTC Calvin Cheatham, USA
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MAJ Curtice E. Holland, Jr., USA
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Mr. William Russell
Division Vice President
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NEW DEVELOPMENTS IN OMB CIRCULAR A-76

The panel presented certain proposed changes to Office of Management and Budget (OMB) Circular A-76, which deals with the Government's policies on contracting out for its requirements. The proposed changes to the Circular, itself, and to its attendant Cost Comparison Handbook reflect an effort to streamline the cost comparison process and to make the contracting out program more workable and effective. The changes currently under consideration are scheduled to be released for a sixty-day public comment period in the near future. Upon receipt of comments and any resultant modifications to the changes originally proposed, the final version of the revised circular will become effective in October 1982. In a sense, the Federal Acquisition Research Symposium served as an early test of reactions from the acquisition community to the proposed changes. Panel attendees did raise numerous questions and issues concerning the revised circular, and there was a lively exchange of views between the panelists and the attendees. Of particular concern was the impact of the Government's contracting out policies on government-owned, contractor-operated armament plants. All in all, the panel's proceedings illustrated the controversial nature of the contracting out policies reflected in OMB Circular A-76.

PANEL G

SOURCE SELECTION

PANEL CHAIRMAN

Dr. Thomas J. Keenan
Director of Procurement and Production
US Army Troop Support and Aviation Materiel
Readiness Command

Identifying Future Requirements and Potential Small Business Contractors With Resultant Cost Savings Mechanisms

Ray Dellas: Defense Logistics Agency (DLA-U), Alexandria, VA
David Rothenberg: Inductive Inference, Inc., New York, NY
Wallace Weiss: Defense Logistics Agency (DLA-LOO), Alexandria, VA
Will Risden: Dun and Bradstreet, Inc., Rockville, MD
Joe Sebasteanski: University Computing Company, New York, NY

This paper suggests that a method, currently being used to develop subsistence demand forecasts at The Defense Logistics Agency, be used to evaluate the effects of small business participation in the government procurement process. We describe how this method can be used to analyze both the effects upon the costs of a variety of items purchased by selected federal buying centers and the effects upon small business growth and survival. The following results are produced:

1. identification and characterization of those types of procurement items
   a. for which small business participation in the procurement process has been accompanied by cost reductions.
   b. for which small businesses have been awarded prime contracts.
2. characterization of small businesses that
   a. have been awarded prime contracts.
   b. whose participation in the procurement process has been accompanied by cost reductions.
3. Construction of a model that can be used to identify individual firms whose inclusion in the bidding process will likely be accompanied by cost reductions.
4. Evaluation of the effect of acquiring government contracts upon the growth and survival of small businesses.

DATA

Such historical procurement data as is available from various government buying centers and other sources (e.g.- FPDC individual contract action reports) are combined to form a data base of individual procurements, to be called the procurement data base. The following information is, when available, included for each procurement within the most recent five years.

a. type of item; to be specified by Standard Industrial Code (SIC's). This is in 7 fields; the first is the 1-digit SIC code, the second is the 2-digit code, the third is the 3-digit SIC code, etc. Both the specific item and its more general classifications are thereby specified.

b. cost per unit of the item (based on prior similar procurement).

c. procurement quantity.

d. date; e. delivery lead time.

f. solicitation complexity (e.g.- level of assembly).

g. end use, e.g.- aircraft part, vehicle, ordinance, etc.

h. The number of firms that participated in the bidding process.

i. The number of firms (in g. above) that were small businesses.

j. The size and location of the firm that was awarded the contract.

k. The size and geographical distributions of firms that participated in bidding.

l. whether or not the procurement was a small business set-aside.

This data is arranged in a sequence such that information on current and prior procurements of the same item type are sequential according to date and may be treated as a unit of information, to be called a data unit. A data unit, therefore corresponds to each type of item.

Historical data descriptive of individual firms is available from commercial sources, such as Dun and Bradstreet. As much as five consecutive years of data of the following kind is available for a major portion of American firms:

a. income and balance sheet information.

b. operating information (e.g.- sales, number of employees, etc.)

c. financial ratios.

d. norms of financial ratios for the firm's industry, location, and size.

This data base of firm-specific information will be referred to as the business data base.

Other historical data, to be called econometric data, is available from government sources (e.g.- Country Business Patterns, Department of Transportation and Census, etc.). For each industry (i.e.- Standard Industrial Code or SIC) and geographical location, this includes historical information such as:

a. consumer price index

b. gross national product by product type and sector.

c. growth in industrial sector.

d. number of businesses in sector.

e. employment.

f. inflation rate.

g. consumption by product type.

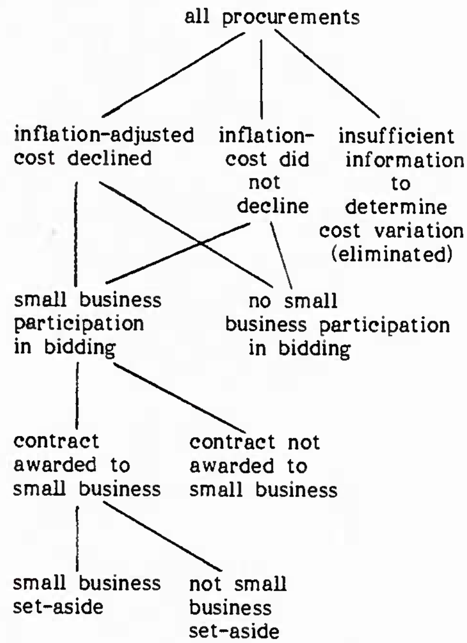
The business data base is expanded so that the local econometric data corresponding to each firm is appended to its financial and operating data. Also, by matching against the procurement data, the information for each firm is augmented by whether or not the firm received government contracts. on which products, when, and for what amounts.

Both the procurement data bases and business data bases will be incomplete, contain random data errors and large amounts of missing information. This is accomodated by the proposed method.

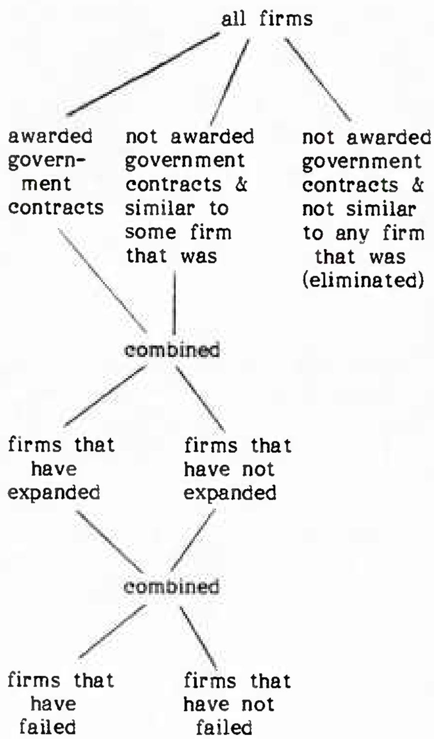
PREPARATIONS FOR ANALYSIS

The procurement data base is examined to identify those items for which the inflation-adjusted cost has declined over successive procurements. These are separated from the remainder, from which data units where there is insufficient information to determine cost decline or increase are eliminated. Each of these two classes is partitioned into two classes of data units, (i.e.- types of items); those where small businesses at some time participated in the bidding process and those where such was not the case.

The former class is subdivided into those data units where at some time a small business was awarded a contract, and those where no contract was awarded. The former of these collections is further subdivided into those data units where the procurement was a small business set-aside and those where it was not. Variables that specify membership in each of these classes are appended to the information in each data unit.



All except small businesses are eliminated from the business data base. The remaining data is partitioned into two classes of firms; those that, in the recent past, were awarded government contracts, and those that were not. All firms in the latter class to which there corresponds no firm in the former class with the same (primary) SIC and same size category are eliminated from the latter class. That is, of those of the firms that were not awarded contracts, we retain only those that resemble some firm that was awarded a contract. The collection of all firms remaining in the combination of these two classes is first independently partitioned into the class of firms that have grown (in number of employees) and the class of those that have not. Then the collection is independently partitioned into the class of firms that have failed and the class of those that have not. That is, the following three independent partitions (shown one above the other) of the business data base. are performed:



ANALYSIS METHOD

Any method that, by means of data examination, characterizes any of the classes we have constructed in terms of the data, must construct a model from among an enormous number of possibilities. That is, the number of characteristics (i.e.- variables) to be considered is very large, and their interactions and the ranges within which they occur is unknown. The number of possible models is very large relative to the available data. Furthermore, the variables are hardly independent. Stepwise discriminant analysis techniques have often been applied in such cases but have produced dismally unreliable and misleading results (see Reference 1).

Statistical methods are designed to test, by the examination of data, hypotheses formed prior to data examination, and are not validly used for model construction by means of data examination. The inadequacy of stepwise methods is clearly revealed by the fact that stopping criteria fail to consider the number of candidate models (which is determined by the number of variables available for inclusion in the model). Most stopping criteria depend exclusively upon the reduction in variance due to the last variable included in the model. Stepwise cross-validation procedures and "leaving- one-out-methods" do not resolve these problems. (see Reference 2).

The method here proposed is specifically designed for model construction by data examination. A realized model is defined as a model together with a measure of how well it performs on (i.e.- fits or discriminates) the available data sample. All realized models are organized into an hierarchy of complexity classes, so that, assuming that a model has the highest performance measure of any in its complexity class, the likelihood that this measure is spurious (i.e.- favorably biased) increases as its complexity class becomes more inclusive. An unbiased measure of performance (and hence of probability of error) is derived by logic resembling that customarily used for the construction of confidence intervals (prior probabilities are not required). This unbiased estimate governs model selection. Often the result of the search for a model is that no reliable model exists; that is, no unbiased performance estimate for any model significantly improves on random classification.

The proprietary software realization of this technique (called ADAM, an acronym for Adaptive Data Analysis Method) is being used to develop models for forecasting the demand for secondary items at the Defense Logistics Agency and has been applied, with remarkable success, to forecasting commercial loan evaluations (see Reference 3). The method is insensitive to random data errors and missing data values. Variables need not be independent of one another. Multivariate time-series data and both continuous and discrete variables that do not vary with time can be simultaneously modeled.

When ADAM is used for discriminating classes, the following outputs are produced:

1. A collection of patterns that corresponds to each of the classes. Each of these patterns is a combination of conditions that may or may not apply to a given data point. Each of these conditions states that the value of one of the candidate variables (i.e.- those available for inclusion in the model) lies within a given range (e.g.- $.3 \leq x \leq .7$). Typically, a pattern includes only a few such conditions, all of which must be satisfied in order for the pattern to apply to a data point (i.e.- a procurement data unit or the characteristics of a given firm and its environment). Typically, a data point satisfies several patterns, and to each such combination of patterns there corresponds a probability that the point lies in each of the classes of interest. A pattern is generally easily understood when its constituent conditions are expressed in English.

2. The patterns are arranged in an hierarchy of groups of patterns wherein patterns that are more likely to simultaneously apply to the same data points are grouped together and those that rarely apply to the same firm are in separate groups. The groups are progressively subdivided as one proceeds down the hierarchy. Each group characterizes a type of individual and the entire hierarchy constitutes a taxonomy of individuals with respect to the factors that determine membership in the various classes of interest. An examination of the hierarchy clearly reveals these factors and their interactions.

3. Each data point presented to ADAM is assigned a probability of being a member of each of the classes of interest. The patterns that apply to that data point and the corresponding positions in the hierarchy are specified.

ANALYTIC PROCEDURE

ADAM is used to discriminate each of the following pairs of classes:

1. procurement data units where inflation-adjusted cost declined from those where it did not.

2. small businesses that were awarded government contracts from those that were not.

3. Small businesses that have grown from those that have not.

4. Small businesses that have failed from those that have not.

These four analyses produce a set of patterns corresponding to each of the eight classes involved. Each set of patterns is organized into an hierarchy of groups of patterns where each group defines the characteristics of a significant sub-category of the class of interest. These characteristics are those that account for membership in the class. In addition, each individual in the data samples is placed in the hierarchy. An examination of the individuals in each group in the hierarchy facilitates intuitive understanding of the significance of the patterns that define the group.

An analytic technique is included within ADAM that specifies forms for arithmetic models that may be used to estimate the value of a dependent continuous variable (e.g.- cost reduction) rather than simply assign class membership (e.g.- declining costs or rising costs). Standard statistical methods may be used to determine the parameters of these models. This technique is here used to develop a model that can be used to forecast cost variations as a function of characteristics of items being processed and of firms included in the bidding process. More significantly, a model is constructed that can be used to identify individual firms whose inclusion in the bidding process will likely be accompanied by cost reductions.

RESULTS

Declines and increases in inflation-adjusted costs of procured items are characterized with respect to traits of the item and the procurement. Included among the latter, as candidates for inclusion in the model, are whether or not small businesses were currently or previously included in the bidding process, whether such procurements, if any, were small business set-asides, etc. The inclusion, if any, of these factors in the patterns generated by the analysis, define whether or not these factors are relevant, for which types of items, under which conditions, and the dimensions of such relevance.

Similarly, small businesses that are awarded contracts are characterized in terms of traits of the business' finances, operations, the economic environment, procurement policy and items being procured. A classification of small business relative to their ability to successfully acquire government contracts is also provided and correlated with corresponding cost savings, if such exist. The inclusion of various of the candidate variables in the patterns generated by the analyses defines the nature, context, and extent of their relevance. A model (possibly unrelated to firm size) that can be used to identify firms whose inclusion in the bidding process will likely result in cost reductions is produced. Such a model can also provide guidance to firms interested in participating in bidding.

A similar characterization of the effect upon the growth and survival of small businesses in various locations, industries, and various sizes, of successful procurement is produced. This can serve as a guide for procurement policy and as a tool for business planning.

It would be of great value to include the participation of small business in acquiring subcontracts as well as prime contracts in such a study, but the acquisition of pertinent data seems, at present, excessively difficult and expensive. The limited study described, however, should provide much valuable information that reveals the effects upon procurement costs of various procurement policies and the nature and extent of the effects of these policies upon small business growth and survival.

REFERENCES

1. R. E. Frank, W. R. Massy, and D. G. Morrison, Bias in Multiple Discriminant Analysis, Journal of Marketing Research II, August 1965.

2. S. Raudys. Comparison of the estimates of the probability of misclassification, Proceedings of the Fourth International Joint Conference in Pattern Recognition, Kyoto, 1978, pp. 280-282.

3. D. Rothenberg, Predicting the status of your loan...Three years from now, Journal of Commercial Bank Lending, Robert Morris Associates, April 1980, pp. 28-41.

SOURCE SELECTION, MONITORING, AND CONTRACTOR PAST PERFORMANCE

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ABSTRACT

This study was directed to a brief review of the experience of industry and the non-military governmental sector in the use of information on past performance in the source selection and contractor monitoring processes. The study was conducted in two phases over a period of eleven months. The first phase was primarily data gathering in the form of interviews with selected decision-makers and an examination of relevant documentation. The second phase was concerned with the assessment and analysis of the information obtained.

In general, it was found that there is considerable variety in the use of information on past performance across the non-military governmental sector, but the sharp distinctions are between the governmental and commercial (private) sector. A major distinction is in the presence of specific legal constraints in the governmental sector, and related indirect effects of those constraints. However, the direct effect of the constraints is primarily with respect to the determination of "responsibility," which is of little significance in the overall source selection process. In both the governmental and commercial sector, it appears that the most effective use of past performance information is in its contribution to the reduction of uncertainty and risk with respect to the major factors considered to determine future performance; and, in this process, the commercial sector is generally more efficient and effective because of the absence of (perceived) constraints on its use.

INTRODUCTION

In commonsense usage, "past performance" (PP) refers, generally, to the behavior (or the immediate effects of behavior) of some specific person (or set of persons, including "organizations") as of some time prior to the time of observation and is distinguished from "future" (planned, predicted, expected, desired, proposed) performance. Another broad use of PP, and the one of particular interest here, is its contribution to the prediction or estimate of the future performance of a specific person, etc. The concept of PP, in government procurement, takes on some additional specialized meanings, resulting in its use as a "term-of-art." This development, as will appear later in this study, provides some desired specificity in formal reference, e.g., laws or regulations, but also introduces confusion and ambiguity when applied, without distinction, to situations where the broader context is relevant.

The study upon which this paper is based was sponsored by the Air Force Business Research Management Center, Wright-Patterson AFB, OH 45433, under contract No. F33615-80-C-5107 with International Applied Science and Technology Associates, Inc. (IASTA), Evanston, IL 60201. The first phase of the study, of five months duration, consisted of a review of existing laws and regulations, a review of commercial industry and non-military Government agency practices, interviews of selected decision-makers, and the preparation of a data/information gathering and analysis report. The second phase, of six months duration, consisted of an assessment of the information gathered and preparation of a final report.

The primary "existing laws and regulations" were the relevant provisions of the Federal Procurement Regulations (and the Defense Acquisition Regulations); this was supplemented by review of 117 Decisions of the Comptroller General obtained through FLITE, documents from six non-DOD government agencies (including handbooks, "regulations," sample RFP's and contracts, and other documents describing source selection practices), four commercial procedures manuals, over 100 documents and microfiche obtained through a DLSIE search, and approximately 100 additional reports and articles obtained through search of libraries and personal collections.

More than thirty interviews were conducted, almost equally divided between commercial and non-military federal agencies. In most cases, the individuals were directly and actively engaged in the source selection process. The commercial interviewees were drawn primarily from major manufacturing organizations, with emphasis on high technology, including electronics, medical, engines, pharmaceutical, chemical, steel, and food. These were complemented by a major airline, a utility, a trade association, and two local government agencies. The non-military federal agencies interviewed include the Departments of Commerce, Education, Energy, Housing and Urban Development, Interior, and Transportation, the National Aeronautics and Space Administration, and the General Services Administration.

In the present study, the background information and statement of objectives available at the beginning of the study provided the basis for an extensive list of questions (and, at least, in some cases, preliminary hypotheses) which provided the initial framework and the specific guides used in carrying out the study. The major analytical activity waa a progressive reexamination of the extensive notes taken during interviews, a rereading of documents collected, particularly the voluminous collection of excerpts from Decisions of the Comptroller General, and cross-annotation of the notes which were developed in terms of questions ("issues") and working hypotheses ("findings").

Because of space constraints this paper will be limited to a presentation of the major general findings of the study and the specific findings related to source selection. In the full study, in addition to these findings, there appear other findings related to specific areas, as well as a discussion of the issues which provided a basis for the findings. A complete listing of issues and findings appears at the end of this paper. Also included in the full study, but not in this paper, are more detailed discussions of the study objectives, design, data gathering and analysis, applications, and 43 selected references.

GENERAL FINDINGS

WITH THE EXCEPTION OF ONE SPECIFIC CONTEXT, "PAST PERFORMANCE" IS DEFINED IN PRACTICAL TERMS

The one exception, to be discussed below, is the use of "past performance" (as a separate factor) in making determinations of "responsibility" in the governmental sector. Otherwise, there appears to be no clear, explicit demarcation of what is to be considered in PP. Again, with the exception noted, neither individuals interviewed nor documents consulted indicated that PP was something specific and identifiable, with rules for use or definition. Beyond its commonsense limits, it appears to have no special meaning.

When placed in a practical context, e.g., "How do you get and use information on past performance?", the limits begin to appear. With respect to time, <u>current</u> and <u>recent</u> performance clearly are included; there appears to be a consensus that performance <u>some years ago</u> is not useful (relevant), with the possible exception of performance which has not changed (or is not expected to change), e.g., an individual with a strong personality. The relevance in terms of similarity of programs (and, sometimes, where the same individuals and organizational elements are involved) does not appear to be as clear. Where there is some significant difference, most people appear to be uneasy, at least in admitting they will use the information; and, even where there is great similarity (or identity), there appears to be a range of positions. Here, the range appears to be less in the commercial sector, reflecting a belief that past performance is a good indicator of future performance. In the governmental sector, a common reaction is that it is a "new ball-game," that conditions may have been different before, we don't really know what happened, that we might have trouble defending a decision based on use of PP.

The general issue of "quality" of information is, again, treated very practically. First-hand information, information which appears consistent and reasonable, and information which is consistent with other information received are given more weight. This is reflected in the overwhelming preference in the commercial sector for site visits, usually called vendor surveys. Purchasing personnel, with some minor exceptions, consider a visit to the supplier's plant for a first-hand look at what he is doing (which reflects what he has done) very important; and they supplement this with, in many cases, formal, detailed ratings, and references to other purchasers, general reputation, and so on. Where it is a technical purchase, this is supplemented by visits of technical personnel, and a continuing interchange.

Whether PP includes "good" as well as "bad" performance depends upon the context, although it appears that the dominant reference is to "bad" PP. Where the issue is pre-screening (selecting prospective bidders in both sectors, and determining "responsibility" in the government sector), the overwhelming reference is to "bad" PP, and, in the governmental sector, explicitly so. Although it may be argued that "bad" PP is a measure of capability, and, thus, "good" PP is also a measure of capability, the practice appears to be uniform in both the governmental and commercial sectors to use the term "capability," or similar terms descriptive of the factor of interest, rather than to refer directly or separately to "good" PP. Where the issue is evaluation of competing proposals, there appear to be sharp distinctions between the commercial and governmental sectors. In the commercial sector, the pre-screening process nearly always eliminates "unacceptable suppliers," so the emphasis is on the comparative evaluation of relative weak and strong points, drawing upon both "good" and "bad" PP. At this point, PP becomes a predictor of how likely the supplier will perform as required. In the governmental sector, "bad" PP may appear as a separately identifiable factor and, usually, a less important one (and treated differently); as such, the distinction is between "bad" and "not bad" PP, without further distinctions between "neutral" or "unknown" and "good". In the governmental sector, as in the commercial sector, both "good" and "bad" PP may be used in evaluating other factors, e.g., technical competence, management capability, although, again, the term PP is usually identified with "bad" PP only. It appears likely that "good" PP is considered, and, perhaps, given more consideration than "bad" PP, particularly if there is a separate factor for "bad" PP. In contrast, however, to commercial practice, there appears to be much more uncertainty (and an unwillingness to admit) that "good" PP is specifically considered. It is likely that "good" PP is an important contributor to the evaluation process, at least as important as "bad" PP; it appears that evaluators are "more comfortable" in generalizing from "good" PP, and it is easier to reconcile with assertions in the proposal. In contrast, the uncertainty and hesitancy in acknowledging the use of "good" PP may lessen the effort to collect (including specifying its importance in the RFP) and the weight given in the evaluation process. An important corollary is that prospective (and current) suppliers believe that they can be punished but not rewarded for PP; this is a point which appears in comments from industry and is described as one of the ways in which commercial practice is superior to governmental.

EXCEPT IN THE PRE-SCREENING PROCESS, "PAST PERFORMANCE," AS A SEPARATE, IDENTIFIABLE FACTOR, IS OF LITTLE INTEREST IN THE COMMERCIAL SECTOR AND IS RELATIVELY UNIMPORTANT IN THE GOVERNMENTAL SECTOR

It is important to make clear that information on PP is not, itself, unimportant in either sector. The point here is that it is not important when used as a separately identified input to a source selection decision, at least those involving substantial technical uncertainty.

Interviewees in the commercial sector generally directed their responses to factors, such as "capability," and described their PP practices in terms of how PP contributed to the evaluation of these other factors. It seems clear that PP is an important consideration, but primarily as an indicator in evaluating other, specific performance factors. This near absence of any separate consideration of PP carries over in the several manuals obtained and in general texts and articles on commercial purchasing. In the governmental sector, the reaction was similar, except for some concern for requirements to treat PP separately. The pre-screening requirement concerning "responsibility" was often identified with PP, usually followed with comments to the effect that it was not very important, either because it was difficult to use (and defend) or because the set of bidders (on significant technical procurements) were all likely to meet or exceed minimum requirements.

In the governmental sector it was not uncommon to include a separately identifiable factor (or factors) to assess "bad" PP, but the importance of this to the overall evaluation varied. Characteristically, the PP factor was listed not only separately but in a separate section, and evaluated differently, and, in some cases, reported separately. In one agency, where the interviewee considered PP an important factor, the separate listing was the last of eight factors, and last in weight and importance (although the interviewee made clear that both "good" and "bad" PP were considered in evaluating other factors). Another interviewee said the question is really "can he do it," not what he did somewhere else, under other circumstances. The only direct support for separate use was a suggestion that PP might serve as a "tie breaker," although this was advanced with some hesitation.

While not within the scope of this study, some examination of the DOD practice, and, particularly, the Air Force was made. Air Force and Air Force Systems Command regulations spell out the separate use of PP information, and there has apparently been considerable discussion (and examination) of this issue. From various sources, including a 1979 memorandum of the Council of Defense and Space Industry Associations (CODSIA), it appears that the issue has been posed in terms of whether PP should be considered a "major ranked factor" (i.e., separately) or "as a general consideration" (i.e., as an indicator of or contributor to the evaluation of other factors). While there may be significant additional progress in the last two years, a further inquiry here was considered beyond the scope of the study.

It should be noted that PP, as a separate consideration, may have important uses, other than in pre-screening. These may include decisions concerning disputes, approvals, award fees, and the like; however, none of these was considered within the scope of the study.

INFORMATION ON "PAST PERFORMANCE" CONTRIBUTES SIGNIFICANTLY TO THE EVALUATION OF OTHER FACTORS

Central to the source selection process is the identification of characteristics (factors) which are considered to be important in the successful carrying out of the contract. These factors generally include a combination of important problems to be overcome and capabilities necessary in their solution, as perceived by the purchaser. The bidder's understanding of the problems and his proposed approach, particularly in technical areas, are important indicators of his likelihood of success, but they may not, standing alone, assure that he has the capability to perform. It is in assessing his capability to perform, including the technical areas, that PP information may contribute in several ways. In the specific sense of the record of performance on previous contracts, his past failures (or successes) in solving technical problems, or controlling costs or schedules, or, in general, meeting past commitments may contribute to the evaluation of his present proposal. More generally, his present (and/or projected) capabilities are themselves evidence of past performance, e.g., his financial capacity is likely to be based upon an extended history of past performances, his technical capability a function of the past performance of his technical staff.

The above comments reflect, it is believed, the general sense of the commercial (and governmental) sector, although not in that exact form. The great variation in specific factors and the kinds of information used to evaluate the supplier's capability with respect to them reflect the diversity in products, suppliers, and purchasers, and their differential perceptions of the uncertainties faced in predicting the likelihood of successful future performance, particularly in complex, technical procurements. If the proposal and a site visit provide sufficient information to make a confident evaluation, no additional inquiry into specific PP may be made, with the possible exception of some general, routine confirming checks. Where the type of procurement is expected to be difficult, or where past experience indicates problem areas (with the particular supplier, or in general), additional examination of specific PP may be warranted. Generally, present capability (as evidenced by the proposal and site visits) is the focus, with implicit recognition that past performance may contribute to its evaluation.

The governmental sector appears to parallel the above, but not as clearly. For example, AFSCR 80-15 (31 Dec 1974) sets out, in paragraph 2-7, the concern with the bidder's "Understanding (of) the Problem" and his "Soundness of Approach" and, separately, in paragraph 2-8, discusses measures of his capability, i.e., "Experience." This separating of the treatment of capability (and the further separating of the treatment of different types of capability, i.e., technical versus management versus cost and financial) apparently is at least partly responsible for the hesitation and ambiguity in the use of PP in the evaluation of other factors. One interviewee pointed out that they always ask for the record of "experience" of key personnel, evaluate it separately, as required (although it apparently doesn't contribute as such to the evaluation), and then use the information in evaluating the technical factors. While the practice varies, in agency after agency, it appears to be the practice to not only ask for specific references to PP (e.g., biographies of key personnel, lists of relevant prior contracts, and names of cognizant purchasing and technical personnel) but to examine them (including telephone calls to references) and use the information in evaluating the main factors.

If there is a systematic difference between commercial and governmental practice, it is in the sense of whether the use of PP for this purpose is "proper," and this may be a function of the constraints upon the separate use of PP in pre-screening, i.e., determination of "responsibility." Government personnel (correctly) perceive that the use of PP information in the determination of "responsibility" is subject to considerable controversy, and the likelihood of formal protests where both the process used and the determination made is examined (and "often" disapproved). This additional exposure to unpleasantness is (correctly) considered to be more likely when PP is used as a separate factor in the evaluation, and is (incorrectly) considered to be more likely where PP is used as part of the evaluation of a major factor (particularly, a technical one). A similar perception is apparently shared by suppliers to the government, as noted in the previously referenced CODSIA report. A cursory review of a large number of Comptroller General's Decisions makes it apparently clear that his willingness (and ability) to review evaluations of major factors (whether including PP or not) is considerably circumscribed.

WHERE THE CHARACTERISTICS OF THE PRODUCT OR PROCUREMENT PRESENT LITTLE UNCERTAINTY OR RISK, INFORMATION ON "PAST PERFORMANCE" IS LESS IMPORTANT

If the function of PP is to decrease the risk of unsatisfactory future performance, this finding is relatively obvious. Most of the examples concerned products outside the scope of this study: commercial, off-the-shelf products, standard items, repeat buys. In the commercial sector, this appears to be a commonsense distinction, including cases where the governmental practice does not follow. For example, one interviewee in the commercial sector pointed out that he would never bother with PP if he is dealing with a supplier with an established reputation, and, in this context, this apparently extends to a more general inquiry into capability. It appears that, at least in competitive procurements, the governmental practice requires at least a pro forma evaluation of capability.

A different aspect is presented by the use of alternative means to minimize risk. In the commercial sector, use is made of performance bonds, samples, benchmarks, trial orders, warranties, and other techniques to minimize the risk of unsuccessful performance. While these techniques are also available and used in the governmental sector, both ease in use and effectiveness appear, except in some cases, to be limited by the additional formalities and complexities involved.

WHERE THE PROCUREMENT PRESENTS SIGNIFICANT UN-

CERTAINTIES AND RISKS, INFORMATION ON "PAST PERFORMANCE" IS USEFUL

Particularly where the procurement concerns a complex, technical equipment or system, the uncertainties and risks are sufficiently large to force the purchaser to seek "all the help he can get." In the commercial sector, at least those parts which were contacted, any information which would contribute to decreasing the uncertainty of future performance was sought out and used in the evaluation. The size of the procurement, i.e., its dollar size as well as the amount of uncertainty and risk, appears to dictate the scale of effort; large programs justify a more extensive and elaborate (and expensive) inquiry and evaluation process; smaller projects warranted a more modest effort. Particularly, in decentralized organizations, the form followed was established by the immediate purchasing element, based upon past practice and the perceived uncertainty. Throughout the governmental sector, policies (and regulations) have formalized different scales of effort according to the size (and sometimes the nature) of the procurement; however, it appears that the formalities are considerably less flexible for large programs, i.e., systems and subsystems of the size and visibility which come under OMB Circular A-109, than for smaller systems and equipments. In the latter case, it appears that the scope of effort and the extent of obtaining and using PP varies according to the perception of how it will contribute to reducing risk or uncertainty.

CHARACTERISTICS OF THE SUPPLIER HAVE MORE EFFECT UPON THE USE OF "PAST PERFORMANCE" INFORMATION IN THE COMMERCIAL SECTOR

As a general rule, the commercial sector uses PP information when it is perceived to contribute to the acquisition decision; there are few, if any, "requirements" to use PP, and there do not appear to be any restrictions. Whether the supplier is sole source or competing against others, PP will be used if it will help. A previous supplier usually presents much less uncertainty than a new supplier, resulting in a great difference in use. Where the supplier is much smaller (and has less economic power), PP is used as much as is required; where the supplier is much larger (and has more economic power), it may not be possible to insist on receiving detailed information, whether needed or not.

In the governmental sector there is, generally, less flexibility. Whether sole source or competitive, the forms and procedures are to a degree standardized, although it appears that PP is less likely to be used, except pro forma, where it is not needed. With previous suppliers (or, more narrowly, current suppliers on directly held contracts), little use of PP is apparently made, unless there is some specific area of interest. The treatment of new suppliers (or, more generally, suppliers who are "new" to the procuring organization) varies considerably. In some cases, a nominal check is made, in other cases extensive use is made. As is true with the commercial sector, there is some preference for previous suppliers, but, when faced with the new, there is not the uniform examination of past performance. Finally, differences in size in suppliers does not seem to have a strong effect.

THE SPECIAL CASE OF THE "NEW SUPPLIER" PRESENTS MORE PROBLEMS IN THE USE OF "PAST PERFORMANCE" INFORMATION IN THE GOVERNMENTAL SECTOR

In the governmental sector, the assumption, if not also legal requirement, that all prospective suppliers have a "right" to be considered presents some problems with the "new supplier," i.e., suppliers who are "new" to the procuring organization, beyond those which are faced in the commercial sector. In prescreening, i.e., the determination of "responsibility," a previous supplier, particularly a current supplier, will have a record of PP which may be both (or either) "bad" and "good"; while both "good" and "bad" are potentially relevant to questions of capability, the "bad" is specifically a factor to be considered with respect to "past performance," under the laws and regulations. For a "new" supplier, the absence of any PP, or, in most cases, an absence of clearly relevant and visible PP, will give him a "free ride" with respect to the latter requirement. This presents a comparable, but, perhaps, lesser, problem in using PP as an indicator of other factors; there may be little or no PP (or experience), "good" or "bad," to consider. The more extreme (and, perhaps, rare) problem occurs when the supplier is not only "new" to the purchasing organization but is also a "new" organization; here, the supplier has no PP! And this may be compounded, again, perhaps, rarely, where the subject of the procurement is "novel" and there are no suppliers with PP (or experience).

To the extent this is a problem, there are a variety of practices to deal with it. Even with previous suppliers, changes in personnel or the "novelty" of the procurement may decrease the value (or availability) of conventional PP of the supplier; if the PP is to assess some factor related to capability or "track record," the PP of the individual, even if with a previous employer, may be relevant (especially with regard to technical competence), and PP of the supplier on other, different programs may be relevant, at least with respect to underlying performance characteristics. It appears, however, that there is a generally higher reluctance to draw upon these in the governmental than in the commercial sector.

ONLY IN THE GOVERNMENTAL SECTOR ARE THERE

SIGNIFICANT FORMAL LEGAL CONSTRAINTS ON THE USE OF INFORMATION ON "PAST PERFORMANCE," AND THESE ARE PRIMARILY IN THE DETERMINATION OF "RESPONSIBILITY"; THERE ARE, HOWEVER, ADDITIONAL INDIRECT EFFECTS UPON MORE GENERAL USE

In the governmental sector, the term "past performance" appears explicitly in laws and regulations, and appears to be even used as a "term-of-art." The major reference appears in the sections of the respective governmental regulations concerning determination of "responsibility" of prospective contractors, generally, as follows: Federal Procurement (Acquisition) Regulations (now FPR, proposed FAR) Subpart 1-1.12--Responsible Prospective Contractors; and Armed Services Procurement (Defense Acquisition) Regulations (previously ASPR, now DAR) Part 9--Responsible Prospective Contractors. The general organization and content of the two parts parallel, and the brief discussion which follows will be taken from the DAR (ASPR text, as of 3/26/80).

Regulations on "responsibility" apply to both advertised and negotiated procurement, and establish, generally, a policy of awarding contracts only to "responsible prospective contractors." The regulations specify "minimum standards" in four categories, all of which relate to PP but only two of which explicitly identify it. The first category, "General Standards," includes "adequate financial resources, or the ability to obtain such resources...", ability "to comply with the required or proposed delivery or performance schedule...", "a satisfactory record of integrity...", "otherwise qualified and eligible to receive an award under applicable laws and regulations," and the explicit reference, as follows:

> "(iii) have a satisfactory record of performance (contractors who are seriously deficient in current contract performance, when the number of contracts and the extent of deficiency of each are considered, shall, in the absence of evidence to the contrary or circumstances properly beyond the control of the contractor, be presumed to be unable to meet this requirement). Past unsatisfactory performance, due to failure to apply necessary tenacity or perseverance to do an acceptable job, shall be sufficient to justify a finding of nonresponsibility..."

The second category provides "Additional Standards" for procurements involving production, maintenance, construction, research and development, and others as appropriate which specify "necessary organization, experience, operational controls and technical skills, or the ability to obtain them..." and "necessary ... facilities"; but there is no explicit reference to PP.

The third category adds further "Special Standards" to cover "particular procurements," and includes the following:

> "Such special standards may be particularly desirable when a history of unsatisfactory performance has demonstrated the need for insuring the existence of unusual expertise or specialized facilities necessary for adequate contract performance."

The fourth, and final, category covers "Ability to Meet Certain Minimum Standards" which deals with the form of assurances the prospective contractor will provide where he does not have the present resources.

The regulations continue, covering the "Determinations of Responsibility and Nonresponsibility," "Procedures for Determining Responsibility of Prospective Contractors," "Subcontractor Responsibility," and "Disclosure of Pre-Award Data." Of these, the major relevant discussion concerns the second, and includes explicit instructions for assuring that the proper information is obtained, including reference to "currently valid information," maintenance of "useful records and experience data," advising about the existence of "unfavorable information," a list of sources of information, and the use of pre-award surveys.

In addition to these two central, explicit provisions, there are other laws and regulations which affect the use of PP, ranging from specific provisions which provide that the Small Business Administration can certify the "responsibility" of a small business to the manifold interactions of other provisions bearing upon the overall acquisition process. In the interviews, and the search of the literature, little specific reference to other laws and regulations appeared, except for the review of the Decisions of the Comptroller General. While there may be some uncertainty concerning the legal standing of these decisions, it is clear that the opinions expressed have a significant impact upon the acquisition process and its determination. A detailed analysis and tracing of all of the other referenced or implied laws and regulations appeared to be not only an endless but also a relatively unrewarding task.

In addition to the "laws and regulations" referred to above, within the governmental sector there are, typically, additional detailed regulations and other internal documents, e.g., manuals, guides, procedures, which serve to "implement" the laws and regulations and which, at least for subordinate elements, have a "law-like" effect. It is not always clear what "constraining" effect these internal regulations have, particularly in view of the access, through appeal, to an administrative level with authority to grant exceptions and the analogous specific review of the detailed process. It does appear that these internal regulations, manuals, etc., are intended primarily as guides, subject to modification by the appropriate authority as circumstances warrant. A somewhat different question arises when their effect is brought into question in the legal process (or formal administrative appeals); when an unsuccessful bidder "protests," whether against an unfavorable determination of his "responsibility," or some issue of "fairness" or "reasonableness" related to PP, he may argue that the government procuring body did not follow its own procedures. Based upon a cursory examination of a number of protests, it appears that the substantive effect of the variation, i.e., did the process used accomplish the underlying purpose in the "laws and regulations," is determinative rather than equivalence in form. Some confirmation of the above comments may be found in the extreme variation in the form, completeness, and availability of these administrative regulations, manuals, etc. While major procurements tend to be surrounded by formal documentation, it appears characteristic of smaller procurements to follow locally developed forms and procedures, prepared as the need arises by drawing upon prior procurements and experience. In at least two agencies, knowledgeable personnel were "sure" there were regulations and directives but "apologized" that they were "old" or were "being revised," or "I'll try to dig up a copy." In no case did this uncertainty appear to present any substantive disadvantage, either in carrying out a procurement or in legal consequences.

It is likely that there are general laws, particularly contract laws, which have some impact upon both governmental and commercial sectors with respect to the use of PP. During the interviews, and through the literature search, no explicit, significant examples were found, however, suggesting that the impact may be indirect, through affecting other, related processes. For example, several commercial interviewees mentioned that patents, licenses, and similar constraints affected their choice of a supplier. In the commercial sector use of the pre-screening process (which is where the major impact of PP appears in the governmental sector), the general absence of any basis for an unsuccessful supplier to protest, legally, against exclusion (e.g., by a finding of nonresponsibility) diminishes the likelihood that the law provides significant constraints. Similarly, internal administrative requirements of a commercial purchaser provide a "constraint" in a far different sense.

The major "impact" of "laws and regulations" in the governmental sector appears to be in the perception, in some cases justified, that the relatively stringent rules associated with determination of "responsibility" are applicable where PP information is obtained and used for other purposes, e.g., in competitive or sole source evaluation. Generally, the acquisition process, including source selection, must be carried out under the laws and regulations which reflect not only specific mandates but also broad, policy standards of conduct. Various terms, in specific contexts, are used to describe how the process shall be conducted, e.g., "on a reasonable basis," "without arbitrary abuse of discretion," "findings based on substantial evidence," "fairly evaluated," "fair and equitable," "matter of discretion," and the like. These terms, and others, reflect varying degrees of constraint in several dimensions, including, for example, the amount of information (in the record) which must be available (and used) to support a decision, the degree to which the decision is discretionary (not subject to examination or "second guessing"), or the degree to which the decision may be affected by collateral issues (bias).

It seems clear that the use of PP in the determination of "responsibility" is subject to considerable constraint, as reflected in the explicit standard presented in the laws and regulations, and these may reflect the consequences of an adverse decision--the prospective supplier is "out of the game" before he has a chance to make his case, i.e., submit a proposal or participate in negotiations. In contrast, and, generally, decisions in the competitive source selection stage, particularly those which are based upon consideration of a wide range of information and in areas within the special competence of the evaluators, are under less constraint, i.e., granted more discretion and less subject to review. This appears clearly so where the evaluation is concerned with major factors, whether or not they include consideration of PP; it appears less clearly where the evaluation has "segregated" factors which "look like" and are "treated like" those factors explicitly included within the laws and regulations on determination of responsibility. In practice, these distinctions do not appear to be generally understood, resulting in hesitancy and confusion in the use of PP.

In addition to legal constraints, there appear to be other constraints (or characteristics) which distinguish the governmental from the commercial sector. The relative freedom to acquire and use PP information in the commercial sector, in both small and large firms, results in a relatively direct and effective use, although there is a perception that the process can be improved. In the commercial sector, the purchasing element characteristically draws upon any source at any time, including vendor surveys (or site visits), queries to third parties, and direct dialogue with the prospective supplier not only before and after (i.e., during negotiation) the evaluation period but also during. Conversely, there are few or no affirmative (formal) requirements to use specific sources or to conduct the evaluation in any particular way. In the governmental sector, there are constraints, particularly in the determination of responsibility, with respect to all of the above processes. It appears not uncommon that members of an evaluation team do not have access to information they consider relevant, and are limited in obtaining it. For example, site visits and direct (informal) communication with the prospective supplier are, generally, if not always, precluded during the evaluation period. Generally, the governmental sector is considerably more dependent upon the offering in the supplier's proposal, including with respect to PP.

IN THE COMMERCIAL SECTOR, THE USE OF INFORMATION ON "PAST PERFORMANCE" IS INTEGRATED INTO THE OVERALL SOURCE SELECTION PROCESS, IMPROVING BOTH EFFICIENCY AND EFFECTIVENESS

The "integration" (or use of a systematic approach) is, generally, so complete in the commercial sector that interviewees had trouble distinguishing PP from other parts of the process. Characteristically, the procuring element treats the source selection process as a part of the overall acquisition process, drawing upon information of whatever kind is considered relevant, and support from whatever personnel resources are needed, to select the supplier who is likely to be able to provide the materials or services required. While there is a wide range of variation in specific practice, there does not appear to be any characteristic special treatment of PP.

In the governmental sector, there is considerably more isolation and segregation, again, with a range of variation. The determination of responsibility is, characteristically, made with heavy emphasis on PP, and at a separate time, under a separate set of rules and regulations, with information obtained by a separate set of people, and the decision made by contract personnel. In the competitive source selection process, the evaluation requirements (RFP) may be prepared by personnel different from those who conduct the evaluation, at least in part, and may include requirements written at different times for different purposes, often overlapping or even inconsistent, e.g., specific sections as contrasted with "boiler plate" sections. There are often organizational constraints on the identifying and availability of personnel with specific skills, e.g., technical specialties, "users." Finally, the complexity and uncertainty in how to treat PP increases the difficulty, at least, and appears to diminish the effect of PP.

IN THE COMMERCIAL SECTOR, THE EFFECT OF "PAST PERFORMANCE" ON THE CONTRACT MONITORING PROCESS, ALTHOUGH PRIMARILY INDIRECT, IS SUBSTANTIAL

Specific PP information obtained during the source selection process is not identified as being of particular significance in the monitoring of the contract which follows, and this is true in both the commercial and governmental sectors. The reason for this is apparently the belief that current performance information is not only "better" but also sufficient. In both sectors, interviewees acknowledged that the information was or could be made available; however, individuals concerned with monitoring believed that a "new" supplier ought to be checked closely (whatever the source selection process indicated), and that observation of his current performance (both "new" and "old" supplier) provided not only the "best" (and most easily available) information on the likelihood that he would be able to perform but also information which would directly help in identifying the necessary corrective action.

It is in the treating of PP as part of a systematic, continuing relationship between the purchaser and supplier that the commercial sector is distinguishable from the governmental sector. In the commercial sector it appears overwhelmingly clear that both the purchaser and the supplier consider the current contract as part of a (potentially) continuing relation. The supplier perceives that his current performance will affect future business; if it is "good," he is likely to get more business, if it is "bad," he will surely be out. This provides a powerful incentive to meet both the spirit and the terms of the contract and to cooperate in the monitoring process.

In the governmental sector, comparable relations appear to exist, although not as clearly. Because of the formalities in disbarment and, more generally, the determination of (non) responsibility, it appears that only the most unambiguously and extremely "bad" PP is perceived to have a substantial effect, and that may be limited in time or with respect to specific procurement offices. In the other direction, "good" PP is, generally, not considered to be particularly effective in assuring future business, i.e., the procuring activity "must compete" the next contract and may be either constrained or otherwise unable to give proper weight to "good" PP. And this tends to be compounded where different procurement organizations are involved.

SOURCE SELECTION FINDINGS

IN THE COMMERCIAL SECTOR, THE USE OF "PAST PERFORMANCE" INFORMATION IN THE PRE-SCREENING PROCESS IS CONSIDERABLY MORE EFFECTIVE AND SIGNIFICANT

With, essentially, unlimited freedom to choose whom to do business with, the commercial sector characteristically pre-screens out all prospective suppliers except those which, in the governmental sector, would be considered "within the competitive range." Where the purpose is to obtain an "acceptable supplier" (or, perhaps, the "best" acceptable supplier), there appears little interest in wasting time evaluating suppliers beyond that minimum number, sometimes one, considered necessary to obtain one acceptable supplier. The advantage of PP information is that it is already "available," is considered strongly indicative of present or potential capability, and it minimizes the cost of collection (to both the purchaser and the supplier). The relative freedom to use any source, and, particularly, the use of a site visit, combines with the significant (or nearly absolute) discretion in screening out to make the contribution of PP very powerful. It is, perhaps, worth pointing out that the pre-screening is not limited to the conventional PP factors but draws upon PP to provide an indication of the "present or potential capability" to perform in "major factor" areas, i.e., "technical factors."

In the governmental sector, determination of responsibility, whether accomplished prior to or concurrent with the competitive evaluation of sources, is largely constrained by laws and regulations, and is, generally if not always, carried out separately from the rest of source selection. It appears, particularly in highly complex and technical procurements where PP information is of the most value, that the determination of (non)responsibility is seldom made. This may be for several reasons: the informal "pre-screening" which is accomplished in the preparation of the bidders' list not only delays non-invited bidders in their decision to request inclusion but also "discourages" them if the list includes a set of strongly competitive bidders. Further, there does not appear to be a clear "right" to be added to the bidders' list (especially if it includes "sufficient competition"), although, in practice, the likelihood of inclusion upon (a strong) request appears to vary widely. In addition to this process, which tends to exclude suppliers who might subsequently be found "nonresponsible," there appears to be a strong perception that not only is it difficult to "find" a supplier nonresponsive (and/or avoid the additional problem of defending against a protest) but it is relatively easy to sort out these (unacceptable) bidders during the evaluation process, particularly with the addition of the discriminating power of major factors. It should be noted that there is some evidence of "pressure" to do more, i.e., get rid of clearly "bad" suppliers early and to cut down on the cost of the evaluation process.

INFORMATION ON "PAST PERFORMANCE" HAS A PERVASIVE EFFECT ON THE SOURCE SELECTION PROCESS, AND MUCH MORE CLEARLY SO IN THE COMMERCIAL SECTOR

The commercial sector treats information on PP as an integral part of the source selection process. In all, or nearly all, cases information on PP is considered just one of many indicators of present or potential capability (and, sometimes, of the understanding of the problem and proposed approach) and is used either to establish the capability, e.g., where a question of the availability of appropriate physical facilities or an in-being process, such as quality control, is relevant, or to contribute to the evaluation of some other factor, e.g., the likelihood that his technical team will be able to carry out the promises in the proposal. Generally, the evaluation process in the commercial sector is more direct and informal and is not characterized by the explicit and detailed procedural documentation found in the governmental sector. Because of the potential relevance of comments on the governmental sector, the information to follow will, generally, follow the broad steps in the governmental process.

Early in the acquisition process personnel are identified who will follow the procurement at least up until the time of award; the completeness and continuity of the "team" may vary, particularly in the governmental sector, with a small "core" supplemented, at various steps, with others as needed or as required by internal administrative procedures. Generally, in the governmental as well as commercial sector, an attempt is made to recruit the specialized talent particularly required by an often extensive evaluation process, and some of these are functional specialists located permanently in the contracting and engineering organizations and others are obtained on a temporary basis as "consultants" or on a permanent basis in anticipation of the formation of a project management office. In large procurements, the personnel may be divided up into several different groups, often hierarchically related and with very distinctly different roles in the evaluation process. These variations in recruitment and organization may have a considerable impact upon how PP information is used. Individuals with specialized technical skills whose experience is limited to research or staff positions and who have no direct "hands on" experience with performance on a development/production contract may be well qualified to assess a bidder's understanding of a technical problem and his proposed approach but may also not only be unable to assess his capability to perform but also even unaware of the related and supporting factors (often among the capability factors which are revealed by PP) which may be absent in the technical proposal, or buried in some other, "uninteresting" and unavailable, section of the proposal entitled "past performance." Similarly, as has often been observed in laboratory experiments on the human decision making process, individuals who are making an "abstract" decision, i.e., one which they do not expect to have to "live with," may be considerably different from those who are making a real-world decision, i.e., one which has real consequences for them; if, as is often true, the members of the evaluation team are not those personnel who will be responsible for the eventual contractor's performance, their assessment of PP may be significantly different.

Closely allied, at least in time, with the previous step is that of generating the procurement documentation (RFP). Because of its critical importance in telling the bidders what information (including that on PP) is required, and in setting the stage for the use of that information in the evaluation, how this is accomplished, and by whom, has a strong effect upon both the obtaining and use of PP. The basic issue is the identification of the several factors to be evaluated, and how clearly they are presented. Characteristically, in the governmental sector (and in the commercial sector), the establishment of the "major factors," i.e., those critical areas which are believed to represent the important problems and disciplines, is relatively straightforward. It is in their interrelation with one another and with "other factors" and the other parts of the bid set that problems appear. It appears that the difficulty experienced arises out of two unfortunate perceptions: first, that there is some requirement to treat some "other factors," e.g., PP, as different in kind from the major (technical) factors; second, that there is some requirement that the several factors be mutually inclusive and exclusive, i.e., independent. The first mis-conception is easily traceable to the formality associated with "responsibility"; the second appears to be traceable to academic (and/or "scientific") preoccupations with models for aggregating subjective data, and particularly quantitative models with stringent data requirements. This problem, usually limited to the set of specially created "evaluation factors," is further compounded with the common occurrence of other sections of the bid set, usually derived from previous, different bid sets, which include, out of an abundance of over-caution, instructions which (appear to) describe wanted information and/or additional "evaluation factors," which may overlap (or even be inconsistent with) those set out elsewhere.

This appears to serve to aggravate, if not confuse, suppliers, and, in a large proposal, may require the presentation of desired information in places, or forms, which are relatively less accessible to the evaluation team. And the process for reviewing the RFP, where required, may well exacerbate this by ensuring that each specialist area "beef up" its part.

In the governmental process, the gathering of information (including that on PP) is centered in the RFP and the proposals in response. Beyond the previous comments, there appear to be only a few observations to be made here. One specific issue which recurs is limitations on the lengths of proposals. Apparently the major reason for limits is to cut down the reading time for the evaluation team, with ancillary interests in "saving the bidder the costs of extensive proposals" and in "eliminating irrelevant material." It appears, at least among bidders, that a considerably more important (and related) objection is to extensive requests for information which is perceived to be less relevant to the source selection decision, particularly information which would be expected to be developed by the successful contractor, and to requests which are ambiguous and unclear, requiring extensive preparation to "cover all bases." In a few cases, the problem of length has been successfully handled by carefully identifying those factors which will be critical in the evaluation process, tying all requests for information (and all related documentation) explicitly to those factors, and carefully spelling out not only what kind of information is desired but also for what purpose it will be used. This appears, generally, to assure that the bidder can direct his attention and resources to preparing information which will affect his chances, and directs the attention of each member of the evaluation team to those parts of direct interest. This integrated approach also minimizes problems of weighting (aggregation), of missing or incomplete information, and in using both "good" and "bad" PP.

In the governmental sector, the actual process of evaluation is, characteristically, relatively formal, with a number of variations reflecting adaptations within the laws and regulations. The organization of the evaluation team and the RFP determines, to a large extent, the ease in obtaining and using PP, with variations in the degree to which it is treated separately an apparently important characteristic. While the evaluation process is important and interesting, the other area which appears particularly relevant to PP is that part of the process which aggregates the evaluations across individual evaluators and across factors. The most common form appears to be as follows: individual reading and evaluating of specific factors, with rating primarily against "objective" scales as distinguished from a straight comparison of one bidder against another; various intermediate processes are used to aggregate across evaluators, ranging from mechanical aggregation of numerical scores (usually used for "major factors") to various consensus producing processes; aggregation across factors is accomplished by mechanical means, for scores, but always accompanied by either the factor scores or verbal ratings (and comments), or both. In those cases (and commonly) where PP information is segregated in separately identified factors, the rating is, characteristically, made verbally (as distinguished from numerical scoring), and usually limited to a nominal scale. Interestingly, there appears to be a general recognition that weighted numerical scores, and various methods of mathematical aggregation, provide guidance rather than confident discrimination, with heavy reliance on a combination of individual factor (and sub-factor) scores and verbal description, e.g., "excellent," and comments, e.g., "bidder A is deficient with respect to ...". The treatment of PP information as a separate factor in the evaluation represents one of three, rather than two, approaches; at one extreme, characteristics usually associated with PP are listed as a separate factor, often identified as such; at the other extreme (and rarely), PP is fully integrated into the set of "major factors"; between these two extremes, PP may (also) be associated with specific factors, usually factors concerned with "management," "cost," physical facilities, and personnel. In the (relatively few) cases where PP is fully integrated, the evaluators appear to have no hesitancy in using any available "good" or "bad" PP in assessing the bidder's likely performance with respect to the factor, and this would appear to be the most efficient and effective use. Where PP information is associated with specific factors, a degree of hesitancy appears, perhaps also characteristically reflected in the generally lesser weight given to these factors. Finally, where PP is separately evaluated, it does not appear that the result makes any significant (direct) contribution to the overall selection process.

The scores (and verbal ratings) may go through several intermediate processes before presentation to the decision-maker, and it appears that this, if anything, diminishes the significance of separately rated PP as part of the necessary summarizing process. Interestingly, it appears that PP information may make a critical contribution, particularly with respect to areas of identified potential deficiency, in the process of discussions with bidders in the "competitive range" and, later, during negotiations with the successful bidder.

SUMMARY

The first major implication of this study is that past performance information is primarily useful as a contributor to the reduction of uncertainty with respect to those major factors considered to determine future performance. The amount and kind of uncertainty and risk in a program, rather than the size of the program or its categorization as a system, subsystem or equipment, should determine the use. A second major implication is that the use of past performance information in the source selection process (as distinguished from the determination of "responsibility") should be integrated into the evaluation of "major factors," i.e., those otherwise identified as significant determinants. The third, and last, major implication is that experienced personnel in both government and industry are generally quite knowledgeable about how to identify, obtain, and use past performance information and should be given an opportunity to assess the findings presented here, particularly with respect to the specific problems they are faced with in a particular procurement. It does not appear necessary, and it may even be less effective, to translate these findings into specific, mandatory changes in the present guidelines. To the extent the findings are credible and useful, knowledgeable personnel can be expected to develop improved procedures and, where necessary, request review and approval.

TABLE 1

ISSUES AND FINDINGS

ISSUES	FINDINGS
A. General	
WHAT TYPES OR KINDS OF BEHAVIOR ARE INCLUDED WITHIN THE DEFINITION OF "PAST PERFORMANCE"?	WITH THE EXCEPTION OF ONE SPECIFIC CONTEXT, "PAST PERFORMANCE" IS DEFINED IN PRACTICAL TERMS
IS "PAST PERFORMANCE" A SEPARATE CHARACTERISTIC (OR FACTOR) OR IS IT AN INDICATOR OF OTHER PERFORMANCE CHARACTERISTICS, OR BOTH?	EXCEPT IN THE PRE-SCREENING PROCESS, "PAST PERFORMANCE", AS A SEPARATE, IDENTIFIABLE FACTOR, IS OF LITTLE INTEREST IN THE COMMERCIAL SECTOR AND IS RELATIVELY UNIMPORTANT IN THE GOVERNMENTAL SECTOR INFORMATION ON "PAST PERFORMANCE" CONTRIBUTES SIGNIFICANTLY TO THE EVALUATION OF OTHER FACTORS
DO THE CHARACTERISTICS OF THE PROCUREMENT AND/OR THE SUPPLIER AFFECT THE USE OF "PAST PERFORMANCE"?	WHERE THE CHARACTERISTICS OF THE PRODUCT OR PROCUREMENT PRESENT LITTLE UNCERTAINTY OR RISK, INFORMATION ON "PAST PERFORMANCE" IS LESS IMPORTANT WHERE THE PROCUREMENT PRESENTS SIGNIFICANT UNCERTAINTIES AND RISKS, INFORMATION ON "PAST PERFORMANCE" IS USEFUL CHARACTERISTICS OF THE SUPPLIER HAVE MORE EFFECT UPON THE USE OF "PAST PERFORMANCE" INFORMATION IN THE COMMERCIAL SECTOR THE SPECIAL CASE OF THE "NEW SUPPLIER" PRESENTS MORE PROBLEMS IN THE USE OF "PAST PERFORMANCE" INFORMATION IN THE GOVERNMENTAL SECTOR
DO CHARACTERISTICS OF THE PURCHASER (INCLUDING SPECIAL LEGAL REQUIREMENTS IMPOSED UPON HIM) AFFECT USE OF "PAST PERFORMANCE"?	ONLY IN THE GOVERNMENTAL SECTOR ARE THERE SIGNIFICANT FORMAL LEGAL CONSTRAINTS ON THE USE OF INFORMATION ON "PAST PERFORMANCE", AND THESE ARE PRIMARILY IN THE DETERMINATION OF "RESPONSIBILITY"; THERE ARE, HOWEVER, ADDITIONAL INDIRECT EFFECTS UPON MORE GENERAL USE
DOES A SYSTEMATIC OR INTEGRATED APPROACH AFFECT THE USE OF "PAST PERFORMANCE"?	IN THE COMMERCIAL SECTOR, THE USE OF INFORMATION ON "PAST PERFORMANCE" IS INTEGRATED INTO THE OVERALL SOURCE SELECTION PROCESS, IMPROVING BOTH EFFICIENCY AND EFFECTIVENESS IN THE COMMERCIAL SECTOR, THE EFFECT OF "PAST PERFORMANCE" ON THE CONTRACT MONITORING PROCESS, ALTHOUGH PRIMARILY INDIRECT, IS SUBSTANTIAL

ISSUES	FINDINGS
B. <u>Related to Kinds of PP Information (Factors)</u>	
HOW DOES ONE IDENTIFY (OR CHOOSE) THE FACTORS TO CONSIDER WITH RESPECT TO "PAST PERFORMANCE"?	IDENTIFYING "PAST PERFORMANCE" (OR OTHER) FACTORS DOES NOT APPEAR TO PRESENT A SIGNIFICANT PROBLEM, AND THERE DO NOT APPEAR TO BE ANY THAT ARE PARTICULARLY NOVEL OR EFFECTIVE
WHAT KINDS OF FACTORS ARE USED WITH RESPECT TO "PAST PERFORMANCE"?	PRACTICALLY ANY FACTOR CAN BE USED WITH "PAST PERFORMANCE", ALTHOUGH THERE ARE DIFFERENTIAL USES, PARTICULARLY IN THE GOVERNMENTAL SECTOR
C. <u>Related to Source of (and Methods for Obtaining) PP Information</u>	
WHAT IS THE GENERAL AVAILABILITY OF INFORMATION ON "PAST PERFORMANCE"?	INFORMATION ON "PAST PERFORMANCE" IS, GENERALLY, MORE AVAILABLE IN THE COMMERCIAL SECTOR
SHOULD COLLECTION OF INFORMATION ON "PAST PERFORMANCE" BE AN ON-GOING PROCESS OR SHOULD IT BE DIRECTED IN SUPPORT OF A SPECIFIC PROCUREMENT?	WHILE ON-GOING PROCESSES, PARTICULARLY THOSE ESTABLISHED FOR SOME INDEPENDENT PURPOSE, ARE USED AS A SOURCE FOR INFORMATION ON "PAST PERFORMANCE", THE MAJOR DEPENDENCE IS ON INFORMATION OBTAINED DIRECTLY FOR THE SPECIFIC PROCUREMENT
WHAT ARE THE KEY SOURCES?	SOURCES OF INFORMATION ON "PAST PERFORMANCE" ARE GENERALLY WELL KNOWN, WITH SOME DIFFERENCES IN USE BETWEEN THE SECTORS
D. <u>Related to Use of PP in Source Selection</u>	
HOW IS "PAST PERFORMANCE" USED OTHER THAN IN COMPETITIVE SOURCE SELECTION?	IN THE COMMERCIAL SECTOR, THE USE OF "PAST PERFORMANCE" INFORMATION IN THE PRE-SCREENING PROCESS IS CONSIDERABLY MORE EFFECTIVE AND SIGNIFICANT
HOW DOES "PAST PERFORMANCE" AFFECT THE SOURCE SELECTION PROCESS (FORMAL EVALUATION OF COMPETITIVE PROPOSALS)?	INFORMATION ON "PAST PERFORMANCE" HAS A PERVASIVE EFFECT ON THE SOURCE SELECTION PROCESS, AND MUCH MORE CLEARLY SO IN THE COMMERCIAL SECTOR
E. <u>Related to Use of PP in Contract Monitoring</u>	
HOW IS INFORMATION ON "PAST PERFORMANCE" USED IN THE CONTRACT MONITORING PROCESS?	INFORMATION ON "PAST PERFORMANCE" OBTAINED DURING THE SOURCE SELECTION PROCESS HAS LITTLE SIGNIFICANT, CONTINUING EFFECT UPON THE SUBSEQUENT CONTRACT MONITORING PROCESS

PANEL H

INDUSTRIAL PREPAREDNESS

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STRATEGIC AND CRITICAL MATERIALS

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ABSTRACT

Accelerating defense programs will require significantly increased supplies of special property materials that have temperature-, corrosion-, and abrasion-resistant properties. Estimates of DOD requirements for such materials must be developed at the sub-contractor levels where they can be quantitatively and qualitatively identified. The need for specialized processing and fabricating facilities must also be identified.

* * * * * *

Accelerating defense programs will generate increased demands for such materials as chromium, cobalt, columbium, molybdenum, nickel, platinum, tantalum, and titanium. Materials resistant to high temperatures, corrosion, and erosion are necessary to impart high performance characteristics to many items of sophisticated military materiel. For example, the Pratt & Whitney F-100 Turbofan engine for the F-15 and F-16 planes requires 5,366 lb of titanium, 5,204 lb of nickel, 1,656 lb of chromium, 910 lb of cobalt, 720 lb of aluminum, 171 lb of columbium, and 3 lb of tantalum. Only a limited number of materials possess high temperature resistance (Fig. 1) and the U.S. currently uses a substantial portion of world production thereof (Fig. 2), many of which come from distant and potentially unreliable sources (Fig. 3). The USSR has long been conscious of the requirements for such materials (Fig. 4).

Fig. 2

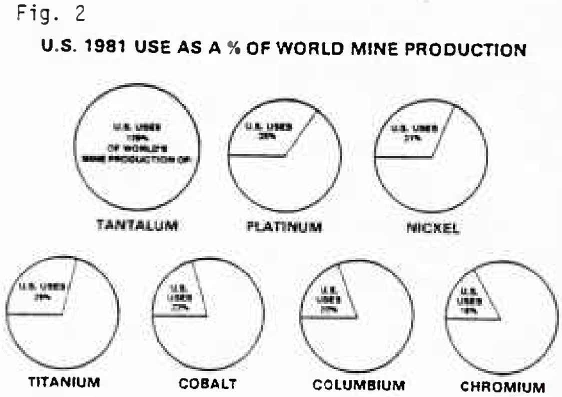
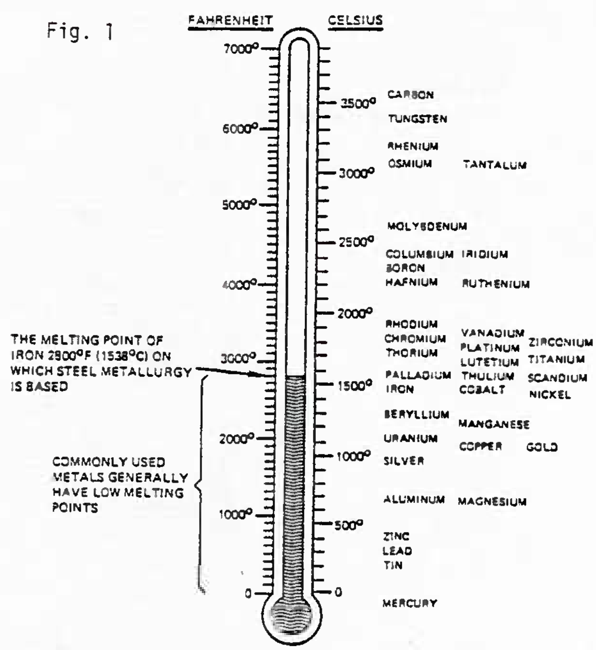


Fig. 4

Fig. 1



(THIS CHART SHOWS ALL KNOWN ELEMENTS WITH MELTING POINTS ABOVE IRON AND MAJOR METALS MELTING AT LOWER TEMPERATURES)

The problem now confronting DOD is how to get defensible estimates of future requirements when multifarious war plans are required to meet a broad spectrum of contingencies ranging from minor insurrections to global nuclear devastation, and future service roles and missions are not completely defined. When the material requirements probably first emerge at the 4th or 5th tier subcontractor, what is to be done? DOD should make no effort to calculate the requirements for all materials for all materiel programs - it can't be done. Indeed, in the case of most common materials such as steel, copper, and aluminum, DOD should attempt only to assess the materials and special processing needs (such as for forgings and castings) for the few programs that would use either large quantities or unusual shapes or forms, for example: a World War II type ship-building program, a major tank program, or a massive military and defense industry site hardening program. In the case of other materials, DOD efforts should be narrowly focused on high performance systems reaching down beyond the prime contractors to the 4th and 5th tier subcontractors to get at the specific quantitative and qualitative needs for such materials as columbium, tantalum, cobalt, titanium, platinum, beryllium, zirconium, and rhenium, that possess unique properties not required for normal civilian usage. Further, attention should be focused not just upon raw materials requirements but also upon the specialized

Fig. 3 **U.S. NET IMPORT RELIANCE OF SELECTED MINERALS AND METALS AS A PERCENT OF CONSUMPTION IN 1981**

MINERALS AND METALS	NET IMPORT RELIANCE AS A PERCENT OF APPARENT CONSUMPTION (0%–100%)	MAJOR FOREIGN SOURCES (1977-1980)
COLUMBIUM	100	BRAZIL, CANADA, THAILAND
DIAMOND (industrial stones)	100	IRELAND, REP. OF SOUTH AFRICA, BELG.-LUX., U.K.
GRAPHITE (natural)	100	MEXICO, REP. OF KOREA, MADAGASCAR, U.S.S.R.
MICA (sheet)	100	INDIA, BRAZIL, MADAGASCAR
STRONTIUM	100	MEXICO
MANGANESE	98	REP. OF SOUTH AFRICA, GABON, FRANCE, BRAZIL
BAUXITE & ALUMINA	94	JAMAICA, AUSTRALIA, GUINEA, SURINAME
COBALT	91	ZAIRE, BELG.-LUX., ZAMBIA, FINLAND
TANTALUM	91	THAILAND, CANADA, MALAYSIA, BRAZIL
CHROMIUM	90	REP. OF SOUTH AFRICA, PHILIPPINES, U.S.S.R., FINLAND
FLUORSPAR	85	MEXICO, REP. OF SOUTH AFRICA, SPAIN, ITALY
PLATINUM—GROUP METALS	85	REP. OF SOUTH AFRICA, U.S.S.R., U.K.
ASBESTOS	80	CANADA, REP. OF SOUTH AFRICA
TIN	80	MALAYSIA, THAILAND, BOLIVIA, INDONESIA
NICKEL	72	CANADA, NORWAY, BOTSWANA, AUSTRALIA
POTASH	68	CANADA, ISRAEL
ZINC	67	CANADA, MEXICO, SPAIN, AUSTRALIA
CADMIUM	63	CANADA, AUSTRALIA, MEXICO, BELG.-LUX.
TUNGSTEN	52	CANADA, BOLIVIA, MAINLAND CHINA, THAILAND
ANTIMONY	51	REP. OF SOUTH AFRICA, BOLIVIA, MAINLAND CHINA, MEXICO
SILVER	50	CANADA, MEXICO, PERU, U.K.
SELENIUM	49	CANADA, JAPAN, YUGOSLAVIA
BARIUM	43	PERU, MAINLAND CHINA, IRELAND, MOROCCO, CHILE
TITANIUM (ilmenite)	43	AUSTRALIA, CANADA, REP. OF SOUTH AFRICA
VANADIUM	42	REP. OF SOUTH AFRICA, CHILE, CANADA
MERCURY	39	SPAIN, ALGERIA, JAPAN, ITALY
GYPSUM	37	CANADA, MEXICO, JAMAICA
IRON ORE	28	CANADA, VENEZUELA, BRAZIL, LIBERIA
IRON & STEEL	19	JAPAN, EUROPE, CANADA
LEAD	10	CANADA, MEXICO, PERU
GOLD	7	CANADA, U.S.S.R., SWITZERLAND
SULFUR	7	CANADA, MEXICO
COPPER	5	CHILE, CANADA, PERU, ZAMBIA

SUBSTANTIAL QUANTITIES ARE IMPORTED FOR RUTILE, RHENIUM AND ZIRCON. DATA WITHHELD TO AVOID DISCLOSING COMPANY PROPRIETARY DATA capacity for processing such raw materials through each stage to the finished product, including forging, welding, machining, etc. And as we become increasingly involved in international procurement, we must also consider the needs of our Allies, who are more dependent upon imports of many materials than is the United States.

Several clear historical examples of DOD success in assuring adequate supplies of special property materials for military purposes follow:

Columbium-Tantalum: In the late 1940's DOD told the National Security Resources Board that columbium and tantalum - high temperature metals - were of particular importance to the emerging jet engine programs. Prior to the Korean War U.S. and Allied studies concluded that only 1 million lbs per year could be produced world-wide. Nevertheless, early in the Korean War a worldwide 100% bonus program under Title III of the Defense Production Act resulted in such an expansion of supply that in only 3 years the U.S. stockpile alone acquired 15 million lbs meeting specifications, while additional supplies were also available for military and industrial uses.

Tungsten: At the start of the Korean War DOD made known its needs for large quantities of tungsten for high velocity armor-piercing projectiles. Domestic mine production was then only half of normal U.S. industrial needs and the other half came from imports, largely from China. A DPAct domestic purchase program at $63 a short ton unit (about 4 times the previously prevailing price) quadrupled domestic mine production of tungsten in 2 years, met the needs of the HVAP program, and more than filled stockpile goals to the point that the U.S. Government is still selling surplus tungsten at prices more than double $63.

Titanium-Zirconium: Recognizing that titanium metal although twice as heavy as aluminum was six times as strong, DOD advocated a titanium expansion program in the Korean War which in a few years created a viable domestic titanium metal industry through guaranteed contingent procurement contracts under Title III of the DPAct. Titanium metal was thus made available for military airplanes and ships, and for chemical industry applications. Later, similar metallurgical processing technology was utilized to develop zirconium for nuclear reactors for military and civilian applications.

Strategic stockpiles have played a major role in U.S. defense planning ever since World War II. The Strategic and Critical Materials Stock Piling Revision Act of 1979, PL 96-41, reaffirmed the need for stockpiling, conservation, and development of domestic sources. It specified that "the purpose of the stockpile is to serve the interest of national defense only and is not to be used for economic or budgetary purposes," and that "the quantities of the materials stockpiled should be sufficient to sustain the United States for a period of not less than three years in the event of a national emergency." The Act also reaffirmed the need to develop domestic resources. At current prices the overall stockpile status as of early 1982 was about as follows:

$20 billion - cost of all goals
8 " - on hand toward goals
5 " - excesses that could be sold

Table 1 lists the 93 materials singled out by the U.S. Government as "basic stockpile materials," largely on the basis of import vulnerability. Several of the 93 materials have been recognized as stockpile candidates ever since World War I, while newer ones have been added to the list only after research and development have proved their utility, such as titanium. 80 of the stockpile materials are of mineral origin and 13 are of agricultural origin. However, it would be fallacious to conclude that only the 93 are strategic. For example, neither steel, nor iron ore, nor coke, nor coking coal, nor limestone is on the stockpile list, yet steel is considered a highly strategic material in every modern economy. In 1980 the Congress declared that "energy" is a strategic and critical material, and petrolum is stockpiled by the Department of Energy, while helium is stockpiled by the Bureau of Mines. Despite the large domestic synthetic rubber industry developed in World War II, natural rubber, a major stockpile item, is still a preferred material for tires for aircraft and many off-the-road vehicles because it resists high temperatures and abrasion. Materials have been removed from the stockpile list because substitutes or alternates have been found. For example, hog bristles for paint brushes have been replaced by tapered nylon, and Egyptian extra long-stable cotten by domestic sea island cotton and/or synthetic fibers. The Federal Emergency Management Agency (FEMA) oversees stockpile management, while the General Services Administration (GSA) buys, sells, rotates, and stores stockpile materials.

The Defense Production Act of 1950, as amended, currently in effect through September 30, 1982, provides the basis for defense mobilization efforts. Title I of the DPAct provides specific authority for priorities and allocations, and Title III provides broad authority for expanding supplies of materials - making specific provisions for exploration, development, and mining of strategic and critical minerals and metals, and the development of substitutes for strategic and critical materials. The definition of "materials" in the DPAct is very broad, viz: "The word "materials" shall

Table 1 . FEMA's STOCKPILE GOALS, (OESIREO INVENTORY MIX), ANO INVENTORIES AS OF SEPTEMBER 30, 1981

	Goal	Inventory
Aluminum Metal Group	7,150,000 ST Al	3,444,064
(Alumina)	0	0
(Aluminum)	700,000 ST	1,733
(Bauxite, Metal Grade, Jamaica Type)	21,000,000 LOT	8,858,881
(Bauxite, Metal Grade, Surinam Type)	6,100,000 LOT	5,299,596
Aluminum Oxide, Abrasive Graln Group	638,000 ST Abrasive Grain	259,124
(Aluminum Oxide, Abrasive Grain)	0 ST	50,904
(Aluminum Oxide, Fused, Crude)	0 ST	249,867
(Bauxite, Abrasive Grade)	1,000,000 LCT	0
Antimony	36,000 ST	40,730
Asbestos, Amosite	17,000 ST	42,534
Asbestos, Chrysotlle	3,000 ST	9,958
Bauxlte, Refractory	1,400,000 LCT	174,599
Beryllium Metal Group	1,220 ST Oe Metal	1,061
(Beryl Ore 11% BeO)	18,000 ST	17,987
(Beryllium Copper Master Alloy)	7,900 ST	7,387
(Beryllium Metal)	400 ST	229
Bismuth	2,200,000 LB	2,081,298
Cadmium	11,700,000 LB	6,328,809
Castor Oil (Sebacic Acid)	22,000,000 LB	12,524,243
Chromium, Chemical & Metallurgical Group	1,353,000 ST Cr Metal	1,324,921
(Chromite, Chemical Grade Ore)	675,000 SDT	242,414
(Chromite, Metallurgical Grade Ore)	3,200,000 SOT	2,488,043
(Chromium, Ferro, High Carhon)	185,000 ST	402,696
(Chromium, Ferro, Low Carbon)	75,000 ST	318,892
(Chromium, Ferro, Silicon)	90,000 ST	58,355
(Chromium, Metal)	20,000 ST	3,763
Chromite, Refractory Grade Ore	850,000 SOT	391,414
Cobalt	85,400,000 LB Co	40,802,393
Columbium Group	4,850,000 LO Cb Metal	2,510,528
(Columbium Carbide Powder)	100,000 LB Cb	21,372
(Cnlumbium Cnncentrates)	5,600,000 LB Cb	1,780,463
(Cnlumbinm, Ferro)	0 LB Cb	930,911
(Columbium, Metal)	0 LB Cb	44,851
Copper	1,000,000 ST	29,048
Cordage Fibers, Abaca	155,000,000 LB	0
Cordage Fibers, Sisal	60,000,000 LB	0
Diamond, Industrial Group	29,700,000 KT	41,939,184
(Oiamond Oies, Small)	60,000 PC	25,473
(Diamond, Industrial, Crushing Bort)	22,000,000 KT	23,692,702
(Oiamond, Industrial, Stones)	7,700,000 KT	18,233,666
Feathers & Oown	1,500,000 LB	0
Fluorspar, Acid Grade	1,400,000 SOT	895,983
Fluorspar, Metallurgical Grade	1,700,000 SOT	411,738
Graphite, Natural - Ceylon, Amorphous Lump	6,300 ST	5,499
Graphite, Natural - Malagasy, Crystalline	20,000 ST	17,904
Graphite, Natural - Other than Ceylon & Malagasy	2,800 ST	2,004
Indine	5,800,000 LO	8,013,074
Jewel Bearings	120,000,000 PC	69,908,738
Lead	1,100,000 ST	601,036
Manganese Oioxide, Battery Grade Group	87,000 SOT	222,136
(Manganese, Battery Grade, Natural One)	62,000 SOT	219,125
(Manganese, Battery Grade, Synthetic Oioxide)	25,000 SOT	3,011
Manganese, Chemical & Metallurgical Group	1,500,000 ST Mn Metal	1,970,715
(Manganese Ore, Chemical Grade)	170,000 SOT	221,044
(Manganese Ore, Metallurgical Grade)	2,700,000 SOT	3,370,005
(Manganese, Ferro, High Carbon)	439,000 ST	599,978
(Manganese, Ferro, Low Carbon)	0 ST	0
(Manganese, Ferro, Medium Carbon)	0 ST	28,920
(Manganese, Ferro, Silicon)	0 ST	23,574
(Manganese, Metal, Electrolytic)	0 ST	14,172
Mercury	10,500 Flasks	191,391
Mica, Muscovite, Block, Stained & Better	6,200,000 L8	5,212,444
Mica, Muscovlte Film, 1st & 2nd Qualities	90,000 L8	1,274,489
Mica, Muscovlte Splittings	12,630,000 L8	19,035,147
Mica, Phlogopite 8lock	210,000 L8	130,745
Mica, Phlogopite Splittings	930,000 L8	1,704,097
Molybdenum Group	0	0
(Molybdenum Oisulphide)	0	0
(Molybdenum, Ferro)	0	0
Nickel	200,000 ST Ni + Co	0
Opium Group	130,000 AMA L8	71,303
(Opium Gum)	0 AMA L8	31,795
(Opium, Salt)	130,000 AMA L8	39,508
Platinum Group Metals, Iridium	98,000 TrOz	16,991
Platinum Group Metals, Palladium	3,000,000 TrOz	1,255,003
Platinum Group Metals, Platinum	1,310,000 TrOz	452,640
Pyrethrum	500,000 LB	0
Quartz Crystals	600,000 L8	2,128,149
Quinidlne	10,100,000 Av Oz	1,800,462
Quinine	4,500,000 Av Oz	3,246,164
Rubber	864,000 MT	120,508
Rutile	106,000 SDT	39,186
Sapphlre & Ruby	0 KT	16,305,502
Silicnn Carbide, Crude	29,000 ST	80,550
Silver (fine)	0 TrOz	139,500,000
Talc, Steatlte Block & Lump	28 ST	1,092
Tantalum Group	7,160,000 L8 Ta Metal	2,391,940
(Tantalum Carbide Powder)	0 LB Ta	20,688
(Tantalum Metal)	0 LB Ta	201,133
(Tantalum Minerals)	0,400,000 LB Ta	2,551,302
Thorium Nitrate	600,000 L8	7,131,812
Tin	42,700 MT	201,535
Titanium Sponge	195,000 ST	32,331
Tungsten Group	50,666,000 LB W Metal	80,047,625
(Tungsten Carbide Powder)	2,000,000 LB W	2,032,942
(Tungsten, Ferro)	0 LB W	2,025,361
(Tungsten Metal Powder)	1,600,000 LO W	1,890,911
(Tungsten Ores & Concentrates)	55,450,000 L8 W	87,062,763
Vanadium Group	8,700 ST V Metal	541
(Vanadium, Ferro)	1,000 ST V	0
(Vanadium Pentoxide)	7,700 ST V	541
Vegetable Tannin Extract, Chesnut	5,000 LT	16,393
Vegetable Tannln Extract, Quebracho	28,000 LT	140,810
Vegetable Tannin Extract, Wattle	15,000 LT	16,399
Zinc	1,425,000 ST	376,310

Source: FEMA

include raw materials, articles, commodities, products, supplies, components, technical information, and processes." In 1980 $3 billion was made available under the DPAct for synfuels, but funding for nonfuel minerals was not available as of this date. The creation or enlargement of domestic productive capacity, if it can be done at reasonable prices should in most case provide greater flexibility than stockpiles. In fact, one ton of domestic productive capacity is equal to three tons of stockpiled material under current stockpile planning. During the Korean War DPAct supply expansion programs totalled over $8 billion and in addition to examples cited earlier in a few years these programs doubled U.S. aluminum production, increased U.S. copper mine capacity by a quarter, initiated U.S. nickel mining, and expanded supplies of many other materials for production needs and stockpiles.

The Korean War machine-tool program is another outstanding example of the use of Title III to strengthen the defense industrial mobilization base expeditiously. Before the war, DOD and Commerce had identified typical machine tools that would be needed in a mobilization. During the war, acting under authority granted by Title III, GSA avoided usual delays associated with securing defense appropriations and completing the contracting process by placing orders for these tools directly with the manufactures. If the tool builder was unable to furnish an order by the established completion date, GSA promised to pay 82.5% of the list price anyway. Production of tools under this program was prompt; tools were ready when needed by defense subcontractors. The machine tool backlog dropped from 18 months in January 1952 to 12 months by September 1952 and to 7 months by July 1953. Orders placed under this arrangement covered more than 92,000 machine tools and totalled more than $1.3 billion. Program losses amounted to less than $8 million, or substantially less than 1 percent.

Also available under section 708 of the DPAct is authority to enter into voluntary agreements with manufacturers, which, though restricted to specific, limited objectives, are immune from antitrust laws and the Federal Trade Commission Act. During the Korean War, the Attorney General approved 77 such voluntary agreements. Several agreements involving Army integration committees, including those for ammunition loading, propellants and explosives, and small arms ammunition, are still in standby status. Properly utilized, these voluntary agreements can allow DOD to more efficiently allocate the limited resources of the defense industrial base.

Pursuant to Executive Orders 10480 and 11490, under the DPAct, FEMA is in overall charge of emergency planning and program execution for strategic materials. FEMA utilizes the regular line departments and agencies to the maximum extent possible. The Department of the Interior is, in general, responsible for mines, concentrating plants, and refineries, and for the ores, concentrates, and other materials treated in such facilities. The Department of Agriculture is responsible for food resources, including vegetable and animal fats, oils, and fibers, and naval stores. The Department of Energy is responsible for fuels and energy. The Department of Commerce is responsible for facilities and materials that are further along in the chain of processing and utilization, and it maintains the Defense Materials System and the Defense Priorities System to channel materials to defense and defense-related production. Steel, copper, aluminum, and nickel alloys have long been designated as "controlled materials." In a supply disruption, the first action would be to monitor exports, followed, if necessary, by export controls. The Export Administration Act of 1979 authorizes the Department of Commerce to use export controls to restrict exports detrimental to U.S. national security, to further U.S. foreign policy, or to protect the domestic economy from the excessive drain of scarce materials and to reduce the serious inflationary impact of foreign demand. A worsening supply situation would require imposition of a system of priorities under Title I of the Defense Production Act, whereby rated orders would have to be filled first. If priorities proved to be inadequate, they would be followed by a system of allocations, also authorized by Title I. Interior, Agriculture, Energy, and Commerce would implement priorities and allocations in their respective areas of responsibility. At some point in a serious shortage situation recourse to the strategic stockpile might be required. The Stock Piling Act provides for release at any time the President determines such materials are required for purposes of the national defense. Export controls, priorities and allocations, and stockpile releases, however, are only temporary measures of limited effectiveness. In contrast supply expansion programs under Title III of the Defense Production Act would bring in additional supplies from domestic and strategically accessible sources. Interior, Agriculture, Energy, and Commerce, as appropriate, would recommend needed expansion programs to FEMA, which would then authorize the appropriate agencies to implement them.

EXTENSION OF THE DEFENSE PRODUCTION ACT, NOW SCHEDULED TO EXPIRE SEPTEMBER 30, IS AMONG OUR HIGHEST PRIORITIES.

SURGE INITIATIVES: A NEW CONCEPT TO MEET CRISIS IN THE EIGHTIES

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PURPOSE

The purpose of this paper is to provide Department of Defense (DOD) personnel with information on how contracts can be structured to gather data on the defense industrial base capability to meet emergencies. It will also provide industry with an understanding of the need for providing accurate information on their subcontractors. This data will facilitate realistic planning and enhance the readiness of the armed services. This paper further calls attention to the contract procurement leadtimes and allows DOD to accelerate contractor production and deliveries to meet surge situations in a minimum period of time.

BACKGROUND

In 1979 and 1980, people in the Government were concerned about the ability of the US industrial base to rapidly increase production rates to meet crisis. Many questions were raised during this period on the ability of the US Army Armament Materiel Readiness Command (ARRCOM) to meet a rapid acceleration of demands to support the Army and the Department of Defense (DOD) as the Single Manager for Conventional Ammunition. Could ARRCOM obtain a quick response from their contractors to produce more in a short period of time? The acceleration of contractors became known as "Surge." The key question was under what conditions would this situation evolve? Surge would result from a need to support exceptional or unusual military requirements short of war; a situation where there would be a commitment of the Rapid Deployment Forces. It would also happen during the warning period prior to a declared national emergency or to fill foreign military requirements under a support agreement. It could also conceivably happen if we needed to aid a friendly foreign government with military equipment and other logistical support, but would not require deployment of US Forces. Regardless of the particular characteristics of the scenario, the situation would require the providing of equipment and ammunition in a short period of time, attaining sustained high levels of production for extended periods, and then the resupply efforts for the duration of the crisis or emergency.

In early 1980, the Chief of the Procurement and Production Policy and Plans Office, HQ, ARRCOM, tasked the Chief of the Policy, Plans, and Control Division to develop and implement a policy covering "surge" for use in ARRCOM contracts. We were to publish a policy that would provide standard contract language for use of contracting personnel of ARRCOM in our contracts for selected items. The concept would authorize the contracting officer to "surge" a contractor's production to satisfy military consumption rate, if in a hot war; the requirements of deployed forces; or needs of a friendly foreign government.

IDENTIFICATION OF THE PROBLEMS

The Chief of the Policy Division began to research how the Government increased the rate of production of US industrial base in World War II, Korea, Vietnam, and during other periods of emergency when a quick response was required from defense contractors. During the course of this research, a basic difference became very evident. The difference is that during periods of national emergency or declared war, different powers and authority are available to DOD. Those powers and authority stem from the Defense Production Act of 1950. During such periods as Vietnam (a non-declared war situation), we do not have the benefit of statutory powers to invoke the acceleration and direction of the industrial base to produce military items. ARRCOM has identified that difference by defining "surge" as the situation which would result from a non-declared war. In this situation, it would be necessary to have agreements entered into, in advance of the event, that requires American industry to respond.

When we examined the results of mobilization during World War II, we found that the Government directed industry to make items for the armed services. The contractors were very optimistic about their ability to meet the demands of the armed services. But, when the contractors were provided the funds that they had indicated would be needed to expand their facilities and acquire the equipment to produce the quantities that the services had indicated were needed, the contractors ran into problems. The money was provided to the contractors in June of 1940. Immediately, shortages of skilled personnel, machine tooling, and production equipment were discovered. The services were competing for the limited industrial base that existed. Armed with the results of this mobilization crisis, the services decided that following World War II, that better planning was needed to preclude and eliminate future problems. The planning with industry and the participation of industry in this program is based upon the contractor's preparing and executing the "DOD Industrial Preparedness Program Production Planning Schedule (DD 1519) and becoming a mobilization planned producer.

The shortfall of this program is that the DD 1519 is not a binding agreement. It is a plan that is based on government established quantities which may require plant expansion, use of Production Equipment Packages which are to be furnished by the Government, plus a host of other options. Many contingencies are included in the delivery schedule that the contractor prepares. But, he is only required to exert his best efforts to achieve the level of production that he indicates in his plan after mobilization day. The production schedule provides for accelerated deliveries, taking into account known constraints such as shortages, and the construction of new or expansion of existing buildings. Many companies have executed these DD 1519's to produce items for which the contractor has no current production capability, indicating only that they will direct the company's assets and personnel toward production of identified items when mobilization occurs. They have planned on paper how they would achieve the plan, but only on mobilization day. It remains to be seen if they can obtain the necessary production equipment, machine tools, and skilled personnel required to meet the Government's requirements. If history is a teacher, then the planners must remember the lessons of World War II and the results of the initial mobilization. Our research revealed problem areas that had to be identified before we could adequately plan for surge. Some of these problems could be identified by careful review of the DD 1519's that have been executed by contractors, but other problems are not readily identifiable. These unidentifiable problems center around the need for contractors to acquire facilities and people and for those elements to be available during crisis. Subcontractor problems that are not identified in the DD 1519 can have major impact upon exercise of the plan.

After careful evaluation of the information that was uncovered during our research, we narrowed the problems to several basic needs. We found that these needs were:

a. To identify the capability of our prime contractors to accelerate their production with existing facilities and equipment to the maximum rates on a one-shift, one-shift with overtime, two-shift, three-shift, or other basis.

b. To have the contractors identify the long leadtime items, components, impediments and constraints which might reduce their ability to achieve the maximum production rates attainable on existing equipment in existing facilities. This would be complemented by an identification of commitments which might affect the contractor's ability or willingness to accept additional military requirements during a surge situation.

c. Similar information regarding critical and pacing items from the prime contractors' subcontractors and suppliers down to the lowest tier subcontractor. This information was required to insure that all possible impediments were identified. This information would require the contractor to identify dual commitments that he had to surge for other services which might affect the ability of the prime contractor to meet surge commitments to the Army.

d. To identify the strategic and critical materials that could impact, because of lack of availability, the contractor's capability to surge. To complement this information, the Government needed to know of any possible substitute materials that could be identified by the contractor which would satisfy scheduled contractual commitments.

e. To know the geographic availability of skilled manpower that would be available to the contractor to expand to multishift. If the skills were not available, how does the contractor propose to acquire or obtain the skills to meet the surge requirement.

f. To have the contractor identify items of production or test equipment that, if acquired, would increase rates of production in a surge situation.

g. That the Government needed a way to reduce procurement administrative leadtimes in the acceleration of contractor production during a surge situation.

After we had identified the problems, we looked at various remedies that would resolve those problems. We needed ways to obtain the information from contractors and then how to use that data. It required the development of new and better ways of doing business.

We knew, from comments of American industry, made in the American Defense Preparedness association's (ADPA) White Paper: "Defense Readiness - Force Sustainability and Industrial Preparedness Why We Are Concerned," published in final form in August, 1980, that many contractors do not spend much time in the development or preparation of the DD 1519 planning documents.

The reason for this lack of devotion to good planning and development of the DD 1519's on the part of industry is because of the lack of financial benefit that the companies have experienced because of their involvement. Many, after a period of time, drop out of the program or pay lip service to the effort. The mobilization planners of DOD need more reliable data from the contractor so they may develop high confidence level mobilization plans.

The ADPA indicated that if the Government allowed industry to tell them what their capabilities are and offered to pay them for this information and the effort that went into developing those plans, the Government would obtain better information. As contracting personnel, we recognize that there has been no "free lunch" and that the Government has always paid for mobilization planning. Most planning is either included in the contractor's overhead or as a direct charge against a Government cost-type contract.

THE INITIATIVES

The ADPA suggested that a Data Item Description (DID) should be used for mobilization planning. ARRCOM decided that a DID (copy attached as Appendix A) would be the best way to obtain the information needed by the command to do planning for a surge situation. By using the DID, the command would be able to require the contractor to identify his ability to produce for surge and what the maximum rate of production was that could be expected at his facility. This data would be furnished and revised, as necessary, during the performance period of the ongoing contract. The command would also require the contractor to identify any impediments that preclude the achievement of maximum production rates. These impediments might result from raw material shortages, subcontractor limitations in supplying critical or pacing items, or shortages of critical skills. The contractor would be required to obtain on critical and pacing items information from the lowest tier subcontractor that could have an effect on the prime's ability to attain his maximum production rates.

The DID requires a contractor to develop a Production Surge Plan to identify his maximum sustained rate of production for one, two, three, or other shift capability that he might possess. It requires the listing of both subcontracted and nonsubcontracted long leadtime critical and/or pacing items by part numbers, nomenclature, leadtime, and production buildup. The DID calls for the contractor to identify the personnel requirement that will be needed to achieve the surge production plan including the method of recruitment, training, and assignment of those people.

In addition, the DID requires the contractor to list other Army customers or other military services contracts on which he is currently performing that could presumably be surged simultaneously with the contract from ARRCOM. Since we are dealing in a nonmobilization environment, ARRCOM felt that this added information would be important to our overall planning. ARRCOM also wanted to know what commercial contractual obligations the contractor had in-house. We recognize that during buildup periods these commercial commitments would have some effect on the ability or willingness of the contractor to accept additional requirements and thus affect our capability to surge.

We also needed a list of strategic and critical materials and any possible substitute materials that could be considered. By requesting information on possible substitute materials in advance of the surge situation, we would evaluate the value of these substitutes prior to an emergency situation and could even preposition waivers to be implemented in time of need.

It was determined that the command would benefit greatly by obtaining a list of tooling or equipment, down to the lowest tier subcontract, that if acquired, would have the effect of increasing the contractor's ability to increase production rates beyond the rate that had been identified in his plan. The identification of equipment was to include the cost and time required to acquire and install that equipment in existing contractor facilities. This data would help Government planners in making decisions to enhance the base to offset projected shortages.

The obtaining of a Production Surge Plan at the beginning of the contract would give the Government a baseline from which to plan, but it was determined that the Government should have the contractor maintain that plan in a current state throughout the performance of the contract. The contractor must provide updates to the Production Surge Plan as events change. The kind of changes contemplated by these updates are improvements to the contractor's ability to increase his production over the initial plan that he had submitted or a degradation of his ability to produce. This situation could be the result of modernization of his production capability or deterioration of his current capacity by accident, wearout of equipment, etc. Loss of subcontractor capability or change in the subcontractors' capabilities must also be included to insure the integrity of the total plan. Obtaining this type of information on the contractor's ability to increase production rates at any given point in time is of substantial value to the Government planners.

To complement the data provided by the Production Surge Plan, the Government needed a method of requiring the contractor to increase his rates of production to the submitted plan. It was decided there would have to be an agreement between the contractor and the Government that would permit the Government to increase the rate of production without delay or prior negotiation. An option clause was determined to be the best method to achieve this objective. We were not talking of the usual option clause for increased quantities which is placed into production contracts, but a clause that, as we envisioned it, would provide for both increased quantities and increased rates. The normal clauses that are used provide for increased quantities at a rate of production exactly the same as that which is being accomplished under the contract and to follow on after the completion of the contract production. This would not meet the needs of the Government in a surge situation. At that time, we would need an accelerated rate of production and delivery not contemplated by the normal option clauses. The Government also needed a way not only to increase the quantity being required under the contract, but also to accelerate the rate of production on all of the items on the contract. The size of the option envisioned could be as large as 1,000 times the requirements of the existing contract. We developed a "surge option clause" that requires the contractor to accelerate his rate of production of the contract items to the level that he had indicated in his Production Surge Plan and to the number of shifts that the contracting officer might elect from that plan. That increase could be to any level above that of the current contract delivery schedule. It was recognized that this could not be done overnight, but the contractor would have the time phasing established within his plan. The option clause served another purpose in that it alerted the contractor that we did not want "pie in the sky" type planning on the Production Surge Plan. The contractor would run the risk of the Government exercising the option and to a rate indicated in the contractor's plan. This could cause embarrassment to the contractor.

While developing the option clause to be used with the Production Surge Plan, we also recognized that often we purchase items that are provided to contractors as Government Furnished Property (GFP). These GFP items could, if not delivered, delay delivery of the end item or could preclude production or assembly of the end item. These items might normally be readily available and thus would not justify the required investment in a Production Surge Plan. ARRCOM developed a surge option clause that committed the contractor to a definitive delivery schedule for the option percentage listed in the clause. This clause, sometimes called the "stand alone surge option clause," obtained the bottom line information that would normally be provided in the Production Surge Plan, but did not obtain identification of impediments nor how the contractor planned to surge his production to meet the requirements of the option clause. It was felt that the delivery schedule might provide an identification of a problem that would have to be explored in the next procurement by the purchase of a Production Surge Plan Data Item. That is, if the delivery schedule provided by the contractor created a problem for the end item contractor or for the Government.

The next element that was reviewed was the problem of contracting with producers who did not have current contracts for items which we had identified as planned items for mobilization and/or surge situations. These contractors may have produced the item before or they may have indicated in a recent solicitation that they had the capability and willingness to produce the required item. They are often referred to by Government planners as "cold base" producers. The ADPA in their "White Paper" had indicated that prepositioned letter contracts with cold base producers would be a method of accomplishing this level of readiness. The problem with letter contracts are that they require the signature of the contracting officer and the acceptance of the contractor before they become a binding agreement. Even during the Vietnam conflict, many days of administrative time were required to obtain the approvals necessary to place a letter contract, the time required to obtain the latest technical data, and to prepare the final award document. A prepositioned letter contract may have to be updated because of changes in contract clauses in effect on the date of intended award, scope of work changes, drawing changes, etc. We determined that the Basic Ordering Agreement (BOA), executed by both parties with the right of the Government to place unpriced task orders for identified items would be a quicker procedure for handling the situation. This would be complemented by providing a complete, current technical data package with the BOA contractor and providing him periodic changes and updates to that technical data package. If funds became available to accomplish surge planning, a task order could be issued for the preparation of a Production Surge Plan against the BOA. The BOA would be broadly written so that it could be used by the Government to place routine orders with the contractor. One of the complaints that has been registered by Mobilization Planned Producers about the DD 1519 is that they seldom receive any value from the fact that they are a planned producer and the contractor spends a considerable amount of time and effort preparing the form. The use of the BOA's in the ARRCOM surge concept would be that they could be used whenever possible and thus demonstrate some value to the contractor. The time saved by avoiding the preparation of the contract and obtaining the supporting technical data would amount to the saving of several weeks. This time could be used by the contractor in his production leadtime and facilitate earlier delivery to the Government in a surge/ mobilization situation.

With the development of the surge provisions, we needed to identify the items for which planning would be required. The ARRCOM Policy Office decided that there was a need to develop a Surge Items List. In order to utilize existing systems and data that were available, a decision was made that ARRCOM would use the Industrial Preparedness Planning List (IPPL) as the basis of the list. The IPPL is a list of items and components essential to combat consumption and mobilization planning. It was recognized that the IPPL had a quantitative restriction and that many items that were being transitioned from a development manager to a readiness manager would not have been included on the IPPL, but would be used in a surge situation. The Surge Items List was envisioned as a very flexible list of items and since the planning was done in a peacetime environment, we were not dealing with the limitations required by mobilization. The production managers were established as the people responsible for development and maintenance of the Surge Items List. They would coordinate the development with the industrial preparedness planners, material management personnel, and other people responsible for ordering items.

What has been gained from the implementation of the Surge Initiatives by ARRCOM? ARRCOM has been able to gather information that will be based upon a contractor's existing production equipment and facilities and what specifically the contractor can do now. The data that is gathered is more reliable because it will be current and not predicated upon the purchase of production equipment and tooling during a period when many contractors will be seeking additional production equipment. It will identify shortfalls that the production planners can use to make decisions to increase the size of the production base through direct Government funding or when considering the need to expand the mobilization base of the private sector.

The information that can be gathered will provide production and mobilization planners with information on current capacity and the impediments of utilization of that capacity. Identifying subcontractor shortages that would impact the ability of prime contractors to achieve maximum rates is very important. This information is not readily available to the Government from other sources. The ARRCOM Surge Initiatives will provide a better base of knowledge on critical material and possible substitutes for these materials that has been available from other sources.

The plans submitted by the contractor will provide a list of tooling/equipment and test equipment with costs and leadtimes which can be used by the production planners to increase the production base if funds become available for that use. The Government might find ways that they could increase the production of critical items with a minimum amount of investment in additional equipment. The purchasing of the equipment in advance of an emergency could save precious weeks or months and dramatically change the course of events.

INITIATIVES WERE TIMELY

The ARRCOM Surge Initiatives were implemented in October, 1980 when a test of the concept was authorized by Major General William Eicher, who was the Commander of ARRCOM. This test began before the completion of the hearings or report of the Ichord Congressional Panel and the testimony that was presented. The report of the Defense Industrial Base Panel of the Committee on Armed Services, "The Ailing Defense Industrial Base: Unready for Crisis," commonly referred to as the Ichord Report, was published on 31 December 1981.

A close review of the report of the Ichord Committee validated the need for the ARRCOM initiatives. In fact, in presentations before various groups of Government and contractor personnel explaining the ARRCOM Surge Initiatives, quotes from the Ichord Report were used to validate the necessity for obtaining the data and prepositioning ARRCOM's contract provisions and the Surge BOA's.

The only way to compare what benefits the ARRCOM Surge Initiatives provide is to compare them with some of the major findings of the committee's report. Let's examine how ARRCOM's initiatives resolve or enhance resolution of the findings:

a. The Ichord Committee found that the Department of Defense has neither an ongoing program nor an adequate plan to address the defense industrial base production issue; Department of Defense inaction in enhancing industrial preparedness, coupled with instability within the 5-year defense program, weapons system procurement stretchouts, inadequate budgeting and inflation, has contributed to the deterioration of the US defense industrial base and, as a consequence, jeopardized the national security. The ARRCOM initiatives cannot correct problems identified in the findings of the committee, but can obtain the necessary information to provide a basis for the development of solutions to the problems. The production Surge Plan would identify the ability of the base to respond to a crisis situation. It would provide a base of information which could be used to correct these problems in advance of the crisis; problems such as the need to stockpile critical material or to use a substitute; the need to provide incentives to create new foundries in this country to expand that base which has shrunk because of Environmental and OSHA regulations. This is only one example of the problems which would be uncovered and validated from the information contained in the production surge plans.

b. The Ichord Committee found that there was a shortage of critical materials, combined with a resulting dependence on uncertain foreign sources for these materials, which is endangering the very foundation of our defense capabilities. These shortages are a monumental challenge to the Congress, the Department of Defense, the defense industry, and the civilian economy. The ARRCOM initiatives would not correct the findings of the committee, but would obtain information to identify the spectrum of the problem. The Production Surge Plan calls for the contractor to identify critical material shortages and to recommend a viable substitute. This part of the plan would highlight the material shortages by types and would also provide substitutes for consideration by the Army technical community in advance of emergency.

c. The Ichord Committee found that the defense industrial base is unbalanced; while excess production capacity generally exists at the prime contractor level, there are serious deficiencies at the subcontractor level. The ARRCOM Surge Initiative calls for contractors to develop a Production Surge Plan that identifies the shortages and the impediments to the prime achieving maximum production. The early identification of these problems allows DOD to collect planning information to correct the shortages and impediments permitting the prime contractor to achieve the necessary production level. Currently the DD 1519 data does not provide information below the first tier subcontractor level. Testimony before the committee indicates that the planning below that level is very poor to nonexistent. The ARRCOM Surge Data Item provides information on the commitments of the subcontractors to more than one service. We are thus able to quantify the capacity of the subcontractor. This type of information, if not known at the time of surge or mobilization, would result in the placement of requirements on a prime contractor that would tax or surpass the capacity of his subcontractors. At that point in time it would be too late for corrective action and the consequences might be disastrous to our combat forces and to the country. Advance information of industrial base problems could lead to the establishment of alternate sources for a given item or finding alternate systems to be used in emergencies.

d. The Ichord Committee found that the industrial base is not capable of surging production rates in a timely fashion to meet the increased demands that would develop during a national emergency. The data obtained by the ARRCOM Surge Initiatives would validate the ability of the industrial base to surge. Based upon the data that was received, the production managers could elect to purchase more items for stockpile during peacetime that would give them the cushion to meet a surge situation. The stockpile could be sized to allow industry time to build up to the surge consumption levels that would meet the most likely scenario. It would allow the managers an option of increasing the base or finding additional producers who would like to become part of the base and provide the production capacity that would be needed in a surge situation.

e. The Ichord Committee found that the leadtimes for military equipment have increased significantly during the past 3 years. This is a problem even in a period of relatively low defense and commercial production, 1978-1980. The Production Surge Plan would provide information and data to identify by commodity the US ability to surge production and to identify the impact of the subcontractor base as related to the capability of the prime. It might encourage the industrial base to invest in foundries, machine shops, electronic production capacity, etc. It would highlight the need for additional Government investments in the industrial base. The plans submitted by the prime contractors would give a real time, current assessment by military items and systems of the defense industrial base. The production planner could initiate requests for regulatory relief to protect certain industrial base contractors or request statute changes to encourage contractors to modernize their production equipment and to increase the subcontractor base of supply. A host of options unfolds with the validity of this information.

f. The Ichord Committee found that there is a skilled manpower shortage that currently exists and the projection is that it will continue through the decade. The ARRCOM Surge Initiatives will identify the extent of that shortage and the type of skill mix that is needed to surge the contractors. This information should provide a better data base on what type of effort will be needed on the part of our contractors to obtain trained employees to meet the shortages. It will also identify the need on the part of the Government to develop incentives for contractors that will insure that they train or obtain the needed skills.

g. The Ichord Committee found that the current industrial preparedness planning tool, the DD Form 1519, lacks realism. The Production Surge Plan developed by ARRCOM calls for identification of the current production capability and the limits placed on achieving the maximum rates within that capability. It does not direct the contractor to deliver quantities which require planning based upon the supposition that money, equipment, and time would be readily available; that the necessary skills to run that equipment would be available; that raw material would be available; that adequate subcontractor support would be available; etc. Production Surge Planning is based upon what is available now, what that capacity can produce now, and what the limits are on that capacity to surge to higher levels. The only variables are the expansions to multishifts, which would require hiring and training of personnel.

It was interesting to note that the Ichord Committee found that the war reserves are at a dangerously low level and could only support the shortest of "short war" scenarios. The Production Surge Plans would give a high confidence level assessment of production rates and when these rates would be commensurate with anticipated consumption rates, if ever, and thus provide a better baseline from which to plan our war reserves.

VALIDATION OF THE SURGE INITIATIVES

DOD formed the DOD Industrial Base Task Force in response to the Ichord Report. When the DOD Industrial Base Task Force began to review the needs to improve the US Industrial Base, the Chief of the Policy, Plans, and Control Division, P&P Policy and Plans Office of ARRCOM called the committee and suggested that they review the ARRCOM Surge Initiatives. The committee requested a complete briefing of the concept; at the briefing held in August, 1981, many of the ideas incorporated in the ARRCOM Surge Initiatives were considered for inclusion into the report of the Task Force. The Task Force asked if the Defense Acquisition Regulation (DAR) needed to be revised to include these concepts; the initial response was no. What had been envisioned and developed in ARRCOM's Surge Initiatives did not require a DAR change. The Task Force suggested that the concepts might be included in DAR for the benefit of the contracting people of DOD. The concepts would be readily available for any DOD office to review and use as appropriate.

Upon return to the ARRCOM Headquarters and, after a second request from the committee, it was agreed that changes to DAR Section 1, Parts 15 and 22, and to Section 7, Parts 1 and 2 were appropriate. The changes were developed and submitted to the Industrial Base Task Force. The change to 1-1500 incorporated the Surge Option concept and made reference to the sample clauses which were included in DAR 7-104, 106, and 7-204.70. In addition, DAR Section 1, Part 22 was revised to identify Surge Planning as a concept and to note the differences between surge and mobilization.

In addition, changes to DOD Directive 4005.1, DOD Instruction 4005.3, and DOD Manual 4005.3M were recommended. These added surge requirements developed by personnel of ARRCOM made changes which strengthened the mobilization provisions of those documents and incorporated surge requirements for use by the elements of DOD.

The committee adopted the recommended changes to the DAR and most of the changes to the DOD Directive, Instruction, and Manual. This acceptance validates the value of the 2 years of effort that have been expended by ARRCOM to improve the ability of the Government to surge their contractors during periods of emergency. The utilization of the Surge Initiatives by all DOD elements would provide a ready data base to preclude problems in emergency planning. It allows corrective action to be taken before emergencies evolve. In the end it would improve DOD readiness to respond to crisis.

DATA ITEM DESCRIPTION

1. TITLE	2. IDENTIFICATION NO(S). AGENCY	NUMBER
Production Surge Plan	Army	DI-P-1634

3. DESCRIPTION/PURPOSE

3.1. The Production Surge Plan delineates a contractor's capability to rapidly accelerate and sustain production utilizing existing facilities and equipment without a declared national emergency, declaration of war, or mobilization and use of emergency war powers.

3.2. The Production Surge Plan provides data on the maximum sustained production rate, longlead, critical, and pacing (cont'd)

4. APPROVAL DATE

5. OFFICE OF PRIMARY RESPONSIBILITY

ARRCOM

6. DDC REQUIRED

8. APPROVAL LIMITATION

7. APPLICATION/INTERRELATIONSHIP

7.1. This Data Item Description should be applied in solicitations/contracts for which a production surge capability for select critical items is required.

7.2. The Contract Data Requirements List (DD Form 1423) should require that any production changes which impact the Production Surge Plan be submitted as revisions within 2 weeks of their occurrence.

7.3. This Data Item Description may be used independently, with, but not in lieu of DI-P-7046.

9. REFERENCES *(Mandatory as cited in block 10)*

MCSL NUMBER(S)

10. PREPARATION INSTRUCTIONS

10.1. <u>General</u> - The Production Surge Plan shall delineate the contractor's capability to rapidly accelerate production utilizing existing facilities and equipments in a peacetime environment (no declared national emergency, declaration of war, or mobilization and use of emergency war powers). The plan shall be predicated on utilization of peacetime program priorities to obtain materials, components, and other industrial resources necessary to support the accelerated production requirements.

10.2. <u>Format</u> - Unless otherwise specified on the Contract Data Requirements List (DD Form 1423), the Production Surge Plan shall be in the contractor's format.

10.3. <u>Content</u> - As a minimum, the Production Surge Plan shall consist of the following:

a. The maximum sustained rate of production utilizing a single work shift (1-8-5), a single work shift supplemented by authorized premium pay (overtime effort), a double work shift (2-8-5), and a triple work shift (3-8-5), to include a production buildup schedule by the month until the maximum at each level is attained.

b. Two lists, one of subcontracted and one of nonsubcontracted items, by nomenclature, part number, leadtime, and production buildup of longleadtime, critical, or pacing items which could adversely impact the production rates identified in para 10.3.a. Subcontractors and vendors shall be identified by name and address for each item. This requirement shall flow down to whichever subcontractor tier (level) is necessary to adequately identify the longleadtime, critical, and packing item(s).

c. Identification of all personnel requirements including how additional personnel will be recruited, trained, and assigned. (cont'd)

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Production Surge Plan DI-P-1634 (cont'd)

3. Description/Purpose (cont'd)

items, personnel requirements, other contracts with surge production provisions, and probable surge impact. This data provides for surge (accelerated production) planning of selected items that are identified on the surge items list.

10. Preparation Instructions (cont'd)

d. A list of contracts being performed at the contractor's facility that have a production surge provision or could reasonably be presumed to be surged. The list shall identify the contract number, the item(s), and the Defense Materials System and Defense Priorities System priorities assigned to each contract.

e. What impact surging this contract would have on the performance of any other Government contract that might be concurrently surged with this contract. What impact surging this contract would have on the contractor's commercial business.

f. List and identify strategic and critical materials and precious metals by type and quantity required to attain each of the production levels identified in the Production Surge Plan. Additionally, identify any substitute material that could be utilized for each of the above categories.

g. List of tooling and/or equipment down to the lowest tier subcontractor that could be acquired that would increase production rates and remain within the current facilities limitations. Estimate the cost (including installation costs) and delivery leadtime for the acquisition of the tooling and/or equipment. Data obtained under this paragraph will not be used in the preparation of the basic plan but may be used by the Government for developing additional surge capability if deemed essential.

DOD CONTRACTING AND ACQUISITION: UNPREPARED FOR A NATIONAL EMERGENCY

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ABSTRACT

This paper presents opinions and library-type research which strongly suggests that the Department of Defense (DOD) Contracting and Acquisition process is not prepared for a national emergency (NE). The primary deficiencies include fragmented and little understood acquisition related NE laws, executive orders and directives, inadequate Defense Acquisition Regulations, the under utilization of existing regulations to increase the industrial base, and a lack of planning, especially at the contracting office level.

INTRODUCTION

This paper was written to support the "Wartime Readiness" goals identified in the Hq AFSC "Corporate Guidance for Air Force Systems Command" document dated February 1981. The document states the one of AFSC's "key weaknesses" is that "our war-time planning has not received the emphasis it requires." Hence, to address the problem, thirteen objectives are identified in the document under Goal 2. Wartime Readiness. Two of the thirteen objectives are applicable to contracting:

- Develop and implement streamlined contractual procedures which could be used for wartime acquisitions; and

- Ensure a Quick Reaction Capability (QRC) posture for meeting wartime contingencies.

During 1981 the AFBRMC was informed by DOD acquisition managers, researchers, and the civilian sector that the DOD Contracting process may not be ready to meet the demands of a national emergency, mobilization, or a large scale conflict. Subsequent research strongly suggests that DOD's contracting and acquisition process is unprepared and inadequate if a national emergency or mobilization were declared today.

Study Methodology

This study conducted in July 1981 consisted of library research and unstructured interviews.

Eleven contracting, system program office, legal and program control personnel assigned to the AFBRMC, AFIT, ASD, Hq AFLC and AFALD were interviewed to obtain opinions as to "What Contract or Systems Acquisition Procedures Would Have to be Changed in a Protracted, Non Nuclear High Intensity Large Scale Conflict Similar to World War II."

The interviewees were selected based on experience in their functional specialty to obtain broad generalized opinions on the topic. Since this initial inquiry dealt with "procedural" changes all the interviewees were selected because they are experienced managers at the Directorate level or lower.

Each interviewee was then asked "What legal, financial, contract and weapon system acquisition procedures do you envision in a protracted, non-nuclear high intensity large scale conflict similar to World War II?"

Interview Results

All the interviewees conditioned their responses by stating that any procedural changes would depend on the specific scenario, priorities established at the national and command levels, and the state of the acquisition process a weapon system was in at the time. The responses were based on the following scenarios:

- Increased tension followed by various degrees of mobilization

- A limited "Vietnam" type conflict

- A pre-emptive nuclear strike

- A protracted non-nuclear high intensity large scale conflict

All agreed that any procedural changes would not be applicable in a pre-emptive nuclear attack. Most interviewees felt that with the exeption of certain contracting and system program organizations, it would be "business as usual" in a "Vietnam" type conflict.

The following expedited contract procedures for those organizations directly involved in a "Vietnam" type conflict were envisioned: letter contracts, unpriced Purchase Orders, increased number of change orders, increased sole-source acquisitions, increased use of DX ratings, and blanket deviation authorities - i.e., the BIG SAFARI Program.

No significant System Program Office (SPO) procedural changes were envisioned during a "Vietnam" type conflict.

In the event of an emergency the Air Force Acquisition Logistics Division (AFALD) has developed a Contingency Acquisition Support Kit (CASK) consisting of a sturdy brief case which contains items necessary to perform on-the-spot contract awards. However, funding procedures in support of CASK operations may need to be studied because it appears there is no clear understanding of the funding process other than "contractors will be reimbursed."

With the exception of the AFALD, none of the interviewees were aware of any contingency plan or implementation procedures at the contracting and SPO levels within AFSC and AFLC. Most assumed that some sort of war plan had been developed at the Hq AFSC, AFLC and ASD level but they were unaware of the details. It was subsequently learned from ASD/XR that such a classified plan exists.

Most of the interviewees felt that the real constraints are not in the contracting or acquisition procedural process. They referred to the deficiencies identifed in the December 1981 Congressional report entitled "The Ailing Defense Industrial Base: Unready for Crisis." The deficiencies identified by the interviewees include:

- Lack of stockpiled, critical raw materials, components and spare parts

- An ineffective allocation system

- Antiquated contractor capital facilities

- A limited industrial base, especially at the subcontractor level

- Fluctuating production runs and frustrating reprogramming exercises by SPO's because of inadequate funding

In mentioning the above deficiencies most of the interviewees echoed the same theme. That is, "It's too late once a major war erupts. Something has to be done now so that the resources are available from the beginning."

Most interviewees had a difficult time trying to envision what life would be like or what procedures would be different during a major, non-nuclear confrontation. Their difficulty seems to stem from not knowing what laws and executive orders would be issued at the national level and what priorities would be emphasized especially at the Hq AFSC, ASD and AFLC levels. However, the following composite scenario emerged:

Most R&D projects with the exception of "Manhattan" type projects such as lasers and those that could be readily implementable, would be either cancelled or deferred. Emphasis would be placed on those weapon systems already in full scale production. The Defense Systems Acquisition Review Council (DSARC) process would either be abandoned or revised to concentrate on what could be done to expedite the production of existing systems. "Leader-Follower" and "Second Source" concepts would be used to increase production on less complex systems.

Expedited contract procedures would be implemented, contractual restrictions would be lifted and delegations of authority would be increased down to the contracting officer level. To expedite the contracting process within AFSC and AFLC, the following would probably occur:

- Formal advertising would be eliminated. Negotiated sole source contracts would be let via unpriced orders, pre-set Basic Ordering Agreements, letter contracts and directed contracts.

- Competition would remain but not in terms of today's concept. Competitive awards will be based on two main criteria - schedule and the ability to perform.

- Major purchases will revert to small purchase procedures.

- The emphasis on the applicability of the different types of contracts (i.e., CPFF, FFP, etc.) will be downgraded. Most contracts will be cost reimbursement type with profits to be renegotiated later. The Renegotiation Act will probably be revised.

- The existing funding process would have to be changed. Funding policies even more liberal than the current "multi-year" concept may be enacted-including disregard of the Anti-Deficiency Act and the use of credits to be settled later.

- DCAS and AFPRO's will be delegated procuring activity functions. Engineering surveillance would decline while production and quality assurance surveillance would increase.

- The contracting officer's authority will be increased and in some instances he may become the SPO Director's Deputy.

The following are some of the internal management controls that will most likely be changed:

-- D&F's will be approved at lower levels or the D&F process may be eliminated altogether.

-- Purchase requests will be simplified - statements of work will contain gross performance criteria and delivery schedules. Contract Data Requirements Lists (CDRL's) will be reduced to the bare minimum.

-- Requests for Proposals (RFP's) will be simplified and kept to a minimum.

-- Procurement Plans will be simplified.

-- Solicitation Review Panels (i.e., Murder Boards) will be eliminated.

-- The Source Selection Process will be simplified and the number of Source Selection Boards convened will be significantly reduced.

-- There will be fewer contract reviews, legal reviews and manual approvals.

All of the above were changes envisioned by the interviewees. Not one interviewee could identify any document that addressed contract procedures to be implemented during a national emergency or surge environment. During subsequent research over three hundred bibliographies of national emergency related studies obtained from the Defense Logistics Information Exchange (DLSIE) were reviewed. Not one study addressed what Defense Acquisition Regulation (DAR) changes would be required, what contracting related laws would be enacted, and to what extent national emergency contracting and acquisition planning is being performed.

Post Survey Responses

Copies of the preliminary survey were sent to Headquarters Aeronautical Systems Division contracting and acquisition organizations for comment. Nine organizations responded. All concurred with the need for future research and the development of streamlined acquisition procedures. Their responses (which may be obtained from the AFBRMC) are included in the Chapter entitled "Recommendations for Further Research."

Post Survey Research

Further research was conducted to determine to what extent the national emergency changes envisioned by the interviews were adequately covered by the DAR. Twenty-two Contracting Officer functions yielding 53 issues were identified as candidates for further analysis (Reference Appendix A). Of the 22 functions, 15 functions and 37 issues were categorized as belonging to the Pre-Award phase. Seven functions and 16 issues belong to the Post-Award phase. The issues requiring further investigation deal with:

Issue	Number	Percent of Total
Dollar Thresholds	4	7.5%
Reorganization/Contingency Plans	7	13.2%
Mechanization/Automation	4	7.5%
Training	3	5.7%
Contract Provision Revisions	29	54.7%
Funding	2	3.8%
Delegations of Authority	4	7.5%
	53	100%

The interview resulted in two other significant points. They are the decline in our industrial base and the lack of national emergency contingency planning at the contracting office level. These topics are addressed in the chapters that follow.

Exception 16 - An Awesome Authority

In October 1978, the DOD conducted a major exercise called "Nifty Nugget." It was undertaken to assess our abilities to effectively mobilize in time of war. Industrial mobilization was only part of the overall mobilization exercise. However, the results of the exercise clearly established that the industrial base, in its present condition, could not support our military demands in a major European war.

One of the reasons the U.S. doesn't have an adequate industrial base is because it isn't maintained by the Government. Because of a lack of DOD business, contractors have turned to more profitable ventures. This was confirmed by Jacques Gansler, Deputy Assistant Secretary of Defense for Material Acquisition in November 1976. (4:6-7)

Some will argue that the DOD shouldn't be held accountable, in a free enterprise society, for the country's industrial base. The truth of the matter is that the DOD has taken on the responsibility for maintaining our industrial capability through the Industrial Preparedness Planning (IPP) Program. However, Gansler feels the program isn't working because:

-- It rests on a gentlemen's agreement to increase production (which) implies the declaration of a national emergency and contains no contractual obligation for performance. . .

-- Firms preparing IPP forms have routinely assumed that critical inputs to production (labor, parts, capable equipment, materials, etc.) will be available.

-- It examines only the prime producers and does not look at the often more critical aspect of the effect increased production would have on subcontractor or lower tier producers.

-- Planning is fragmented within the services and within DOD itself. (4:11-12)

Innovative ways are being proposed to improve our industrial base and to prepare for mobilization. Areas currently under review include improved industrial preparedness planning, expanding and prestocking war material reserves and weapon systems, manufacturing technology incentives, multi-year funding techniques, simplified contracts and specifications, a more liberal profit policy, and surge contracting. However, little if anything is being done to emphasize the ways the industrial base can be expanded and competition increased through existing contracting and acquisition regulations and laws. One such method which can be used is "Exception 16" (i.e., 10 USC 2304(a)(16)) which was permitted under the Armed Forces Procurement Act of 1947.

Under Exception 16 "purchases in the interest of national defense or industrial mobilization" can be made. The authority and flexibility of this exception is awesome--and it can be used now, before a national emergency to strengthen our industrial base. This exception currently authorizes contracting by negotiation when:

"He (the Secretary) determines that (a) it is in the interest of national defense to have a plant, mine, or other facility or a producer, manufacturer, or other supplier available for furnishing property or services in case of a national emergency; or (b) the interest of industrial mobilization in case of such an emergency, or the interest of national defense in maintaining active engineering, research, and development would otherwise be subserved." (4:18)

There appears to be a general lack of understanding as to how this authority can be used. Although it is used with discretion, it gives the Service Secretary what is tantamount to a blank check. The authority not only allows the Secretary to "negotiate" contracts, but he can also direct sole source procurements, exclude firms from competition, procure from multiple sources for the same item and just about expand or upgrade the industrial base anyway he sees fit!

The DAR 3-216.2 identifies seven general situations, under which Exception 16 can be invoked.

This means that the Service Secretary has the authority to:

-- Award a sole source contract to a business that otherwise might fail.

-- Equalize, split and continue production levels among suppliers.

-- Limit current competition or create multiple sources to enhance future competition.

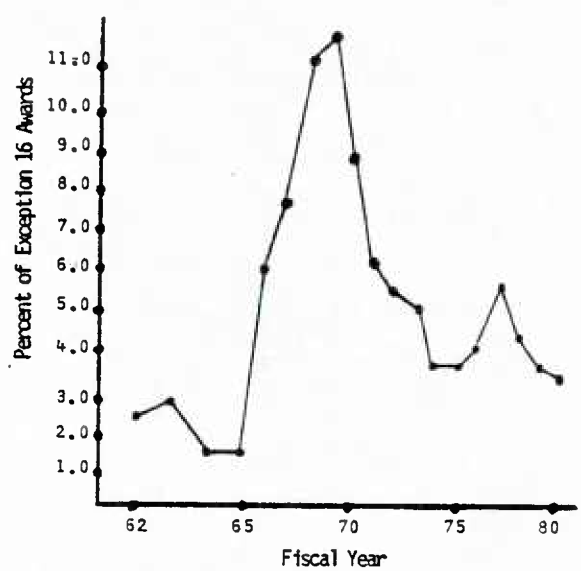
-- Restrict foreign competition to maintain domestic industrial capabilities.

-- Avoid breaks in production by one contractor while two or more other sources are gearing up.

"Exception 16" is only used in about one-tenth of one percent of all Army procurements. As a percent of total negotiated Army dollars, it has declined from approximately 26% in 1970 (i.e., during the Vietnam War) to approximately 5% during fiscal year 1979. (4:28)

Interestingly, the decline in "exception 16" acquisitions DOD-wide appears to closely precede and parallel the decline of our industrial base in 1972 as shown in the following chart (1:6-22 to 6-25). The chart which was developed from DOD data, also indicates that the use of "exception 16" increased during wartime as evidenced by the trend line beginning in FY 1965.

10 U.S.C. 2304(A)(16) Awards As A Percent of Total DOD Negotiated Dollars



It's interesting to note that the use of "Exception 16" during FY 1980 is at about the same percentage level as it was in FY 1973-FY 1974. It was during this period, as a result of the Arab-Israel War, that the Chrysler Corporation could not increase Main Battle Tank production from 30 to 100 per month. This event more than any other in recent history spotlighted the decline of our industrial base. Even more interesting and perhaps shocking is that the Army Automotive and Tank Command, who was buying the Main Battle Tank, did not once use "Exception 16" during the period 1970-1979.

The only reason found as to why "exception 16" isn't used more frequently is that it requires a substantial investment to implement and the initial per unit costs of items acquired are high. In light of DOD's cost consciousness during the post-Vietnam era, it is also understandable why it wasn't used. More frequently, savings were realized as a result of innovative schemes such as Value Engineering, Design-to-Cost, Life Cycle Cost and Should Cost. Yet the fact remains that the DOD hasn't increased competition or expanded the industrial base. Another reason why this authority hasn't been more frequently used is that the Service Secretaries, Congress and the President would probably be besieged with a host of political, legal and socio-economic protests.

However, something has to be done. The use of "Exception 16" appears to be a step in the right direction. It created competition and expanded the industrial base in the acquisition of Army night vision goggles.

In 1974 the Army awarded ITT's Electro Optics Division a low rate initial production contract for 120 goggles at a unit price of approximately $13,000. By 1978, after employing a strategy which included sole source, restricted competition and "educational buy" contracts, the per unit price was reduced to $5,066. By 1978 two other firms (Litton and Varo Inc.) were capable of producing the goggles.

Now is the time to increase competition and to develop production capabilities by expanding the industrial base. During a future war:

> The U.S. industrial base would be hard pressed to respond with the volume of war material necessary to assure uninterrupted support in a NATO conventional conflict . after the inventories of war reserves have been exhausted. (4:15)
>
> It may be too late to become innovative after a national emergency or war is declared. "Exception 16" is an authority that is available to prepare for these eventualities. It should be given increased attention.

Procurement Office Planning Needed

With the exception of the Air Force Acquisition Logistics Division, there appears from the interviews and subsequent research that little or no national emergency/mobilization is being accomplished at the procuring office level within the Air Force. Subsequent research suggests that this may be true for the other Services as well.

How and what to plan for during a national emergency within a procuring office requires further study itself. USAF Major Ronald A. Dice developed a framework an Accounting and Finance Office (AFO) could use in planning for contingencies. (3:-) Some of his ideas appear applicable for contracting organizations and have been revised or generalized accordingly.

The Major Commands (MAJCOMS) should become involved in the planning process. Their assistance is required because of the current shortage of experienced personnel at the contracting office level and the lack of guidance the contracting offices have on how to conduct business during a national emergency. After or concurrent with providing detailed guidance on how to contract in a national emergency, the MAJCOMs should work with contracting offices in the development of contingency plans. It is unrealistic to charge the contracting organizations with the responsibility to develop detailed plans in the absence of information. As a minimum, the contracting offices will need to know the role they will assume within the MAJCOM and what laws, regulations, and procedures will be invoked during a national emergency. However, Directors of Contracting/Procurement can do much to get a plan developed. Some "How" and "What" suggestions follow:

Development of Plans (How)

-- Assign key personnel the task of researching significant functions and procedures performed by the organization.

-- Each assignee should write questions, note vague ideas, question feasibility and determine requirements as they go through regulations, directives, and procedures. The implications for each section or function within the organization should be identified.

-- Supervisors should concern themselves with how the actions affect the supervision of the Section.

-- After the initial review all the issues, problems, requirements and questions identified should be categorized and discussed by the Director and key personnel. Several sessions may be required. At the end of each session, specific milestones should be established for the remainder of the process. Questions should be resolved by the appropriate MAJCOM organization.

-- The final review should include a review of all developed items such as formal plans, checklists, instructions, briefing aids, etc. They should be reviewed for completeness, accuracy, and clarity. After the review, the finalized planning package should be coordinated within MAJCOM channels.

-- The final plan should be explained to the lowest appropriate levels within the organization and periodically reviewed.

Substance of the Plan (What)

This section delineates what should be included in the plan. Each plan must be tailored to an organization's mission, requirements, and needs. Hence, only major points are highlighted below:

a. The execution of any plan depends on the availability of people. Hence, each Director of Contracting will have to determine the number and types of people that will be required in various situations (i.e., during general and limited war, mobilization). In performing such an analysis he must consider:

(1) How many people are available now?

(2) Of those available, how many are to be committed to other duties?

(3) What can the available people do prior to reservists coming on board or the hiring of new employees?

(4) What will be the experience level of the new people?

b. What minimal information will be required to document purchases? What requirements will be waived, modified, streamlined?

c. Consideration should be given to levels of support and service to be provided during pre-determined levels of alert. Will the Contracting Director know in advance who he is to support or be supported by? If so, this should be included in the plan. If not, or if there is any question, the answers will have to be obtained from the appropriate sources. If reserve or other units are to be supported, are the details spelled out in Host Tenant Support Agreements or other documents? If the documents are vague or nonexistent then further action is required.

d. Consideration should be given to the need for and composition of pre-determined national emergency contracts, mobilization contracting kits, and mobilization contracting teams so that on-the-spot contract awards can be made.

e. All existing reporting requirements should be reviewed. Agreement and approval should then be obtained for those deemed absolutely essential. During the coordination cycle, the MAJCOM should identify any new reports that will be required and existing ones that will be revised or deleted.

f. The contract accounting and funding process will need a thorough review.

g. If the contracting activity is near a hostile area, a number of questions must be addressed, such as:

(1) Are civilians to continue working or are they to be evacuated?

(2) If the number of people is reduced, what will be the organizations's level of effectiveness? Will there be enough trained people to handle the job?

(3) What documents must be protected? How are they to be disposed of in case of evacuation?

h. To what extent will mechanized equipment make-up for personnel short-falls and the projected increased workload?

The above framework will aid Procurement Directors in developing a plan which addresses some basic questions about the role of their organizations in a national emergency. However, in order to develop an adequate plan they must be given sufficient guidance on what to plan for and what laws and regulations will be in effect at that time.

Findings

The findings of this study suggest that the Department of Defense's contracting and acquisition process is unprepared and inadequate if a national emergency or mobilization were declared today because:

- The laws relating to national emergency acquisition procedures are fragmented. As a result, there is a lack of understanding as to what legislation and executive orders exist, are required, and how they impact specific contracting and acquisition procedures at the working level.

- Very little, if any planning and even thinking as to what should or needs to be done in a national emergency-surge environment exists at the contracting or System Program level. The most signficant reason for this appears to be a lack of wartime guidance from the service departments, acquisition commands, and Defense Acquisition Regulation (OAR).

- The DAR is so restrictive that twenty-two primary Contracting Officer functions and fifty-three limitations or more would have to be revised or deleted to accelerate the contracting process. Yet there is no known documentation available which describes what should be done.

Recommendations for Further Research

In addition to the suggestions in this paper, it is recommneded that research be performed to:

- Identify and analyze contracting and acquisition related laws and executive order which would be enacted prior to and during a national emergency. Based on any findings which indicate deficiencies, prepare proposed laws, executive orders and DOD directives which can be enacted prior to or upon the declaration of a national emergency or war.

- Develop alternatives to restrictive DAR contracting procedures and those identified in the 31 December 1980 Congressional report of the Defense Industrial Base Panel.

- Review and analyze the contracting life-cycle process of an appropriate number of organizations within the Air Force Systems and Logistics Commands to identify what procedures would have to be deleted, revised or added during a major, non-nuclear war. Then develop new procedures accordingly.

- Review and analyze documentation such as AFSC Pamphlet 800-3 "Acquisition Management" to determine which functions and procedures should be changed prior to and during a major, non-nuclear war.

- Examine contractors who are experiencing significant increases in DOD business to learn about similar growth problems to expect during a non-nuclear surge. This will also examine expected working relationships in this environment.

- Develop practical "organization war game" contracting and system acquisition exercises and a curriculum for use by DOD educational institutions based on the findings and end products obtained from the above research efforts.

Appendix A

The following DAR provisions will most likely have to be revised to expedite the contracting process during a national emergency or major non-nuclear war. A more detailed summary is presented in "OAR Revisions Required In A Surge Environment" which may be obtained from AFBRMC/RDCB, Wright-Patterson AFB, OH 45433

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DAR Revisions Required

The Pre-Contract Award Phase

DAR CITE	AREAS TO INVESTIGATE
Pre-Award Surveys 1-900; Appendix K	Performance data for contract awards over $100,000; Expansion and creation of pre-award survey offices; Need for mechanized systems.
Corporate and Oivision ACOs Section 20, Part 9	Contingency plans to identify industry expansion and new DOD contractors; ACO training/placement.
Letter Contracts 3-408; 7-802	Pre-placement definitization provisions; Admendments; maximum Government liability; possible absence of appropriated funds; provisions relating to priority ratings, payments, management systems requirements and audit.
Basic Ordering Agreements 1-1003.1; 3-410.2	Extending BOAs that otherwise would expire; implementation of revised provisions; Delegation of D&Fs for priced and unpriced orders; need for synopsizing.
Deviation Requests 1-109	Decentralization of deviation approvals; Revision of deviations consistent with national emergency laws, regulations and directives.

DAR CITE	AREAS TO INVESTIGATE
Accounting and Estimating System Reviews 3-402	Timing, streamlining and frequency of reviews; Pre-award waiver of system adequacy determination.
Advanced IR&D and B&P Expense Agreements 15-107; 15-205	Authorizing ACOs to negotiate and definitize agreements; Increased Tri-Service Departmental negotiations; Agreements based on other than formal, detailed negotiations.
Contractor Procurement System Reviews (CPSRs) and Consent to Subcontractors 23-100; 23-200	Waiving/streamlining detailed reviews for new contractors; feasibility of a mass certification of contractors.
Cost Accounting Disclosure Statements 3-1203; 3-1204	Increasing the threshold; 90 day post-award submission requirement; Non-submittal authorization and reporting requirements.
Cost/Schedule Control Systems Criteria (C/SCSC) 1-331; 7-104.87; 7-2003.43; 16-815	Overall requirement; Less sophisticated systems which emphasize schedules.
Hazardous & War Related Insurance, Compensation and Indemnification Provisions 7-104.2; 7-104.10; 7-104.65; 7-104.94; etc.	Training on processing claims, group insurance and specialty casualty insurance rating plans.
Hazardous & War Related... (cont'd) 10-403; 10-405; 10-404; 10-406; etc.	Waiving of EPA restrictions and "EPA List of Violating Facilities; Analysis of relaxation and waivers of environment and safety restrictions granted by various laws.
EEO Pre-Award Clearance Checks 12-807.2(a)(2)(b) 12-808	Expedite vs temporarily suspend or modify checks; strengthening of on-going compliance programs to avoid wartime discrimination and racial unrest.
Certificates of Current Cost and Pricing Data (P.L. 97-86-FY82 DOD Authorizations Act) 3-807.3	Validity during a surge environment; Revision of defective pricing guidelines for firms, new to DOD and those who relied on informal commitments.
Synopsizing Awards 1-1004; 1-1007	Need for revised synopses and Congressional notification guidelines during a national emergency and war.

The Post-Award Phase

DAR CITE	AREAS TO BE INVESTIGATED
Post-Award Orientation Conferences 1-1800	Revised guidelines on when/what for post-award orientation conferences.
Change Orders 1-201.1 7-103.2 7-203.2 7-304.1 etc.	Increased issuance of Change Orders by "Written electrical transmission;" Increased delegation to ACOs to issue, negotiate and definitize Mechanization of documentation, accounting and reporting Wartime clause revision.
Issuing Contracts & Processing Requests for Relief Under P.L. 85-804 DAR XVII	Development of practical "Extraordinary Contractual Actions" training exercises for DOD.
Constructive Changes 7-104.86 26-802	Increasing the $1,000,000 "Notification of Changes" clause threshold requirement; Authorization of certain changes by other than ACO/PCO; Dollar limitation covering work done under constructive changes.
Funding 1-2001(c) 7-203.3	Increased mechanized procedures to allot and disburse funds quickly; Requiring contractor to begin or continue work in the absence of immediate funding.

DAR CITE	AREAS TO BE INVESTIGATED
Advance Payments	Revising advanced payments standards, contractor application procedures, approval required by the PCO, and lower delegations of authority; Increasing the $50,000 and $25,000,000 limitations; Sixty day Congressional waiting period.
Renegotiation 1-319	Expansion of Contracting activities to prepare and furnish information required; Raising of $1,000,000 per fiscal year threshold.

REFERENCES

1. Awards By Method of Procurement. Table 15, "Awards by Statutory Authority (By Fiscal Year." DOD Procurement Statistical Data Furnished by the Air Force Business Research Management Center, WPAFB, Ohio, 1981.

2. Defense Acquisition Regulation. Washington: Government Printing Office, 1976.

3. Dice, Ronald A., Major, USAF. "How An AFO Plans For Operations Under Emergency Conditions." Professional Military Comptroller Course. Class 79-D. Air University, Maxwell AFB, Alabama. July 1979.

4. Paulson, Peter G., Major, USAF. "The Use of Negotiation Exception 16 to Support Industrial Mobilization." Defense Logistics Studies Information Exchange, Ft. Lee, VA, LD No. 48013A, December 1981.

5. Perkowski, Peter J., Major, USAFR. "A Preliminary Investigation Into What Contract or Systems Acquisition Procedures Would Have to be Changed in a Protracted, Non-Nuclear High Intensity Large Scale Conflict Similar to World War II." Unpublished Report. AFBRMC/RDCB, Wright-Patterson AFB, Ohio, July 1981.

PANEL I

COST ESTIMATING AND ANALYSIS

PANEL CHAIRMAN

Mr. Wayne M. Allen
Director of Cost Analysis
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AN EXAMINATIDN DF THE
MINI SHOULD CDST EVALUATIDN TECHNIQUE

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ABSTRACT

This paper presents a different managment approach to achieve an effective cost analysis for negotiations of a contractor's proposal. Using this simplified approach the in depth analysis of a Should Cost Study is obtained using fewer manpower resources and the speed of a normal field review.

BACKGROUND

The various DOD buying activities employ several evaluation techniques to identify uneconomical and inefficient estimates proposed by contractor in a noncompetitive environment. These techniques range from grass roots, historical and parametric cost evaluations by field and buying center personnel to extensive Should Cost Team examination. The major weapon system acquisitions normally have the management attention and resources to achieve an effective should cost evaluation.

PROBLEM

The lower dollar value system, sub-system and complex spare parts acquisitions require an evaluation which is more extensive than the major weapon system Should Cost Approach. These acquisitions often are large in dollar value, technically complex and present an extensive estimating problem to the contractor and evaluation problem to the DDD buying element. Many initial production buys require development cleanup or are concurrent, thus needing extensive review. To accomplish this task why not use a Full Should Cost? The problem is obtaining the personnel and keeping them possibly thru negotiations.

MINI SHOULD CDST MANGEMENT TEAM

To achieve an effective evaluation on these types of acquisitions a DDD buying activity needs the in depth insight of a Should Cost Analysis while only using the additional manpower resources of a field review. At Oklahoma City Air Logistics Center, the Mini Should Cost Management Team was developed to fill this evaluation need. Unlike the approach used by the negotiating teams of AFSC this technique employs fewer personnel while achieving an in depth evaluation. This technique employs the systematic approach of a Should Cost Team on a major weapon system while using a different conceptual framework and management approach.

THE ELEMENTS OF THE PROCESS

The key elements of a Mini Should Cost Management team focus upon the team's management structure and the evaluation approach. This team is normally made up of the Contracting Officer, Price Analyst, Project Engineer, Program Manager, Field Auditor and Analyst. The objective is to develop a team where the field personnel understand the technical requirements and the technical people understand how the company operates. The team members participate from the beginning of the evaluation through conclusion of negotiations. Unlike the normal should cost approach, this team's goal is to jointly focus technical, accounting, production and business expertise as a team upon the same cost elements to surface hidden assumptions and making clear their logical implications. Thus, an integrated line and staff function analysis is accomplished on each cost element proposed e.g.; direct costs which should have been an indirect or unneeded costs.

The evaluation methodology implements the teams management structure. Evaluations are made using a work break down approach. Unlike the normal should cost approach the full team is used to evaluate W.B.S. Cost Elements within each category and across all W.B.S. categories. Thus the inefficiencies and duplications of effort are identified throughout the contractor's proposal.

This technique requires fewer people to perform the analysis over a shorter period of time. A recent acquisition using this approach resulted in a contractor's 1.3 billion dollar proposal being reduced to 700 million.

UNDERSTANDING ECONOMIC PRICE ADJUSTMENT BASED ON COST INDICES

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ABSTRACT

Economic price adjustment based on cost indices is one of the least understood aspects of the contracts profession. The Defense Department's proposed changes to Economic Price Adjustment clauses recently promulgated in DAR Case 81-144 include a new 7-106.3 Economic Price Adjustment Clause (Cost Index Method). It is therefore timely to review the essential elements of economic price adjustment based on cost indices so that they are more easily understood by members of the contracts profession who are either unfamiliar with them or who do not work with them on a daily basis. This paper reviews the theory and practical application of key elements involved in arriving at workable economic price adjustment provisions based on cost indices. The proposed DAR 7-106.3 EPA Clause (Cost Index Method) is included along with a sample Price Adjustment Table.

ECONOMIC PRICE ADJUSTMENT

For many years, economic forecasting was not a major area of concern in the pricing of Government defense contracts. Generally speaking, the rate of inflation was modest and steady. Therefore, escalation was not a significant factor in the overall determination of price.

More recently, because of high and fluctuating rates of inflation and interest, national dependency on limited energy sources, and the scarcity of certain materials, economic forecasting has become a perilous uncertainty. Price escalation can have a major effect on contract costs, particularly during protracted periods of performance.

The objective of an EPA clause is to protect both the Government and the Contractor from the effects of significant economic fluctuations in labor and material costs. EPA provisions are designed to provide for the upward and downward revision of the stated contract price on the occurrence of certain contingencies which are specifically defined in the contract. Use of an EPA clause is appropriate when serious doubt exists as to the stability of market or labor conditions which will exist during an extended period of contract performance, and when contingencies which would otherwise be included in the contract price can be identified and covered by a price adjustment clause. It is essential that the base period in the clause be the same as the period used to establish the base price, and that the clause provide for price changes consistent with the actual changes in the contract costs resulting from economic changes beyond the control of the Contractor.

Defense Acquisition Regulation 3-404.3 specifies three broad types of EPA clauses. The first provides for adjustments based on established prices where basic commodities and commercial items comprise a major portion of the contract work. The second type provides for adjustments based on the Contractor's experienced labor or material costs and is commonly referred to as the actual cost method. It is used when there is no major design engineering or development work involved. The third type is referred to as the cost index method. It is used when there will be an extended period of performance and the amount subject to adjustment is substantial.

Inclusion of a Cost Index Method EPA clause is appropriate when there is an extended period of contract performance (normally in excess of 2 years), the amount subject to adjustment is substantial, the adjustments based on labor and material costs are limited to contingencies beyond the control of the Contractor, and for the reasons cited above the economic variables for labor and material are too unstable to reflect a reasonable division of risk between the parties absent EPA provisions.

SELECTING THE PROPER COST INDICES

Inflation is measured most commonly over time by changes in wage and price indices. Movements of price indices usually are expressed as percentages rather than index points. Index point changes are affected by the level of the index in relation to its base period, while percent changes are not. A 1-point increase in the index yields varying percentage rates of inflation depending on what base the change is calculated. (1)

Before graphic or computational analysis can be developed to project future expenditure levels, it is necessary to adjust historical costs to a common base. Actual experience by the Contractor, area indices, or national price level indices may be used, depending on availability. The projections then must be escalated from the base year to the period covered. Costs incurred in one period may be converted to equivalent costs in another period as follows:

Costs Incurred

Index for Period When Costs Were Incurred	X	Index for Period to Which Converting	=	Converted Costs

The most extensive and accessible compilation of historical wage and price information is maintained by the Department of Labor, Bureau of Labor Statistics (BLS). The BLS collects wage and price data from businesses and other sources on a wide variety of carefully defined products and services.

Construction of indices is largely dependent on two general series published by the U. S. Department of Labor, Bureau of Labor Statistics (BLS). These are the Wage and Income Series of Standard Industrial Classification (SIC) for labor and the Industrial Commodities portion of the Producer Price Index for material.

Normally, two indices are used in EPA clauses - one for labor (direct and indirect) and one for material (direct and indirect). Each index should be structured to encompass a large sample of relevant items and yet bear a logical relationship to the type of contract costs being measured. The basis of the index should not be so large and diverse that it is significantly affected by fluctuations not relevant to the contract performance, yet it must be significantly broad so as to assure the minimal effect of any single contractor, including the anticipated contractor.

BASIC PRICE/EPA INDICES ESCALATION CORRELATION

To ensure that inclusion of an EPA clause will not result in duplicate recovery of costs already contained in the basic price, it is important that there be a close correlation between escalation factors used in developing the basic prices and the escalation projections used in the EPA indices. In addition, they must both start from the same base point.

DEVELOPMENT OF PHASED EXPENDITURE PROFILES FOR COSTS SUBJECT TO EPA

In the expenditure profile, estimated costs are grouped into labor and material - the two logical categories to which inflation rates can be applied. The labor profile should be developed on an expenditure profile in accordance with the hardware delivery schedules. The material profile should be developed based on the estimated expenditure costs from suppliers.

All prime material costs should be segregated and incorporated in the material profile. All other costs should be covered in the labor profile. The prime material costs consist of the material profile per DAR 3-404.3(3)C.7 and cover all indirect and direct costs for the suppliers. An analysis should be performed of overhead pools to determine the percentage of material contained in indirect pools. Inasmuch as material is usually an insignificant portion of overhead costs, all overhead costs are normally contained in the labor profile.

BASIC PRICE/EPA LABOR ESCALATION CORRELATION

The correlation between the labor escalation factors used in the basic pricing and those used in the EPA labor index is illustrated in the following example:

Year	Basic Pricing Labor Rate Change, Percent	EPA Labor Index Change, Percent
1982	6.6	8.80
1983	7.8	6.90
1984	5.7	5.53
1985	7.1	6.75
Average Change	6.8	6.99

The same comparison can be made on an indices basis by designating December 1981 = 100 as the base point for both the basic pricing labor rate change and the EPA labor index change. This is shown as follows:

Year	*Basic Pricing Labor Index	*EPA Labor Index
1982	1.0660	1.0880
1983	1.1489	1.1631
1984	1.2146	1.2274
1985	1.3008	1.3102
Average Change	1.1825	1.1971

*December 1981 = 100

As indicated above, there should be a close correlation between the labor escalation factors used in the basic pricing and those used in the EPA labor index. On a percentage basis, the difference in average annual change shown in this example is less than 0.2, i.e., the average annual change for the EPA labor index is 6.99 percent, and the average annual change for the basic pricing labor rate change is 6.8 percent.

BASIC PRICE/EPA MATERIAL ESCALATION CORRELATION

There should be a one-for-one correlation in material escalation factors utilized in the basic pricing and those used in the EPA material index.

LABOR RISK ASSESSMENT

The labor index selected to measure inflation and apply it to the expenditure profiles in this example is SIC Code 372 (Employment and Earnings/Gross Average Hourly Earnings of Aircraft and Aircraft Parts Production Employees). The average annual rate of increase in SIC 372 over the last 6 years was 9.4 percent. If it were assumed that inflation does not decrease but rather continues increasing at the average of the last 6 years, then the impact of this continued high inflation rate can be seen below.

Year	Basic Pricing Projections, Percent	SIC Code 372, Percent	Potential EPA Delta, Percent
1981	9.40	9.4	0.00
1982	8.80	9.4	0.60
1983	6.90	9.4	2.50
1984	5.53	9.4	3.87
1985	6.75	9.4	2.65
1986	6.00	9.4	3.40

Data Resources, Inc. (DRI) is a widely used economic forecasting service which makes long term forecasts which are updated quarterly. The DRI forecasts use "Cyclelong" projections. These projections contain a mixture of shocks and imperfectly timed policy initiatives that are arbitrarily introduced to produce a cyclical environment similar to postware experience. Such a simulation naturally embodies a more pessimistic record of employment, inflation, and capital.

The DRI forecasts for BLS SIC Code 372 prepared during the first and second quarters of 1981 for the years 1982 through 1986 are shown below:

Year	First Quarter 1981 Forecast, Percent	Second Quarter 1981 Forecast, Percent	Delta, Percent
1981	11.1	11.2	+0.1
1982	11.8	11.1	-0.7
1983	10.2	9.8	-0.4
1984	9.2	9.6	+0.4
1985	10.3	11.0	+0.7
1986	9.8	10.1	+0.3

The authors believe the DRI forecast does not incorporate the downward increase in SIC Code 372 that should occur based on the proposed increases in the defense spending and employment for the B-1 bomber, MX missile, stealth bomber, the F/A-18 sales to Australia, and AWAC sales to Saudi Arabia. Employment should increase at Rockwell International, Boeing, and McDonnell-Douglas as a result of these programs. Consequently, it is believed that, even if labor agreements provide for general wage increases for individual employees, the average labor rates will move in the opposite direction.

An analysis has been made of actual Selected Producer Price Indexes and Standard Industrial Labor Classification Codes for 20 codes utilized frequently by the Army Armament Material Readiness Command and which most correctly represent the predominance of those items procured by that command. (2) This analysis covered the period January 1974 to January 1980. The plotting of those actual indexes indicates a continuing picture of rising inflation throughout that period. However, discounting minor fluctuations, these plotted data indicate an almost straight-line increase throughout the period. This data supports the premise that BLS SIC Code 372 will continue to increase at an annual average rate of 9.4 percent thorugh 1986 just as it did from 1975 to 1981. Again, it is believed there will be a downward increase for the reasons cited above.

A graphic analysis of the basic pricing, DRI, and a straight line projection of the escalations projected for BLS SIC Code 372 is shown in Table 1.

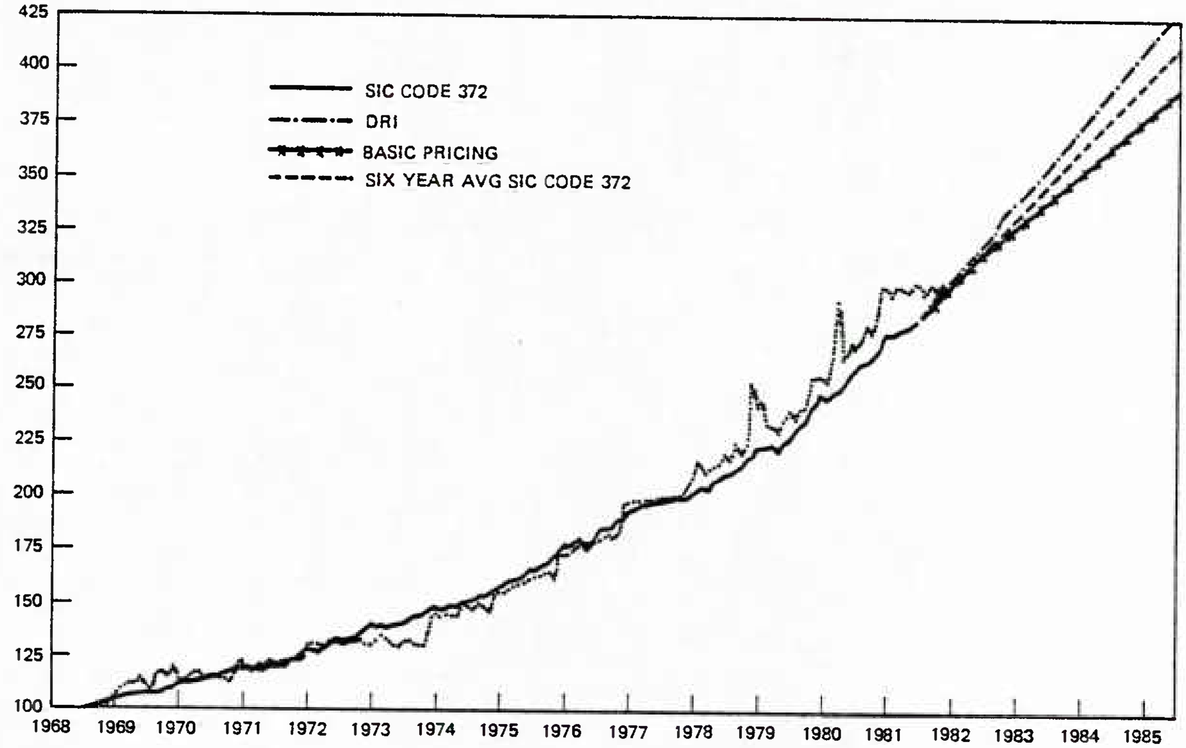
It is important to note that price adjustments would result only if the actual reported BLS SIC Code 372 labor rates vary from the BLS SIC Code 372 projections contained in the EPA clause. In the final analysis, the Government would pay the same price regardless of which BLS SIC Code 372 projection is used because price adjustments would be made on the basis of the actual reported BLS SIC Code 372 labor rates.

DEFENSE DEPARTMENTS PROPOSED CHANGES TO EPA CLAUSES

The DAR Council's EPA *Ad Hoc* Committee proposed the following revisions to current EPA coverage in a report dated 28 October 1981: 1) extends use to fixed-price incentive contracts; 2) provides a less-restrictive clause for use in contracts based on established market or catalog prices; 3) provides revised EPA coverage on formally advertised procurements to permit more equitable bid evaluations; and 4) provides more definitive and uniform provisions for economic price adjustment methods. Proposed DAR coverage is designed to provide greater assurance that contractors and subcontractors are not penalized by unpredictable cost fluctuations.

Under DAR Case No. 81-144, the DAR Council released the Ad Hoc Committee's proposed DAR coverage for Industry and Service/Agency

TABLE 1. COMPARISON OF SIC CODE 372 PROJECTIONS



comments on 7 December 1981. Comments were due to be received by the DAR Council from Industry and Service/Agencies by March 1982.

PROPOSED DAR 7-106.3 EPA CLAUSE (COST INDEX METHOD)

Because the proposed DAR 7-106.3 EPA Clause (Cost Index Method) is scheduled to be implemented by July 1982, it is included below in full text. A sample Price Adjustment Table based on use of the SIC Code 372 Index discussed above is shown in Table 2.

"Economic Price Adjustment - Cost Index Method. (1982)

(a) The Contractor warrants that the prices set forth in this contract include the Contractor's normal pricing factors to account for economic contingencies and fluctuations, but do not include allowances for any contingency to the extent covered by this clause.

(b) Regardless of the actual changes in the cost factors during the performance of this contract, price adjustments shall be made only as provided herein. However, this clause neither prohibits changes in contract price(s) due to other provisions of the contract nor does it preclude revisions to the attached table when other contractual provisions affect the expenditure profile or cost factors.

(c) The calculation required by the table (upward or downward) will be made by the Contractor in accordance with the computation periods shown in the attached table and will be submitted on a yearly basis to the Contracting Officer. Any EPA adjustment will be incorporated in a supplemental agreement which shall include the calculations upon which they are made.

(d) For the purpose of computing adjustments pursuant to this clause, cost factors subject to adjustment will be apportioned as shown in the projected expenditure profile table.

(e) Adjustments to the contract price on account of cost factor fluctuations in the economy shall be made as follows for each cost factor for each performance period shown in the table based on the applicable final published index(ices).

(1) The projected index is agreed to at the time of award for the appropriate periods involved and set forth in Column 2.

TABLE 2. PRICE ADJUSTMENT TABLE

PRICE ADJUSTMENT TA8LE

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INDEX IDENTIFICATION SIC 372 - AIRCRAFT AND PARTS

(1) COMPUTATION PERIOD	(2) PLANNED EXPENDITURE PROFILE	(3) PROJECTED INDEX	(4) TDLERANCE 8AND LOWER/UPPER	(5) ACTUAL INDEX	(6) INDEX DIFFERENCE (5)-(3)	(7) PERCENT DIFFERENCE (6)÷(3)	(8) ADJUSTMENT (7)x(2)
12-82	$10,000,000	$11.72	±1%	$11.78	$0.06	+0.5	NO ADJUSTMENT - WITHIN TOLERANCE 8AND
12-83	$10,000,000	$12.53	±1%	$13.53	$1.00	+8.0	$800,000
12-84	$10,000,000	$13.19	±1%	$12.93	($0.26)	-2.0	($200,000)

INCORPORATED IN CONTRACT (columns 1–4)

ACTUAL DATA (columns 5–8)

(2) When the actual index (Column 5) is within the tolerance band (Column 4), no adjustment will be made.

(3) When the actual index is outside the tolerance band, the difference between the actual and projected index will be computed on a plus or minus figure and set forth in Column 6.

(4) The difference, whether plus or minus, shall be divided by the estimated Index set forth in Column 3. This product is the percentage of change in the Index and set forth in Column 7.

(5) The Planned Expenditure Profile set forth in Column 2 of the table is multiplied by the percentage change (plus or minus) in Column 7, and the resulting amount placed in Column 8.

(f) No upward adjustment shall be made as a result of the failure of the Contractor to deliver supplies or perform services in accordance with the delivery schedule unless the Contractor's failure to deliver or perform results from causes beyond the control and without the fault or negligence of the Contractor within the meaning of the clause of this contract entitled "Default," in which case the contract shall be amended to make an equitable extension of the delivery or performance schedule.

(g) The Contractor shall permit the Contracting Officer or authorized representative to examine and make copies of any documents, papers, or records relating to compliance with the provisions of this clause.

(h) In the event any index cited is discounted or altered the parties shall mutually agree upon any appropriate substitute. Until agreement is reached, an index selected by the Contracting Officer shall be used.

(i) If for any reason during the performance of this contract, there is evidence that there is or will be a material change to the expenditure profile outlined in the attached table, the Contractor shall promptly notify the Contracting Officer setting forth the reasons for the change and provide a new expenditure profile. There shall be no additional cost to the Government for any changes in the expenditure profile unless the Contracting Officer determines that the changes were clearly beyond the Contractor's control or the changes are in the best interests of the Government.

(j) The increased contract unit price shall not apply to quantities scheduled under the contract for delivery before the effective date of the increased contract unit price unless the Contractor's failure to deliver before such date results from causes beyond the control and without the fault of negligence of the Contractor, within the meaning of the "Default" claims of this contract.

TABLE 3

INITIAL TOTAL COST	INITIAL PROFIT RATE	INITIAL PROFIT	INITIAL TOTAL PRICE	EPA ADJUSTED TOTAL COST	FINAL PROFIT	FINAL TOTAL PRICE	FINAL PROFIT RATE
$30,000,000	10%	$3,000,000	$33,000,000	$30,600,000	$3,000,000	$33,600,000	9.8%

(k) If this contract is terminated in whole, for any reason, a price adjustment will be applicable only to units completed prior to said termination. If the contract is terminated in part affecting the completion of one or more contract line items subject to the provisions of this clause, adjustments to the table shall be made."

INFLATION PROFIT IMPACT

In its present version, the proposed EPA Clause (Cost Index Method) presented above does not provide for adjustment of profit. As shown in Table 3, the impact of inflation on profits can be demonstrated utilizing the information contained in the sample Price Adjustment Table shown in Table 2 and assuming a 10 percent profit rate.

As can be seen in Table 3, the profit rate erroded from 10 percent to 9.8 percent as the result of inflation. The proposed DAR coverage in 3-404.3(c)(3)(A) relative to price adjustments based on the cost index method states "the use of this clause reduces the Contractor's risk and its use should be recognized in determining the contract profit objectives." Given that the Contrator's profit rate would be lower with an EPA cost index method clause than without one, it would appear to the authors that having the profit rate further reduced by inflation as illustrated above is double jeopardy and unwarranted.

It is hoped that after the DAR Council has reviewed comments, the revised coverage implemented will provide for contract price adjustments which recognize the impact of inflation on profits.

CONCLUSION

In summary, the purpose of economic price adjustment clauses is to protect the Contractor and the Government from major economic fluctuations which can not be predicted with a reasonable degree of confidence. Contractors are expected to anticipate reasonably predictable economic fluctuations and other costs of Contractor performance, but they should not be expected to predict the unpredictable.

REFERENCES

(1) Department of Defense, Defense Contract Audit Agency, Dealing With Inflation, 1981, p. 6.

(2) Herington, David L., and Kalal, Gerald W., "Economic Price Adjustment Provisions in Government Contracting and Suggested Alternatives," Ninth Annual DoD/FAI Acquisition Research Syposium, 1980, p. 9-21.

COST VARIATION STUDY OF REPARABLE ITEMS

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ABSTRACT

The purpose of this study was to develop a set of indices that reflect the changes in unit cost of recoverable items from 1960 to 1981 for use in price redetermination.

The Air Force Logistics Command (AFLC) currently uses Office of the Assistant Secretary of Defense (OASD) inflation indices to update unit costs for its replenishment spares budgets and Program Operating Memorandums (POMs). Indices are applied to the last purchase price for the needed items to project current purchase prices. This process, called price redetermination, only accounts for price changes due to inflation. The indices used do not reflect other changes such as those caused by finding new sources of supply or by outmoded technology.

The last two budget submissions provided information on how the unit cost of 150 items (30 from each Air Logistics Center) had changed in the previous year. These samples showed that price changes were higher than could be accounted for by inflation. However, the sample size was not large enough to quantify accurately the total price change nor did it address changes in any year other than the most recent. The budget and POM submission are built on prices dating back to 1960. Thus, what is needed is a set of annually updated indices that reflect all changes in cost from 1960 to any year based on a large data set.

There are three sources of data used in this study. Two are from J041 procurement system history records. The master records contain detailed information on all purchases of Air Force managed items made in FY77 or later. The archive records contain less detailed information on each purchase and contain earlier purchases, but few before FY73. The recoverable item purchases could only be identified in the master records. Therefore, the only archive records used were for the same items identified in the master records.

To gather information on purchases prior to FY73, a third data source, AFLC Forms 318, procurement history records manually maintained by item managers, was used. An item's 318 form contains information on all its procurements. Older items can have purchases recorded in the 60's and even earlier. The manual workload of gathering this information and preparing it for key punch limited the number of items for which 318 forms were used. Seventy items reviewed at each ALC by the Materiel Management Review Team in August 1981 were used for this effort.

From each information source, the following was accumulated by National Stock Number (NSN): fiscal years of purchase; quantity purchased each fiscal year; and average purchase cost in those years. The information from the three sources was merged using the average cost and quantity from the source containing the largest purchase quantity for a NSN in any year. This prevented duplication of input from two or more sources.

The last step in the data gathering was to pair purchase information if possible for each NSN. Each year, that a NSN had a purchase, was matched with the year prior to it that had the most recent earlier purchase. This paired data was used in the analysis routine and contains ALC, fiscal year of earlier purchase and average unit cost, and fiscal year of later purchase and average unit cost.

The analysis routine takes each set of purchase data and calculates the change in purchase cost between the earlier fiscal year and in the later fiscal year. This information is accumulated by the fiscal years involved. For each purchase interval ending in FY81, compound interest formulas are used to determine the change between FY80 to FY81. These changes are averaged to determine the rate of change between FY80 and FY81. The rate of change found is then considered correct and used to find the change remaining in those intervals including earlier intervals. The same process is then repeated on FY80 and the preceeding years in turn.

The analysis found annual rates of change for each fiscal year between FY73 and FY81 and the indices that would change a fiscal year cost for fiscal years 73 through 80 to a FY81 cost. The analysis was complicated by FY7T, the interim quarter between FY76 and FY77 when the start of the fiscal year was changed from 1 July to 1 October. The compound interest formulas were modified to use a five-eighths of a year time interval between FY76 and FY7T and between FY7T and FY77 as that was the time lapse between the middle of FY76 and the middle of FY7T and between the middle of FY7T and the middle of FY77.

The analysis did not directly compute annual rates of change for any time prior to FY73 because a sufficient amount of data was not collected for those years. However, regression analysis was performed on the actual changes for FY73 and FY81 and the OASD allowed changes for these years. This provided a method to convert the OASD allowed changes for FY60 to FY73 to more realistic changes in unit cost for these years.

The resulting set of annual changes and indices was used to demonstrate the effect of unfunded cost increases on our budgets and the possible impact on weapon system support.

PURPOSE

The purpose of this study was to develop a set of indices to use in the price redetermination process while building budgets and Program Objective Memorandums (POMs) for reparable items. These indices would reflect price changes for all reasons and would be based on fiscal year 60-81 actual data. They would be updated annually to reflect the latest available data and address the years needed for the current budget and POM.

BACKGROUND

The indices used in the price redetermination process, part of building reparable item budgets, are critical elements in obtaining accurate budgets. The price redetermination process and the Office of the Assistant Secretary of Defense (OASD) inflation indices currently used in price redetermination are described below to demonstrate their importance and the inadequacy of the indices.

I. PRICE REDETERMINATION: The requirements that are used to build a budget are stated in terms of the last available purchase cost. This cost of last purchase is the only one available to D041, the requirements system for reparable items. However, it is not a good estimate of what to expect to pay for these items when they are next purchased. Although the cost of next purchasing one of these items may be much higher or lower than the old cost, building a budget on an aggregate of these items is more reliable.

The price redetermination process takes the requirements that are displayed by apportionment year (AY), budget year (BY) and extended year (EY) and further breaks them down and displays them by fiscal year of last purchase. This groups the requirements so they can be multiplied by the OASD indices to bring them to the expected cost in the year(s) they will be purchased. Now they can be accumulated by AY, BY, and EY again to form the budget. The EY is then used as a basis of building the POM.

Figure 1 shows an example of part of the price redetermination done by Oklahoma City for the budget year in the FY83 budget using the Sep 81 D041 requirements computation as a basis. The expected cost shown for FY60-63 is combined with the expected costs for FY64-81 to form the budget year requirement. The fiscal years used include FY7T, the transition quarter when the start of the fiscal year changed from 1 July to 1 October in 1976.

YEAR LAST PURCHASE	VALUE USING LAST COST	OSD INDICES	EXPECTED COST
FY 60	280	3.268	915
FY 61	15	3.236	47
FY 62	514	3.185	1638
FY 63	31	3.135	97

FIGURE 1

PRICE REDETERMINATION

Oklahoma City FY83 BP15 Budget

$ THOUSANDS

II. OASD INDICES: The OASD indices used in building reparable item budgets are mandated by AFR 173-2 for inflation and provided by HQ USAF Directorate of Cost and Management Analysis (HQ USAF/ACM). HQ USAF/ACM uses the raw indices and guidance provided by the Office of Management and Budget (OMB) through the Office of the Assistant Secretary of Defense (OASD) to calculate the appropriate weighted indices used by the budget programs.

The OASD indices only address inflation where inflation is defined as the increase in amount of currency in circulation that results in an increase in general level of prices. Inflation is measured by pricing the same set of goods from one time period to another with the resulting change in price attributed to inflation. Pricing different groups of items may result in different indices. That is why so many sets of inflation indices exist and it is important to measure inflation using items similar to those you expect to buy. The Producer Price indices for intermediate materials, supplies and components is part of the Consumer Price family of indices and should be comparable to the OASD reparable item indices. However, it is generally higher than the OASD indices. The fiscal year changes in the OASD indices and the Producer Price indices are shown in Figure 2.

The price redetermination process should not use a set of indices for only inflation as the reparable items purchased are not a static unchanging market basket of goods. Instead a dynamic, always changing group of items is purchased whose prices change for reasons other than inflation. The producer of an item could go out of business before the item is next needed, or could already have a workload scheduled at capacity and not want to make the item. Retooling is sometimes necessary if the item has not been purchased in a long time. Many of our weapon systems are being used past their original expected life span. Consequently, technological changes can make it impossible to even find a company that has the capability to make some items for such weapon systems.

This study was started because there were several indications that reparable items are experiencing a larger cost growth than would be predicted by the OASD indices. A study* by Air Staff on the budget and POM process found OASD allowed changes were approximately one-half the actual changes that occured. This result is also found when the OASD fiscal year changes are compared to the annual changes computed by H052, the price variation reporting system for Air Force consumable items. H052 uses actual changes in cost as found in J041, procurement history records. This contrast between H052 and OASD fiscal year changes is also shown in Figure 2.

FY	OSD* INFLATION	PRODUCER** PRICE	CONSUMABLES (H052)
73-74	1.078	1.156	
74-75	1.107	1.262	
75-76	1.069	1.026	1.140
76-7T	1.032	1.030	1.076 #
7T-77	1.033	1.054	1.060 #
77-78	1.069	1.056	1.110
78-79	1.087	1.109	1.122
79-80	1.098		1.168
80-81	1.080		1.169

*INDICES FOR FY83 BP15 BUDGET
**INDEX OF PRODUCER PRICES, INTERMEDIATE MATERIALS, SUPPLIES AND COMPONENTS
#MODIFIED FROM H052 RATE COMPUTED FOR 12 MONTH CHANGE

FIGURE 2

COMPARISON OF FISCAL YEAR CHANGES

The results of using inadequate indices are understated budgets and POMs and reduced weapon system support. This study is an effort to change the situation by building a set of indices for reparable items that are calculated using reparable items already purchased by the Air Force, based on as large a sample as possible, and that capture price changes for all the typical reasons that will always affect some portion of our inventory.

APPROACH

The approach for this study was to examine the methodology used to capture the aggregate price changes for consumable items by H052. H052 was run with reparable items and major inadequacies for this use were found. These inadequacies are discussed below along with the changes that were made to fit the needs of reparable items. The final computation method is then described and illustrated. This is followed by a discussion of the one remaining problem, what can be done for those years in which we were not able to compute a fiscal year change.

I. ADAPT CONSUMABLE ITEM METHODOLOGY:

A. Procurement History: H052 uses J041 procurement history active files which contain information on procurements for all Air Force items for FY77 and later. This was more than adequate for consumable items as the only computation made was for the annual change in the last fiscal year.

Reparable item fiscal year changes were needed for FY60-81, thus more data sources were needed. J041 archive files provided data as far back as FY73. There was an additional problem using this data source. The codes indicating if the item was consumable or reparable were not included. Thus, the reparable items were identified from the active files and additional purchases were used from the archive files if the stock numbers matched.

An effort was made to obtain purchase data prior to FY73 by manually taking it from AFLC Forms 318, procurement history records manually maintained by item managers. The approximately 350 items included in the August 1981 Material Management Review were used for this effort but unfortunately the majority of them did not have procurement history prior to FY73. Thus, there was not enough data to compute FY changes for that time period.

B. Purchases Considered: H052 considers all consumable item procurements. To use the item's information, the item must have a purchase less than one year old and another purchase one to two years older than the first. It will use the most recent purchase that is in each of these time periods to calculate the annual price change. An item's information must also meet other criteria which are outlined in Section I-G before it will be included in the final results.

The reparable item method uses all purchases found in J041 procurement active and archive files, provided the item could be identified as reparable in the active files. In addition, all purchases found in the sample of reparable item Form 318 procurement records were used. These purchases were grouped by fiscal year and the average fiscal year purchase cost found. Since there were three sources of data, care was taken to insure that no purchase was used more than once. Items that were purchased in only one fiscal year could not be used in this study.

C. Compounding of Rate of Change: H052 compares two purchases for each item and the interval between the purchases is one to two years. Therefore, H052 uses monthly compounding of the change in purchase cost to find the one year change for each item.

* Saber Provider Alpha conducted by USAF/SA

The reparable item study had to determine rates of change between several fiscal years. Monthly compounding was not used as there could be more than one purchase in a fiscal year. There can also be several years between purchases. Therefore, the change in purchase cost was compounded by fiscal year. Fiscal year 7T was treated by using the interval between 7T and the years before or after it as five-eighths of a year. This is the length of time between the midpoint of one of these years and the midpoint of the next year.

D. Item Matching of Purchases: H052 only matched purchases when the entire National Stock Number (NSN) matched. When dealing with longer periods of time for reparable items, the first four positions of the NSN called the Federal Stock Class can change for an item. Thus, to find as many matches as possible, it was necessary to compare the next nine digits of the NSN called the National Item Identification Number (NIIN) which is item unique and only changes when the item changes.

E. Validation of Data: Consumable item changes are validated by item managers if the changes are large. Input errors can occur in J041 procurement records and a manual review insures that any errors that will have a major effect on the results are corrected.

Reparable item changes could not be validated because of the larger amount and age of the data used. In many cases, the records to validate these changes are no longer available. Therefore, the extreme changes were treated by eliminating the five percent of the changes with the largest annual increase or decrease.

F. Weighting of Data: Consumable item changes are weighted by the purchase costs for these items. This allows H052 to calculate the effect of the cost change on the budget.

Weighting of the data by purchase costs did not work very well for reparable items. There was a large range of purchase costs for these items as well as a large range of cost changes. Thus when the weighting method was used, the high cost items with large cost changes made the results inconsistent. The method used was to treat each item change with equal weight.

G. Data Eliminated: H052 eliminates items if one of the purchases only has estimated prices, is a first purchase or is a foreign military sale or if quantity discounts decreased the price. For reparable items, these purchases were not automatically excluded as the last price available could easily be affected by this type of situation. Also, exclusion of these purchases would limit the sample size. However, as mentioned above in Section I-E, some data were eliminated for large annual cost changes.

H. Sample Size: For FY81, H052 found approximately 130,000 items with purchases in the right time frames. After items were eliminated for the reasons stated in Sections A-G, there were 20,000 items used to determine the annual price change. When the H052 method was tried directly on reparable items, the sample size was much smaller. If it had been tried at all ALCs, only about 2,000 items would have been selected for determining the FY80-81 change.

The reparable item method found 40,000 purchase changes in the FY73-81 time period which represented information from more than 80,000 purchases. This sample size was large enough to provide consistent results from year to year. Also, when the data were divided by ALC, there was a consistency between the ALC results for the same year.

II. EXAMPLE OF METHOD:

A. Data preparation: Purchase data were prepared for the analysis routine by sorting purchases by National Item Identification Number (NIIN), and within NIIN, by fiscal year purchased. Next by NIIN, for each fiscal year having purchases, the average purchase cost in that year was found. Then, if the NIIN had more than one fiscal year with purchases, the ratio of change between each set of adjacent fiscal years with purchases was found. This ratio of change or change rate was the newer purchase cost divided by the older cost. The rate of change together with the fiscal years the change occurred over is the only information needed by the analysis routine.

Figure 3 is an example of data preparation for two items, NIIN A and NIIN B. NIIN A had two purchases for FY81 and the average cost of those six items was $288. FY79 had the next oldest purchase with a cost of $200 each. The rate of change, 1.44, was found by dividing $288 by $200. The 1.44 change for FY79-81 was passed to the analysis routine. Notice that data from NIIN A were not used with NIIN B in this data preparation.

NIIN	FY	QTY	PURCHASE COST	AVE PURCHASE COST	PURCHASE COST CHANGE
A	81	2	264		
				288	
	81	4	300		1.44
	79	6	200	200	
	78	1	172		1.10
	78	2	190	182	
	78	3	180		
B	80	1	390	390	
					1.30
	78	1	300	300	

FIGURE 3

DATA PREPARATION

B. Accumulation of Changes: The first part of the analysis was to add changes of purchase cost by the fiscal years involved and to keep track of how many changes were added for each fiscal year interval. Figure 4 shows how this process works. The circled changes came from items A and B in Figure 3. Note that the changes for each FY interval within the same block of the figure are totaled. The number of data points added for each interval are also shown in parenthesis.

OLDER YEAR \ RECENT YEAR	81	80	79
80	1.10 1.16 2.26 (2)		
79	(1.44) 1.44 (1)	1.12 1.08 2.20 (2)	
78	1.52 1.60 1.56 4.68 (3)	(1.30) 1.35 2.65 (2)	(1.10) 1.18 2.28 (2)

FIGURE 4

DATA ACCUMULATION

C. Analysis Method: The analysis method is illustrated by Figure 5 using the accumulated changes from Figure 4. The first fiscal year change determined is FY80-81. The data used, from all intervals spanning FY80-81, and the analysis performed are in the upper left section of Figure 5. Each of the interval total rates is divided by the number of data points in that interval to find the average interval change. This is then converted to an average fiscal year change with compounding by fiscal year. This procedure for FY78-81 takes the total change 4.68 and divides by the three data points included in this total to get a 1.56 change per item. Since this interval covers three years, the cube root of 1.56, which is 1.16, is the average interval fiscal year change. The average annual change for FY80-81 is found by taking an average of the average interval fiscal year changes, weighting by the number of data points in the interval. Then each item will be contributing equally to the FY80-81 change. Thus, 1.13 is multiplied by two, 1.20 is multiplied by one and 1.16 is multiplied by three. Then the sum of these products, 6.94, is divided by six, the total of the data points, to get 1.16, the average change for FY80-81.

The second change found in the analysis is for FY79-80. All of the intervals used for the FY80-81 change were used again except FY80-81 which does not include FY79-80. In addition, all the intervals ending in FY80 were used. The intervals used before had the FY80-81 change of 1.16 removed before they were used in the FY79-80 analysis. For FY79-81, 1.44 is divided by 1.16 to leave 1.24 to be applied toward the FY79-80 change. Also, the FY78-81 change, 4.68, is divided by 1.16 to leave 4.03 for the FY79-80 analysis with two years of change remaining. Although other intervals such as FY75-81 or FY73-81 are not shown, they were treated in a similar manner in the actual analysis. The remaining analysis for FY79-80 is done exactly the same as for FY80-81, except there are more intervals to be used. In Figure 5, there are four intervals, two that were previously used and two new ones. The resulting FY79-80 change shown is 1.15.

FY INTERVAL	TOTAL RATE	# IN INTERVAL	INTERVAL FY RATE	AVG FY RATE	REMAINING TOTAL RATE	# IN INTERVAL	INTERVAL FY RATE	AVG FY RATE	REMAINING TOTAL RATE
80-81	2.26	2	1.13	2.26					
79-81	1.44	1	1 .20	1.20	1.24	1	1.24	1.24	
78-81	4.68	3	1.16	3.48	4.03	3	1.16	3.48	3.50
		6		6.94					
				1.16					
79-80	2.20	2			2.20	2	1.10	2.20	
78-80	2.65	2			2.65	2	1.15	2.30	2.30
						8		9.22	
								1.15	
78-79	2.28	2							2.28

FIGURE 5

DATA ANALYSIS

The analysis continues with the FY78-79 interval. This iterative procedure continues until all fiscal year changes are found. FY7T modifies the process only slightly. Intervals spanning FY76-77 use 1.25 years for the FY76-77 portion of the interval. Also, those intervals including FY76-7T or FY7T-77 use .625 for the FY76-7T or FY7T-77 portion of the intervals.

III. MISSING FISCAL YEAR CHANGES: Data were available for FY60-81 and all of the intervals ending in FY74 or later were used to calculate fiscal year changes. However, there were not enough data available to compute reliable changes prior to FY73. The price redetermination process for the budget year of the last budget, FY83, needed indices for changing FY60-82 prices to FY83 prices. Using the annual changes directly available from the analysis, this was not possible. However, regression analysis can be used to find the relationship between OASD fiscal year changes and the actual fiscal year changes. Then the regression analysis relationship can be used to predict fiscal year changes for FY60-73 and FY81-83. Then the fiscal year changes can be multiplied to form the needed indices.

RESULTS

I. Fiscal Year Changes: The Cost Variation fiscal year changes for FY73-81 are shown in Figure 6. Also shown are the OASD, Producer Price, and Consumable Item fiscal changes. The Cost Variation changes are very similar to the actual changes for consumable items and are approximately twice the OASD indices.

FY	OSD* INFLATION	PRODUCER PRICE **	CONSUMABLES (HO52)	REPARABLES
73-74	1.078	1.156		1.112
74-75	1.107	1.262		1.166
75-76	1.069	1.026	1.140	1.113
76-7T	1.032	1.030	1.076 #	1.113
7T-77	1.033	1.054	1.060 #	1.069
77-78	1.069	1.056	1.110	1.127
78-79	1.087	1.109	1.122	1.120
79-80	1.098		1.168	1.143
80-81	1.080		1.169	1.162

*INDICES FOR FY83 BP15 BUDGET
**INDEX OF PRODUCER PRICES, INTERMEDIATE MATERIALS, SUPPLIES AND COMPONENTS
#MODIFIED FROM HO52 RATE COMPUTED FOR 12 MONTH CHANGE

FIGURE 6

COMPARISON OF FISCAL YEAR CHANGES

II. Regression Analysis: Regression analysis found that the best relationship was a straight line. The formula used to convert OASD changes to reparable item changes is:

Reparable Change = .30831 - .67927 (OASD Change).

The regression R^2 of .60 was the highest R^2 found for any line tried.

The final set of indices of Cost Variation with FY83 base are shown in Figure 7 along with the comparable OASD indices as they were used in Price Redetermination.

OC FY83 BUDGET BASED ON SEPT 81 COMP ($ THOUSANDS)

YEAR LAST PUR-CHASE	VALUE USING LAST COST	OSD INDICES	EXPECTED OSD COST	COST VARIATION INDICES	EXPECTED CV COST
60	280	3.268	915	11.166	3126
61	15	3.236	47	10.436	157
62	514	3.185	1638	9.708	4990
63	31	3.135	97	9.030	280
64	4	3.086	12	8.400	34
65	443	3.030	1343	7.793	3454
66	4	2.950	11	7.182	27
67	17	2.865	48	6.607	112
68	831	2.841	2361	6.181	5136
69	259	2.639	683	5.475	1418
70	854	2.500	2134	4.932	4212
71	53	2.381	125	4.463	237
72	27	2.278	62	4.054	109
73	150	2.178	327	3.679	552
74	99	2.020	199	3.308	327
75	89	1.825	163	2.837	253
76	3837	1.706	6548	2.547	9773
7T	8	1.653	14	2.238	18
77	916	1.600	1465	2.141	1962
78	3498	1.497	5237	1.899	6643
79	18098	1.377	24925	1.696	30691
80	25069	1.255	31454	1.484	37202
81	221098	1.161	256792	1.277	282563
82	42658	1.070	45623	1.123	47904
TOTAL	$ 318,850		$ 382,223		$ 441,235

FIGURE 7

Price Redetermination

For OASD Indices and Cost Variation Indices

IMPACT

I. Budget: The impact of using indices that reflect all changes in cost in price redetermination is illustrated for the budget year of the FY83 Oklahoma City ALC Budget using the Sep 81 comp in Figure 7. The OASD indices increased the requirement from $318,850 thousand to $382,223 thousand. However, if the cost variation indices are used, the requirement is 15% higher or $441,235 thousand.

II. Weapon System Capability: The impact of 15% understatement of our requirement is reduced weapon system support. This can be measured using the Logistics Management Institute (LMI) Aircraft Availability Model. This model takes a range of expenditure levels and finds the probability that a random aircraft will be missing at least one reparable item for each level of expenditure.

Figure 8 shows the impact of 15% understatement of the requirements in FY83 if the requirements were correct for FY81 and FY82. It is shown for three priority groupings of weapon systems. Priority group A includes the B-52, B-111, C-5, C-141, E-3, and E-4. Priority group B includes the C-135, C-137, C140, F-4, F-111, H-3, and H-53. Priority group C includes all other weapon systems. The shaded areas represent the reduced weapon system support.

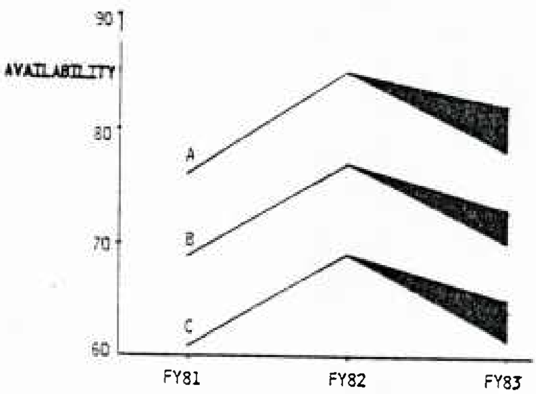

FIGURE 8

IMPACT OF 15% UNDER FUNDING

ON WEAPON SYSTEM AVAILABILITY

FOR THREE PRIORITY GROUPINGS

HOW MUCH WILL IT COST:
SOCIAL AND TECHNICAL ASPECTS OF ESTIMATING ERRORS

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INTRODUCTION

Under the current recessionary climate, in which the amount of Federal dollars available for the acquisition of programs, projects and products fluctuates downward almost daily, the most crucial question to be asked when considering any acquisition activity is, "How much will it cost?" Almost invariably, despite our best efforts, the hypothetical answer -- i.e., the estimated cost -- is wrong. And the gap between the predicted cost of future programs and the actual costs of such programs upon completion is widening.

Approaching solutions to estimating errors requires recognition of the social as well as technical aspects of the problem. It requires that we begin to acquire new perspectives, new ways of looking at estimating errors and the source(s) of such errors. For the past seven years, this has been a primary focus of research conducted in the Construction Engineering and Management Program at The Ohio State University. This paper outlines some of these perspectives and reports some results of research conducted using acquisition data provided by Federal agencies.

The perspectives and approaches toward solving problems associated with estimating errors can be very useful to those who estimate (predict) future program costs, to those who set and enforce procurement policies, and to public and private "watchdogs" who are charged with the responsibility of making hindsight judgments of program estimating performances and procurement policies.

This paper will first present some perspectives that may be useful to DOD personnel who are responsible for cost estimating. Techniques will then be presented that may prove to be of use, followed by a summary of some current and future studies. Finally, the author will address a basic question: "Is a change of thinking needed?" While this paper is primarily concerned with the social and technical aspects of estimating errors, the author also touches on other areas of concern since, in his experience, techniques, perspectives and results of studies in other areas are frequently transferable to the problem of improving cost estimates.

USEFUL PERSPECTIVES

A fundamental perspective, essential for understanding and solving problems related to estimating errors, is that all future program cost predictions are wrong: some are more wrong than others. However, recognition of this fact can be conducive to solving the problem.

We have found that perceived errors are greater than actual errors (Liu, 11). The reason for this fact is that estimates are sometimes unusually low when project costs end up being unusually high while, on the other hand, cost estimates are sometimes unusually high on projects whose costs are unusually low. Thus, if we examine the difference between cost estimates and actual costs, the range of this difference is much greater than the actual difference between cost estimates and costs incurred.

Given the fact that estimates are always in error, one must also recognize the fact that estimates must also be socially acceptable. The author has often speculated as to the mechanism by which estimators arrive at a socially acceptable number (Morrison, 13). It may well be that the process is not as important as the objective. If we are totally honest, we must recognize that a basic objective for government estimators is to avoid embarrassment. The greatest embarrassment would be to have to go to Congress to ask for additional funds. The second greatest embarrassment would be to have money left over at the end of a project. As a practical matter, subconsciously if not consciously, estimators strive to find a number that avoids both types of embarrassment.

The final perspective of use here is that management systems are usually inappropriate. This is especially true in the case of computer-based systems that seem to be consistently designed to intimidate and embarras the user. Clearly, computer-based systems must be made user-friendly (Uwakwey, 18) if we are to capture the major potential benefits in computer-based systems.

It should also be noted that the data base in hierarchical reporting systems adopted for use by various contractors and agencies are usually inappropriate most of the time, the reason being that the data available and/or needed, in the form of information summaries required, will change throughout the life of the project; but a single system is adopted and forced upon all parties at all times.

For example, early in the life of a project, a user may want the information organized according to UNIFORMAT. Later in the project, if one is buying materials, one may need information organized into a CSI Code of Accounts. Still later in the project, if improving the productivity of the work force is intended, one needs an entirely different classification system. Our needs change throughout the life cycle of the project. Thus, given fixed classification systems for our data and hierarchical reports, we find that the system adopted for a project is inappropriate most of the time.

USEFUL TECHNIQUES

If we wish to improve our predictions of future costs, standardized estimating procedures are needed. In studies conducted at Ohio State on data provided by the Navy (Veselenak, 19), we found that the variance of the estimating error was immediately reduced upon the introduction of computer-based estimating procedures, as shown in Figure 1. It was noted, however, that the mean of the estimating error was not impacted by the introduction of computer-based techniques, as shown in Figure 2, since in the Oistrict examined, the data base was not changed when estimating procedures were computerized.

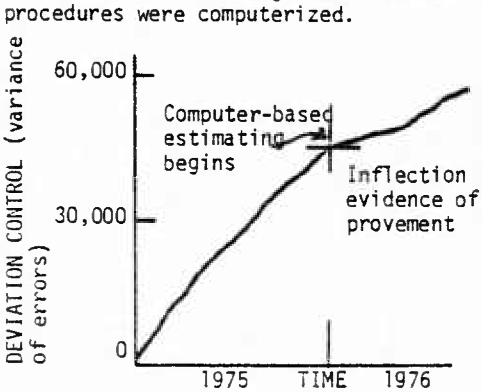

Figure 1. Deviation Control vs. Time (Atlantic Oivision)

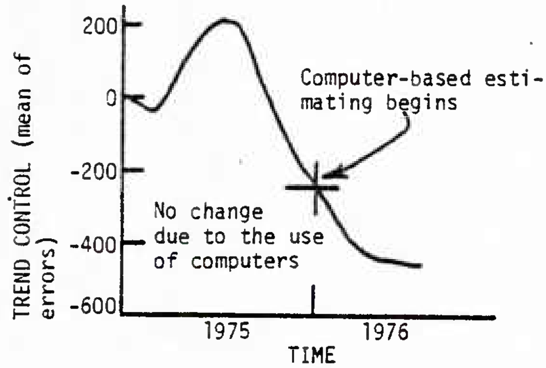

Figure 2. Trend Control vs. Time (Atlantic Division)

A recent study of the GSA problem of preparing pre-design estimates (Saenz, 16) addresses the problem of design decisions being made by estimators. This study suggests that design decisions should not be "consistent" since consistency in design decisions at the time of estimating leads to increased errors in predicting future costs.

When predicting costs, it is also quite important that historical data be tested for cyclic effects. An examination of the R.S. Means construction cost indices over a number of years reveals a 25 to 30-year economic cycle (Al-Shawi, 1). A four to six-year business cycle that has often been observed in data provided by contractors was also found in Navy data (Veselenak, 19). Significant seasonal effects have been noted on the contractor side (Wang, 20), as well as in the GSA data (Selim, 17). These seasonal effects are not insignificant. In the GSA data, for example, the variability in the market is approximately 40% over a six-month period.

If we wish to significantly improve cost predictions, we must begin to use better models and better techniques for estimating parameters (Ludolph, 12). Estimators in government as well as in industry consistently use constant unit cost models that neglect the impacts of mobilization and demobilization, as well as learning effects. Thus, they commonly underestimate jobs that are smaller than normal and overestimate jobs that are larger than normal. Estimators also commonly use averages of prior unit costs to predict future unit costs. While this may sound reasonable, average prior unit costs give the worst possible estimates of future unit costs. Of the various reasonable methods of estimating costs given prior data, this approach gives maximum bias and maximum variance in the error of future estimates.

Another principle of importance in estimating is what the author has termed "The Heisenberg Uncertainty Principle" (Larew, 7). This is a transfer, to construction, of the Heisenberg principle in nuclear physics which states that one cannot simultaneously measure location, direction and speed of a particle in space. In construction, the invariable rule is that one cannot simultaneously achieve the required scope of work, on time and in budget. The reason for this is that the three requirements are often set by three entirely different parties and frankly, we are not skilled enough to predict with certainty the time and cost, given the scope. We thus come to the next technique, which is quite obvious: if we have a fixed budget and a required delivery time, we must vary the scope. As a practical matter, the successful project managers maintain sufficiently vague definitions of scope to allow them to bring in projects on time and within budget.

Another useful technique for those who wish to improve their estimating is to view the difference between the predicted future costs and actual future costs as a random variable. This random variable can be used to measure the bias of past predictions, the range of prediction errors, and the shape of the estimating error cumulative distribution function (cdf). For a variety of reasons, we strongly recommend that estimators utilize a percentile type distribution for approximating estimating errors (Larew, 6 and 9).

A horizontal shift of the cdf reflects a change in bias; a counter-clockwise rotation of the cdf reflects a reduction in range; and changes in parameter values reflect changes in the shape of the error distribution.

A final technique which the author recommends to those who want to improve their estimates is the use of lag functions to examine the impact of the rate of issuance of change orders on costs. In a study of work progress on a nuclear power project (White, 21), job progress at 6-month, 12-month and 18-month periods following the issuance of change orders in a given time period were plotted. It was found that job progress fell dramatically when the rate of issuance of engineering change notices per time period increased above a level of approximately 80. If one wants to improve estimating, one must improve the understanding of the impacts of changes on unit costs. One must also be able to predict the rate of issuance of changes and account for these changes when predicting future costs.

CURRENT STUDIES

In a wide variety of studies conducted at Ohio State from the viewpoint of the sellers of construction services (Li, 10), it was found that a variable pricing policy is essential if one wishes to maximize the profitability of a construction company. In a study which is currently in progress (Selim, 17) using GSA data, the results suggest that agencies might better achieve their objectives if they vary the contingency amount on a project-by-project basis. Figure 3 suggests, for example, that we might examine the probability of rejection of bids to be received prior to the application of any contingency amount, and then establish an appropriate contingency level to achieve a desired level of rejection at a given percentage above the adjusted engineer's estimate.

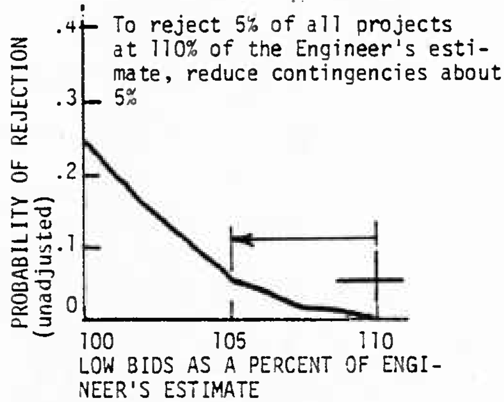

Figure 3. Reduce Continengies to Increase Rejection Rate

Another area of current interest is the application of cost indices in construction estimating (Baswari, 2). Most estimators fail to index their costs to the index. Most estimators do not know how to forecast index numbers into the future. The Ohio State program is directing current studies into the basic issues of selection of an appropriate index, indexing to the index, and forecasting index numbers into the future.

Several years ago, the author developed a rate of comoletion model for work on hand (Larew, 7). This model has been used to study effects of backlog of work within a construction company (Rhye, 15). It has also been used to examine the rate of progress of a typical project (Ramareddy, 14). Within the past year, we have discovered that this rate of completion model is a first approximation of the hazard function. From the contractor's side, it turns out that an optimum pricing policy is achieved when the contractor's markup is equal to the reciprocal of the hazard function. The author speculates at this time that we may find that an optimum contingency will be a function of the hazard function.

A major problem in the use of historical data in cost estimating is one which we call "The Non-Existing Value Problem." While this problem is quite similar to the classical "missing value problem," it is not the same problem. There are no standard analysis programs for estimating parameters when one has non-existing values (Ker, 4). Thus, we can well understand why contractors do not really use their data to find, for example, the cost of various types of blocks on a masonry project. There is no generally recognized technique for doing so. While we have developed programs at Ohio State for six special cases of the non-existing value problem, much more work is needed in this area.

A final area of concern being addressed in current studies of construction estimating at Ohio State concerns the persistent use of the percentage error term in describing performance of estimators. In studies conducted from the viewpoint of the contractor, it has been shown that when estimates are unbiased, the profits earned by contractors are always less than the average markup applied at the time of bidding (Fantozzi, 3).

It has recently been found that when the difference between bids received and the engineer's estimate is expressed as a percentage of the engineer's estimate, the perceived difference is greater than the actual difference in dollars between the bid amount and the engineer's estimate. This means that, for example, when the engineer's estimate is, on the average, exactly correct and the contractor is bidding, on the average, at the same level, when we express the difference between the bid received and the engineer's estimate as a percentage of the engineer's estimate, it will appear in the long run that the contractor is bidding, say, 5 to 15% above the engineer's estimate.

This suggests that a major driving force for including unexplainable contingencies on the order of 10% when preparing an engineer's estimate may be a false perception due to the industry's practice of expressing the difference between low bid and engineer's estimate as a percentage of the engineer's estimate. In our current studies, we are interested in finding an alternative statistic for describing that difference.

FUTURE STUDIES

From the buyer's side perspective, we have developed some sophisticated computer-based systems for optimizing bids to be submitted to public agencies (Kow, 5). In establishing unit prices, we consider the time value of money, timing of work, retainage, delays in receipt of payment, the probable distribution of low bids to be submitted by competitors, socially acceptable upper and lower bounds of unit prices, and perceived errors in quantities on the bid form. The program uses a Fibonacci search technique to iterate between a linear program which allocates unit prices, on the one hand, and a profit maximization program that maximizes expected profits on the project as a whole, on the other.

Several years ago, we did some studies on the problem of evaluation of bids received by a public agency (Morrison, 13). It seems that the time has come to develop a computer-based system for evaluation of each individual unit price and to examine, over the longer run, the pattern of bids being received by contractors to identify prospective cases of collusion or other illegal or unethical practices.

We also expect to be giving much greater attention to the problem of measuring crew level performance (Larew, 8). These studies are particularly important in order to resolve differences in perceptions in processing claims for added costs. We know, for example, that on a given project with a given set of data, we may have significant economies of scale at crew level and significant diseconomies of scale at project level. At this time, we do not know how to link these diverse and apparently contradictory perceptions. If we can develop a linkage, then it would be possible, when processing claims, to utilize the data available and then to transform the data as appropriate to address the claim in a more appropriate fashion.

Finally, another area targeted for future studies is one the author calls the "Invisible Queue Problem." This problem relates to achieving a better understanding of the mechanisms by which project costs rise to seemingly uncontrollable levels in a very short time. It is a topic that, again, may be important in relation to the settlement of claims for added costs.

When illustrating the invisible queue problem, an appropriate analogy is that of the grocery store, where we are all familiar with the process by which the store manager calls clerks from the aisles to attend cash registers and get customers moving after the queues at a few of the registers have grown to unacceptable lengths. On construction projects, we have workers who are customers, and managers and technical personnel who are the servers. Managers and technical personnel are responsible for providing information, materials, decisions, tools and equipment in a timely manner. If these resources are not provided, there is a queue of needed information, tools, equipment, decisions and other resources without which, work will not be done.

However, in construction work, it is not socially acceptable for all of the people who need things to stand in line, waiting for the things they need. Visibility will lead to lay-offs. Workers thus find ways of appearing to be busy. Accordingly, in construction, we never see the queue. It is invisible. In the author's opinion, we need to find ways of monitoring the existence of the invisible queue. This area of future study may also have a significant impact upon the handling of claims in the future.

IS A CHANGE OF THINKING NEEDED?

The perspectives and techniques presented in this paper come from a university program in which we are indeed striving to integrate theory and experience. This integration is essential if we are to reduce construction costs to an affordable level.

An essential component of the progress we have made toward achieving this integration is the fact that, in the course of our graduate study program, students undergo what we call "a change of thinking," in which they acquire the ability to view both theory and experience from new perspectives. This "change of thinking" does not simply derive from newly-acquired skills or knowledge, since it is both intuitive and analytical in nature.

At this time, we are not precisely certain how this change of thinking occurs. We do know that this change of thinking is essential prior to the undertaking of significant research. In our experience, the students must first be capable of perceiving the problem, from new or different perspectives, before they can begin to formulate a solution. While we do not presently understand the mechanism, we can describe some of the elements in this program that lead to this change in thinking:

* Coursework is extensive. The typical student studies both parametric and non-parametric statistics, operations research subjects such as linear regression, linear programming and simulation; and at least a dozen particularized courses related to construction engineering and management practices.

* Case studies are employed using real data. A wide variety of case studies are presented to the students; these data sets come from the smallest to the largest firms in the country, from government agencies as well as the private sector, from buyers as well as sellers of construction services, and from locations on several continents.

* Computer-based diagnostic techniques are utilized. Standard packages that are readily available, such as SAS and BMDP are utilized; in addition, a number of diagnostic programs developed by students and faculty are employed to better understand construction costs and operations.

* The period of study in our program is longer than the one year normally allowed for a Master's program; the typical student spends not less than 18 months and the better students stay for a total of 24 months.

While we cannot, at present, precisely define how we achieve the so-called "change of thinking," we know that it typically comes near the end of the third quarter or sometime into the fourth quarter of study. We know that this change of thinking is a prerequisite if one sincerely wishes to integrate theory and experience.

Given our experiences, the question must be raised: Is a change of thinking needed at the Department of Defense? If it is, then the question arises: What is the most cost-effective way of achieving the needed "change of thinking"?

Finally, the author must note that in his working experience that spans 40 years of work in the construction industry, there have been no significant changes in the ways in which we estimate projects. While it is fair to say that we are developing a new body of knowledge in our program at The Ohio State University, it is also fair to say that we have had little impact upon industry practice up to this point. We would hope that we will not go another 40 years without significantly changing our methods of estimating. For this reason, the author hopes that most participants in this Symposium will find better ways of integrating theory and experience in the Department of Defense.

REFERENCES

1. Al-Shawi, M., "The DEMAR Strategy: A New Approach for Evaluating Alternative Highway Designs," M.S. Thesis, The Ohio State University, 1982.

2. Basraw, Mohammed, M.S. Research in Progress, The Ohio State University, 1982.

3. Fantozzi, L., "Systems Approach for Research in Construction Estimating and Pricing," M.S. Thesis, The Ohio State University, 1979.

4. Ker, Liang Chun, "Non-Existing Value Problems: Initial Solutions for Six Cases," M.S. Thesis, The Ohio State University, 1981.

5. Kow, Fu-Lin, "Pricing Unit Price Contracts: Initial Development of the MANAGE Program," M.S. Thesis, The Ohio State University, 1982.

6. Larew, Richard E. A Quantitative Approach to Estimating and Pricing in a Construction Company. Ph.D. Dissertation, University of Iowa, 1976.

7. _______________, "Heisenberg Uncertainty and Mid-Size is Best," Proceedings, Sixth International Cost Engineering Congress, Mexico City, October 1980.

8. _______________, "Techniques for Recognition of Crew Level Performance in Management Analysis," Proceedings, Mid-Winter Symposium, American Association of Cost Engineers, Houston, January 1981.

9. _______________, "Decision Making in Construction Operations," Proceedings, Risk and Uncertainty Workshop, U.S. Air Force Academy, Colorado Springs, February 1981.

10. Li, Kirk, "Pricing for Profit," M.S. Thesis, The Ohio State University, 1980.

11. Liu, Shin-Lu, "Preliminary Studies of Joint Response Surfaces in Construction Cost Estimating and Pricing," M.S. Thesis, The Ohio State University, 1978.

12. Ludolph, Douglas, "Unit Cost Estimating," M.S. Thesis, The Ohio State University, 1979.

13. Morrison, Malcolm, "Acceptance Testing for Bids Submitted to Public Agencies," M.S. Thesis, The Ohio State University, 1977.

14. Ramareddy, Devaraj, "Initial Studies on Manpower Loadings and Their Effects on Completion of a Project on Time," M.S. Thesis, The Ohio State University, 1982.

15. Rhye, Ralph, "The Influence of the Backlog of Work on Construction Company Operations," M.S. Thesis, The Ohio State University, 1980.

16. Saenz, Gabrial, "Predesign Estimating: The Impact of Design Decisions on Estimating Errors," M.S. Thesis, The Ohio State University, 1981.

17. Selim, Mohamed, M.S. Research in Progress, The Ohio State University, 1982.

18. Uwakweh, Benjamin, "An Initial Study in the Design of a User-Friendly System for GSA," M.S. Thesis, The Ohio State University, 1981.

19. Veselenak, John, "An Analysis of Estimating Accuracy of Government Construction Contracts," M.S. Thesis, The Ohio State University, 1982.

20. Wang, Chuan, "Application of Pricing Policy in a Seasonal Market," M.S. Thesis, The Ohio State University, 1981.

21. White, Jeffrey, "The Impact of Reactor Coolant System Design Changes on the Time of Construction of a Nuclear Power Plant," M.S. Thesis, The Ohio State University, 1980.

THE UNDERLYING LEARNING CURVE TECHNIQUE

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ABSTRACT

This paper introduces the underlying learning curve (ULC) technique this technique combines both engineering and parametric estimating approaches to provide a "should cost" estimate of direct labor. The key to ULC is a disciplined integration of the data found in the work measurement and cost accounting systems. This integration results in the ability to quantify the time associated with Parkinson's Law.

INTRODUCTION

The purpose of this paper is to provide a brief introduction to the underlying learning curve (ULC) method of analyzing direct labor. The paper begins by providing the technique's background. Next it briefly describes the procedure. Finally, it shows the results of using the technique at several Aeronautical Systems Division contractors. It is important to note that while this tool has been used successfully to reduce the cost of negotiated contracts at Aeronautical Systems Division, the procedure is equally useful as a management tool for production control.

BACKGROUND

Two methods have traditionally been used for estimating direct labor. These two methods are the engineered estimate and the parametric estimate. The engineered estimate is also known as a bottom-up estimate. An engineered estimate is developed by specifying each element of work to be performed in manufacturing the product using time standards. Consideration is then provided for all the effort not included in the time standards by multiplying the standards by a factor and using learning curves. The parametric estimate is a top down estimate. The parametric estimate uses statistical techniques to analyze historical data. Often learning curves are used in parametric analysis. The parametric estimate differs from the engineered estimate in the way in which learning curves are used. The parametric estimates uses the learning curve as a first step, while it is usually the final step in an engineered approach. Both techniques have their advocates and detractors.

The underlying learning curve technique combines elements from both approaches. It also differs from both approaches. One difference is that the underlying learning curve technique does not assume that all of the work contained in cost history had to occur. It questions whether the historical relationships shown in the cost system must reoccur in future work by analyzing work measurement system's historical data. Since both systems measure the same elements of work, the two histories can be combined in a disciplined manner to determine whether some of the time measured by the cost accounting system was caused by Parkinson's Law. This Law was first defined by C. Northcote Parkinson (2). It states that work will expand to fill the time allotted to accomplish it. Thus, if the planning organization overestimates the time to perform a task, the workers performing the task will take the amount of time planned rather than the amount of time required; i.e., planning can become a self-fulfilling prophesy. Another difference is that the underlying learning curve technique always uses a unit learning curve. If only cumulative average or cumulative total data is available, then the Algebraic Lot Midpoint Unit Regression Analysis (ALMURA) procedure is used to obtain a unit learning curve (1). The differences allow ULC analysis to quantify the time expansion in the cost history caused by Parkinson Law which will be referred to as "Parkinson's time." Parkinson's time is the difference between the underlying learning curve and standard learning curve. The standard learning curve is a unit curve which is based upon the actual cost history.

The work measurement system contains all of the data used to establish time standards. Time standards can be established using several different methods; however, the most common methods are time study and predetermined time systems. The standard time is the time required for a qualified employee who is working at a normal pace under capable supervision and experiencing normal fatigue and delay to do a defined amount of work of specified quality when following a prescribed method. The definition is important because it provides the basis of integrating work measurement system data with cost accounting system data.

A discussion of the principal elements of this definition provides a background for understanding the underlying learning curve technique. These elements are:

(1) Worker qualifications and pace.

(2) Supervision.

(3) Allowance for fatigue and delay.

(4) Work definition.

Worker Qualification and Pace: The worker's qualifications are directly related to pace because if a worker is not fully qualified, then the worker will work at slower rate than a fully qualified worker. If a worker is experienced, then a faster than normal rate would be expected. Convention has placed the rate for a normal pace at 100%. Psychologists have performed many studies on learning. This large body of literature shows that the power form of the learning curve best describes worker learning. However, most of the literature deals with workers who were initially unfamiliar with the tasks that they were asked to perform. Lieber (1) showed that worker learning did not exist in a production setting in which the workers were already skilled. The majority of government contractors use journeyman, not appentice labor, to perform the production work. Thus, it is important to determine how much worker learning should be projected for new work. This can be accomplished by analyzing the rating data in the work measurement system. Pace rating is a key element of both producing time studies and performing underlying learning curve analysis. It is important to note that all predetermined time systems are based upon time studies in which rating played an crucial role. The rating is the factor used to equalize or normalize the actual time measured by the stop-watch. Rating is performed by the industrial engineer who is performing the stop-watch time study. While rating is a mixture of art and science, it is possible to statistically quantify the accuracy of the rating. This is done through testing which is normally performed at least annually. Most companies not only test, but also certify the results before allowing their industrial engineers to perform time studies. Usually the rating abilities will range between plus or minus five to ten percent of the actual rating with between 90% and 95% confidence. By using the rating, it is possible to define the extent to which worker learning should be addressed in estimating costs. This is done by performing a regression analysis on the rating data in the work measurement system in which the rating is compared to the unit being produced. If worker learning is an important element of the overall improvement curve in a contractor's plant, then the regression analysis will provide the learning curve slope, the value at the first unit, and a high correlation coefficient. However, if the correlation coefficient is low, then worker learning is not a factor in the plant. The average rating from such a study provides the value which should be used in any work estimates. It is important to note that thus far ratings have not demonstrated the existence of worker learning as a factor in the plants studied; however, it is too early to generalize the finding. The rating provides a useful and important tool because it is a direct observation and measurement of actual work which was performed. The results provided by an analysis of rating does not contain any Parkinson's time because the industrial engineer notes any time which should not be included in the standard while performing the study. This feature will be discussed in more detail later in this paper.

Supervision: The supervisor's attitude is very important. Research results, which will be presented later in this paper, show that the attitudes of supervision play a pivitol role in determining the efficiency of the workforce. If the supervision does not believe that the standards are achievable, then the workforce will work at a pace which is below 100%. An underlying learning curve analysis provides a good tool for demonstrating the extent to which standards are achievable.

Allowance for Fatigue and Delay: While the industrial engineer will eliminate the time spent in delay or resting from fatigue when performing the time study, a factor for normal fatigue and delays will be added back into the standard to account for these elements. Normal fatigue and delay is part of the standard. Abnormal delays are measured through vouchering the delay in the cost accounting system. Abnormal delays are measured by the industrial engineers and eliminated from the standard time in the same manner as they are directly measured by the cost accounting system as a separate factor. It is essential that all of the elements which are directly vouchered in the cost accounting system be measured and eliminated from the standard to assure that both systems are based upon the same basic definitions.

Work Definition: The work must have both a defined method and a defined acceptable quality level. A change in either the method or the acceptable quality level results in a change to the standard. The changes will be made during a production program. The underlying curve technique quantifies this improvement activity through performing a regression analysis on standard or earned hours. This analysis provides a learning curve showing the historical ability of a company to reduce the standard time in a production program.

A discussion of the standard at the first unit provides some perspective into why a learning curve represents how standards change over time. As shown in Figure 1 (5), standard hours for the first unit contain the basic work content, the work content caused by defects in design or specification of the product, and the work content due to inefficient methods of manufacture or operation. As the problems that constitute the additional work are eliminated, the standard becomes equal to the basic work content. Similarly, the ineffective time due to the shortcomings of management and within the control of the worker is reduced for each successive unit. The overall result is a learning curve which represents this problem-solving activity. This relationship was recognized by Sahal (3) who demonstrated that the $Y = AX^B$ formulation of the learning curve is isomorphic to the cumulative density function of the Pareto distribution. The Pareto distribution is often used to model problem solving. This relationship becomes even more significant when one notes that industrial engineers usually use a classic Pareto analysis when allocating resources for methods improvement.

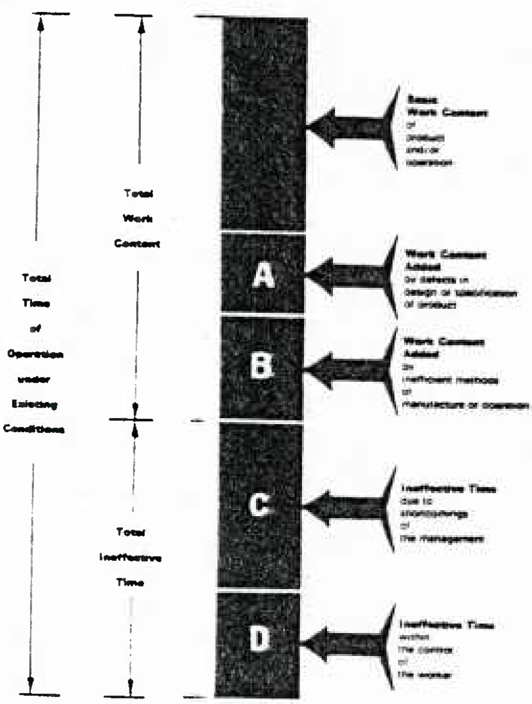

FIGURE 1. MAKEUP OF THE MANUFACTURING TIME FOR THE FIRST UNIT

The cost accounting system measures the actual time spent manufacturing the product. Table 1 shows a comparison of cost accounting and work measurement system data. Note that the data contained in the work measurement system is all measured directly and the value of the standard feeds into the cost accounting system. Overrun which is the time remaining after the standard and the directly vouchered labor has been subtracted from the total time, is an indirect measurement. Parkinson's time, if it exists, will found in the overrun cost account code. However, overrun is usually considered to be the cost account code which measures the time required because workers were learning the job. Thus, the key to quantifying Parkinson's time is determining the extent of worker learning. If worker efficiency is increasing as the number of units increase, then one should be able to quantify the improvement through analyzing the ratings in the time studies since the ratings are quasi-random samples of worker efficiency as measured directly by the industrial engineers. Moreover, there is a mathematical relationship between the overrun and the rating defined below based upon the definition of the rating:

$$\text{Rating} = \frac{\text{Actual Time}}{\text{Standard}} \qquad (1)$$

However, the actual time includes only the elements of overrun and standard because the other elements are subtracted prior to application of the rating. Thus:

$$\text{Rating} = \frac{\text{Overrun \& Standard}}{\text{Standard}} \qquad (2)$$

The measured overrun in the work measurement system is given by:

$$\text{Overrun} = \text{Rating} \times \text{Standard} - \text{Standard} \qquad (3)$$

The analysis of the rating provides a basic method for quantifying Parkinson's time. The specific procedure is outlined below.

THE PROCEDURE

The first step of underlying learning curve analysis is to review and understand the contractor's work measurement and cost accounting systems.

The second step is to perform the underlying learning curve analysis. This consists of four different unit learning curve regression calculations:

(a) The earned hours learning curve. Showing the improvement in standard hours.

TABLE 1. COMPARISON OF THE DATA CONTAINED IN THE COST ACCOUNTING AND WORK MEASUREMENT SYSTEMS

ELEMENT	COST SYSTEM SOURCE	TIME STUDY SOURCE
1. TOTAL HOURS	VOUCHER	CLOCKED TIME
2. SCRAP	VOUCHER	CLOCKED TIME
3. SET UP	VOUCHER	CLOCKED TIME
4. REWORK	VOUCHER	CLOCKED TIME
5. INSPECTION	VOUCHER	CLOCKED TIME
6. RE INSPECTION	VOUCHER	CLOCKED TIME
7. OVER RUN	TOTAL HOURS (SCRAP + SET UP + REWORK + INSPECTION + RE INSPECTION STANDARDS)	RATING
8. STANDARD	WORK MEASUREMENT SYSTEM & PARTS COUNT	(TOTAL CLOCKED TIME · (SCRAP + REWORK + SETUP + INSPECTIO + RE INSPECTION)) × RATING

(b) The worker learning curve. Showing the reduction in the inverse of the rating.

(c) The underlying learning curve. Showing the improvement in total direct manufacturing labor. All of the vouchered elements of the realization factor are analyzed in this step.

(d) The standard learning curve. Showing the actual hours required for the production program.

The difference between the standard learning curve and the underlying learning curve is Parkinson's time. Figure 2 provides a conceptual rendering of the standard learning curve, the underlying learning curve, the worker learning curve, and the earned hours learning curve.

RESULTS

Underlying learning curves have been used at three contractors as a negotiation tool. Each contractor was different. Contractor A's work was performed in one location; Contractor B was in a similar position except that several plants in different geographical locations produced parts. Contractor C was similar to B, except that the work measurement and cost data was not completely traceable. In all three cases, the underlying learning curve technique provided visibility which was unavailable from either the traditional parametric or traditional engineered approaches.

Figure 3 shows the underlying learning curve and standard learning curve for Contractor A. Parkinson's time was 22% of the total hours spent on the contracts for Contractor A.

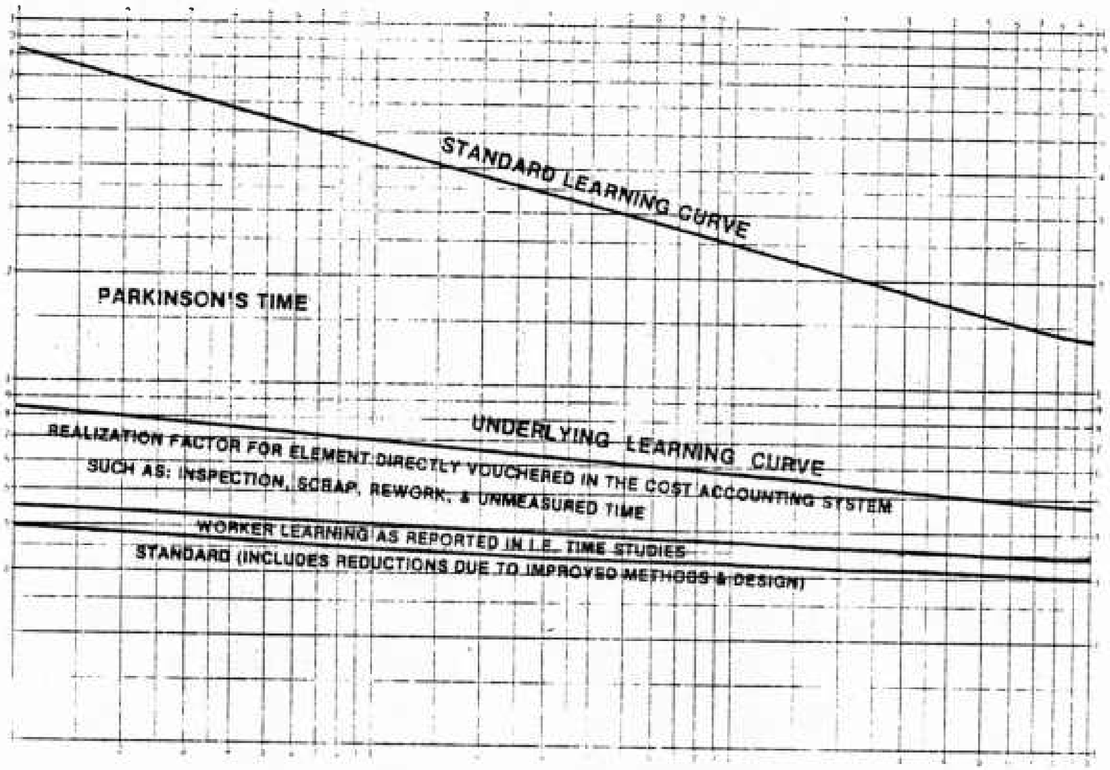

FIGURE 2. RELATIONSHIP BETWEEN STANDARD AND UNDERLYING LEARNING CURVES WHEN PARKINSON'S TIME IS PRESENT (SHOWN ON LOGARITHMIC GRID)

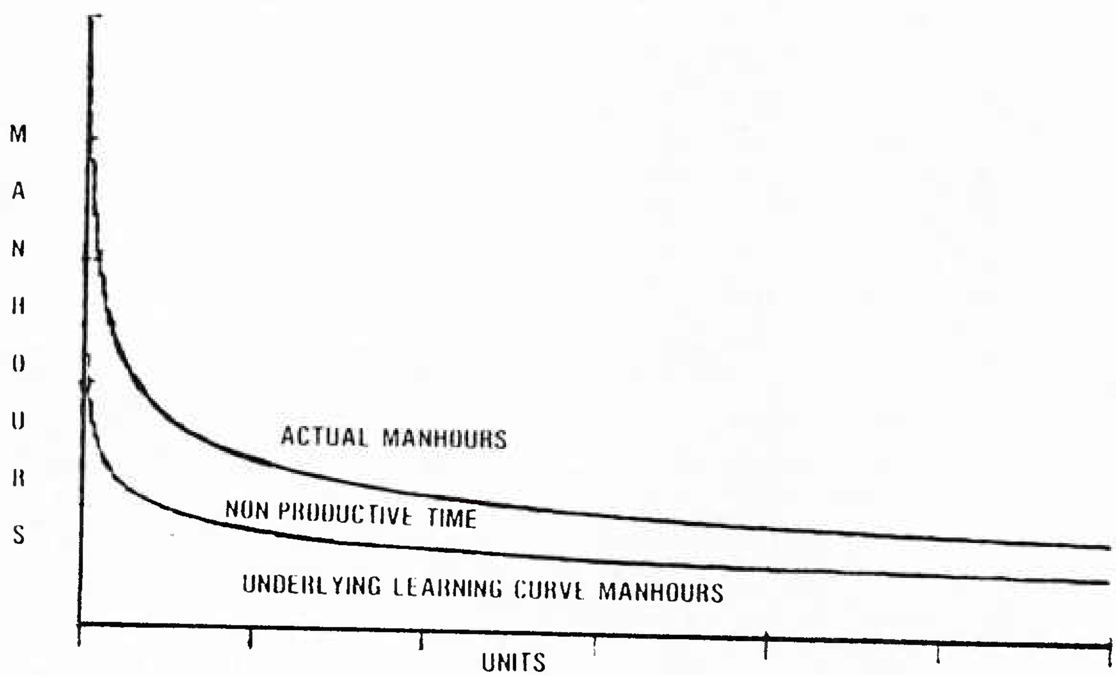

FIGURE 3. UNDERLYING LEARNING CURVE AT CONTRACTOR A (SHOWN ON CARTESIAN GRID)

Figure 4 provides data on three of Contractor B's plants. Figure 4 appeared in Smith (4) without the information concerning the efficiencies at Plants 1, 2, and 3 to show the average worker efficiencies achieved under daywork, measured daywork, and incentive conditions.

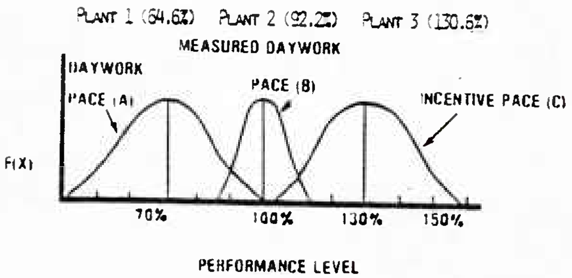

FIGURE 4. DISTRIBUTION OF WORKER PERFORMANCE UNDER DIFFERENT ENVIRONMENTS

Daywork conditions are defined as a situation in which the employees are paid straight hourly wages, work under routine supervision and work within average work conditions (environments). Under daywork conditions, Smith (4, pp 55-56) reports that workers perform at an average of 70% of standard performance. If a work measurement system is implemented with feedback control, Smith (4, pp 55-56) states that the average worker will work at the standard rate.

Under a measured daywork system, each worker is provided with his or her measured efficiency and is exhorted by management to work at standard performance. With knowledge of actual performance (knowledge of results), each worker can and will modify his or her behavior so that standard performance is achieved. With the addition of an incentive system and a direct financial reward for working at rates above standard performance, Smith (4, pp 55-56) writes that an average rate of 130% is achieved by workers.

What was significant at Contractor B was that all of the plants used sophisticated and accurate predetermined time standards supplemented by time study. Plant 1 and Plant 3 were located within 10 miles of each other. The two plants shared the same union, and there were bumping rights between the plants. The principal difference between the two plants dealt with management perceptions concerning the abilities of their workers to achieve standards. Managers at Plant 3 expected the workers to achieve and beat the standard while the managers at Plant 1 believed that the standards could never be achieved. This difference in attitude was reflected in the planning, and a self-fulfilling prophesy was created.

The underlying learning curve technique was used with Contractor C as a negotiation tool. The government made some assumptions about the operations so that the sparse useable data could be analyzed. In this case, as with Contractor B, both parametric and engineered methods were used in conjunction with underlying learning curves. However, underlying learning curves provided the basic means of conveying the government position to the contractor. It was chosen because it is logical, traceable, and easy to comprehend.

However, more important than the initial success at Aeronautical Systems Division is the use of the technique for real-time management control. The bottom line of the initial experience is that standards are achievable, but management must expect and plan for standards to be achieved. The underlying learning curve technique provides a framework for explicitely defining management goals by organizational responsibilities. For example, industrial engineering is responsible for achieving the earned hours learning curve. The first line supervision is responsible for achieving the realization factor. As an aid to assist the first line supervisor, a real time cost accounting system can be programmed to constantly query operator efficiency and provide a signal to the appropriate management level when:

(1) A worker's efficiency is above a specified level.

(2) A worker's efficiency drops below 100%.

(3) A worker's efficiency is below a specified level.

In the first case, upper management would take the time to praise the worker for his achievement. In the second case, the first line supervisor could discover the problem causing poor performance. In the third case, supervision above the first level would become involved to try to solve the problem causing the poor performance. This technique provides both positive and negative feedback to the worker. It provides management a precise management by exception tool. Through using the statistical nature of the regression analysis technique to advantage, it is possible to use the same tool for program management.

The underlying learning curve technique has been used by Aeronautical Systems Division as a negotiation tool. It is scheduled for use as a program management tool in the Technology Modernization Program. Underlying learning curves provides both a method of analyzing the "productivity problem" and the information to solve it.

SUMMARY

The underlying learning curve technique provides a traceable and supportable method of analyzing historical cost data for use in projecting future program costs. It is based upon a disciplined integration of the work measurement and cost accounting systems which enables the analyst to quantify Parkinson's time. It can be used as a framework for a real-time management system. Also, it can be used as a program management tool. The underlying learning curve technique provides a method of quantifying and solving "the productivity problem" which currently exists in the United States.

References

(1) Lieber, Raymond S., Production Cost Analysis Using The Underlying Learning Curve, New Mexico State University, January 1982

(2) Parkinson, C. Northcote, Parkinson's Law, Ballantine Books Division of Random House, New York City, New York, c. 1957

(3) Sahal, Deendra, "A Theory of Progress Functions", AIIE Transactions, Volume II, No. 1, March 1979, p. 23-29

(4) Smith, George L., Jr., Work Measurement-A Systems Apprcach, Grid Publishing, Inc., Columbus, Ohio, c. 1978

(5) International Labour Office, Introduction to Work Study, Revised Edition, Impression Couleurs Weber, 2501 Bienne, Switzerland, c. 1974

PANEL J

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AIR FORCE ACQUISITION AND PROFITABILITY:
A DISAGGREGATED MULTIPLE
REGRESSION ANALYSIS

by

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*Portions of this research were undertaken as part of contract F33615-80-C-5158 for the Air Force Business Research Management Center (AFBRMC/RDCB), Wright Patterson Air Force Base.

I. INTRODUCTION

The question of profits in the defense industry has been the subject of much concern, a concern which is apt to increase with the projected rapid rise in defense expenditures. Prior research has yielded conflicting results regarding the impact of defense sales on firm profitability. Agapos and Galloway[1] examined aerospace profits during wartime and found no evidence of excessive profits. The Comptroller General[2] and Bohi[3] reported little or no difference between profit rates for defense firms and their non-defense counterparts. Weidenbaum[4] found that defense industry profits were unusually high while a Logistics Management Institute study[5] found that defense industry profits were too high during the 1950s and too low during the 1960s. More recently, the Department of Defense[6] found that profits when measured against sales were lower for defense contractors but higher if measured against investment.

This study is also concerned with the profit performance of the defense industry. The specific issue addressed is whether a public aerospace firm can increase its profitability through a heavier concentration of its sales to the Air Force. Thus the present study is distinguished from these prior profit studies in several respects. First, the unit of analysis is the segment of the public corporation which is responsible for the product(s) purchased by the Air Force rather than the consolidated corporation. Second, profits are measured in two different ways: as a ratio to sales and as a ratio to investment. Third, a multivariate analysis of both measures of profitability is accomplished. Fourth, the investigation is updated to cover the years 1977 through 1979.

This study is divided into four parts. The first section presents an overview discussing the issues regarding the use of corporate segments, measures of profitability, and multivariate analysis. The second section is a description of the data employed in the empirical analysis. Results from the multivariate analysis are presented in the third section. The fourth and final section provides a summary of the major findings and explores their implications for the defense acquisition process.

II. OVERVIEW

The logic for the use of the corporate segment rather than the consolidated corporation as the unit of analysis is best demonstrated by example. In 1978 General Dynamics, the consolidated corporation, sold 63 percent of its output to the government. Total sales and government sales were distributed between six operating divisions or segments as follows:

(i) Government Aerospace - 41 percent of total sales with 99 percent to the Air Force;

(ii) Submarines - 22 percent of total sales with 99 percent to the Navy;

(iii) Commercial Ships - 9 percent of total sales with all sales being non-government;

(iv) Telecommunications - 19 percent of total sales with almost all sales being non-government;

(v) Asbestos - 3 percent of total sales with all sales being non-government, and

(vi) Other Products - 6 percent of total sales with 3 percent to the government.

Clearly, in assessing the impact of sales to the Air Force or to the government on the profitability of General Dynamics the results for the Commercial Ships, Telecommunications and Asbestos segments should be completely ignored. Conclusions based on consolidated corporation data would have included these segments and obscured if not distorted the relationship between defense production and profitability. Given the focus of the current study, sales to the Air Force and profitability, only the performance of the Government Aerospace segment is important.

But how is profitability of a corporate segment to be measured? One gauge is simply the dollar value of profits. This level or volume assessment is usually considered as inappropriate in that it fails to control for size differences between firms. Consequently, profitability is usually expressed as a ratio. Two common ratio measures of profitability not used in the current study are the price-earnings ratio and return on equity. These two measures were not utilized because they may have little meaning at the corporate segment level. This is the case either because the segment does not have a stock or equity position distinct from that of the consolidated corporation or because the segment's equity value or common stock price are unduly influenced by the performance of the consolidated corporation.

The two ratio measures of profitability employed in the multivariate analysis are the profit margin ratio (defined as the ratio of operating profits to net sales) and return on investment (defined as the ratio of operating profits to identifiable assets). The former ratio (PMR) reflects return per dollar of sales while the latter ratio (ROI) reflects the effectiveness of the firm in the utilization of its assets. It is felt that two ratios would be more appropriate than a single ratio for two major reasons. First, the two ratios do provide very different perspectives on profitability and, therefore, together, they provide a better overall understanding between sales to the Air Force and its impact on the firm's "bottom line". Second, the use of two ratios would facilitate a comparison with prior studies which have employed one or the other of these ratios.

As a final point it might be noted that from a purely economic point of view, it is ROI which is more important measure of profitability. Whether resources or assets should stay in their present use or be put to some other use depends on their effectiveness in generating profits. Thus, if a corporate segment which concentrates exclusively on Air Force sales earns a below average ROI then this is taken as evidence that either performance must be improved or the consolidated corporation should change the Air Force sales concentration of the segment.

Having calculated the PMR and ROI of the various aerospace corporate segments, there is the problem of meaningful comparison. For example, suppose that the ROI of a corporate segment which sells 50 percent of its output to the Air Force is .1 while the ROI of a corporate segment which sells none of its output to the Air Force is .08. Two questions immediately arise. Is this difference important? Is it due to the fact that the two segments sell such different portions of their output to the Air Force or because of some other difference between the firms? Prior studies have concentrated on the first question but the second question is equally important. Multivariate analysis-regression analysis-allows for a simultaneous resolution of both questions. Besides this advantage multivariate analysis is also useful because it does not require any arbitrary assumptions regarding the level of Air Force sales which may constitute a distinction between involvement and non-involvement. Reworded, the multiple regression analysis allows the researcher to input the degree of involvement with the Air Force as a continuous variable (percent of corporate segment net sales accounted for by sales to the Air Force).

More specifically, the multiple regression equation takes the form:

$$MP_i = a_o + a_1(DSL_i) + a_2(COGS_i) + a_3(COR_i) + a_4(NSALE_i) + a_5(ASSET_i) + a_5(WAD_i) + e_i$$

<u>where</u>:

MP_i = measure of profits (either PMR_i or ROI_i) for the ith segment;

DSL_i = percent of the ith segment's total sales accounted for by sales to the Air Force;

$COGS_i$ = cost of goods sold for ith segment (this variable changes to cost of goods sold divided by net sales when ROI is the dependent variable);

COR_i = capital-output ratio for the ith segment;

$NSALE_i$ = net sales of the ith segment;

$ASSET_i$ = identifiable assets for the ith segment;

WAD_i = a binary variable with WAD = 1 for a segment identified by the <u>World Aviation Directory</u> as a manufacturer and WAD = 0 otherwise;

e_i = a stochastic error term.

The key variable in the regression analysis is DSL. If this variable is statistically significant and positive, then increasing concentration of segment sales to the Air Force leads to greater levels of profitability. That is, it "pays" to be involved in defense activity. If this variable is statistically significant and negative then defense activity is unprofitable and greater returns could be obtained by shifting sales from Air Force to commercial markets. If DSL is statistically insignificant the defense sales neither help nor hurt firm profitability.

The other explanatory variables are not to be considered as factors whose importance has been derived theoretically; rather, they are determined by data considerations. Thus, appropriate interpretation of the regression analysis is the determination of the impact of DSL on profitability while controlling for other differences between firms. With this interpretation, the emphasis is not on the overall explanatory power of the regression equation as measured by the coefficient of determination (R^2) but in the sign and significance of DSL. The coefficient of determination is expected to be low given the cross sectional nature of the data, the ratio form of the profit measures, and the limited number and scope of the explanatory variables.

With this in mind the explanatory variables can be grouped: COGS and COR might be classified as measures of firm efficiency. One would expect an inverse relationship between COGS and profitability while a positive relationship between COR and profitability would exist if capital were seen as a substitute for expensive labor inputs. NSALE and ASSET are measures of firm size and if economies of scale are present, increases in these two variables would be associated with greater profitability.

III. DATA

Given the thrust of the analysis (profitability of corporate segments) the first task is to identify the segment in aerospace industry corporations. This is accomplished by the use of the 1980 World Aviation Directory (WAD).[7] In order to compile the WAD, possible aerospace firms are contacted and asked to complete a series of questionnaires regarding their production. Response to the questionnaire is voluntary. However, because the WAD is the most comprehensive directory covering aerospace firms, there is a strong incentive for firms to complete and return the questionnaires. The WAD offers several different classifications of aerospace firms. The one which is most inclusive and most relevent for present purposes is the list of "manufacturers" and "subcontractors." As defined by the WAD, manufacturers are identifiable consolidated corporations and segments of consolidated corporations which produce completed aerospace and/or missile systems for foreign or domestic, civilian or military markets. Firms like Boeing and General Dynamics obviously fall into this category. Subcontractors represent those firms which produce "products," "components" and "subassemblies." Clearly, the WAD distinction between manufacturers and subcontractors rests solely with the type of output produced by the firm and not in terms of some other criterion such as size of the firm, level of technology associated with the output, or the contractual relationship between the firm and the economic units which purchase its output.

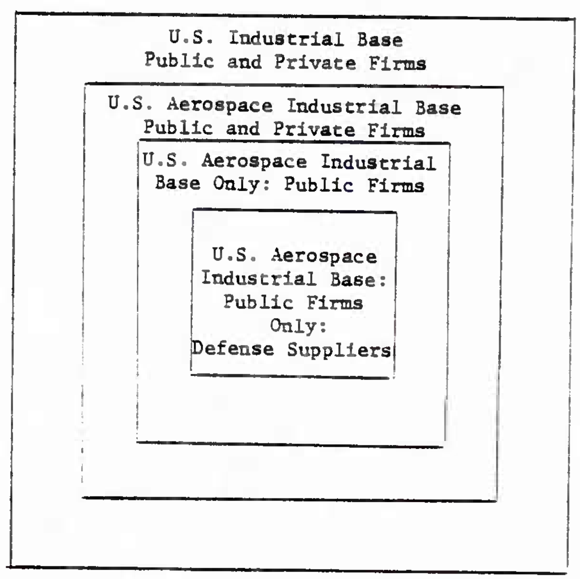
It is important to realize that the Air Force also buys output from firms not listed in the WAD. These firms are identified by other sources and included in the analysis. The number of such firms, however, is limited. With the exception just noted the aerospace industry base is defined as the sum of all subcontractors and manufacturers as specified by the WAD. But the WAD itself does not provide any of the financial information or data necessary for the analysis. As a consequence three other data sources are employed: the COMPUSTAT Business Information File; the Disclosure, Inc. SEC Form 10K File; and the Department of Defense Form DD 350. These sources provide the following data items: net sales, operating income, depreciation, capital expenditures, identifiable assets, percent of consolidated company revenues accounted for by segment, the dollar value of segment sales to the government (if any), and the dollar value of segment sales to the Air Force (if any). The COMPUSTAT Business Information File and the Disclosure Inc. SEC Form 10K only provide data for public firms. As a consequence private firms identified as part of the aerospace industry by the WAD and/or as Air Force suppliers by the Form DD 350 are excluded from the analysis.

Figure 1 is an attempt to show schematically the industry framework for this study. The first distinction between the U.S. industrial base and the U.S. aerospace industrial base is determined by the WAD. The second distinction between U.S. aerospace industrial base and that portion which consist of public firms is determined by the COMPUSTAT Business Information File and the Disclosure, Inc. SEC Form 10K File. The final distinction involves a determination made on the basis of those public firms with Air Force sales, a determination made on the basis of the Form DD 350. The analysis of private firms, many of whom appear to be small business, would require still other data sources and was considered beyond the scope of present research. As it stands the analysis includes some 942 corporate segments for 1977, 1187 corporate segments for 1978, and 1202 corporate segments for 1979.

As a concluding comment on the data, it is important to emphasize that a major distinction of the current study is its reliance on public data sources. This provides several advantages

FIGURE 1

U.S. Aerospace Industrial Base



(i) If public data sources are employed, then the number of firms--both Air Force suppliers and those that do not deal with the Air Force--can be maximized. Increasing sample size in this way increases confidence in the results generated by the regression analysis;

(ii) The use of public data sources ensures an independent interpretation and evaluation of elementary data items. As a consequence, the possibility of bias in the construction of the data set is reduced;

(iii) Public sources will be concerned with standardization in definitions and presentations. Given this standardization, there should be comparability in data items between units at a point in time as well as for the same unit over time;

(iv) The use of public data sources will allow for the periodic updating of the analysis. Such updating may be necessary as changes in the acquisition environment occur, and this will be the case whether the change arises because of new acquisition policies or because of changes in the structure and performance of the economy;

(v) Perhaps most important is the fact that the use of public data sources facilitates replication. In a scientific context replication is paramount because results must be reproduceable by others before they can be fully accepted. The notion of replication extends, however, beyond mere duplication and involves improvements in the analysis. Here researchers can build upon prior work and concentrate their energies not on data collection, but on the use of more advanced theoretical and empirical constructs.

IV. THE EMPIRICAL RESULTS

Table 1 presents the regression results for the complete sample of firms as indicated previously. The explanatory variables include the percent of the segment's total sales accounted for by Air Force sales (DSL), the capital-output ratio (COR), net sales (NSALE), identifiable assets (ASSET), and the WAD manufacturer-subcontractors distinction (WAD). These variables are employed in both the PMR and ROI regressions. There is one additional variable which changes between regressions. In the PMR regression the cost of goods sold ratio (cost of goods sold divided by net sales) cannot be used as explanatory variable for statistical reasons. So in place of the cost of goods sold - a level or dollar value rather than a ratio - is used. To repeat, in the PMR regressions the cost of goods sold (COGS) is used as the second efficiency variable while in the ROI regressions the cost of goods sold ratio (COS) is used as the second efficiency variable.

In these regressions the critical independent variable is DSL. It is the size, sign, and significance[8] of this variable which forms the basis for inferences regarding the impact of Air Force sales upon profitability. As a final technical point it should be noted that DSL represents a continuous variable ranging from .00 to .99 (reflecting zero percent Air Force sales to 99 percent Air Force sales).

Turning to the DSL-PMR relationship, the results in Table 1 indicate an inconsistent sign for DSL. It is positive in 1977 and negative in 1978 and 1979. As for the statistical significance of this effect, the probability values support the hypothesis that increasing proportions of Air Force sales do not lead to higher or lower profit margin ratios.

With respect to the other variables in the DSL-PMR regressions, the first efficiency variable (COGS) is, as expected, consistently negative and statistically significant. The other efficiency variable (COR) is negative and significant in 1977 and 1979 but positive and significant in 1978. The first of the size variables (NSALE) is consistent, positive and significant in all three years. Thus, it appears that firms with larger sales volumes have larger profit margin ratios. The second size variable (ASSET) is both positive and negative but is insignificant in each of the three years. The WAD variable is significant only in 1979 and here manufacturers have a higher PMR than subcontractors. The coefficients of determination (R^2) in the DSL-PMR regression are fairly low especially in 1977.

As for the ROI set of regressions in Table 1, they indicate that there is a positive relationship in each of the three years between DSL and ROI. But the impact which DSL has on ROI is statistically insignificant in each of the three years, almost becoming significant in 1979.

The DSL-ROI results presented in Table 1 also reveal a consistently negative and significant effect for the first efficiency variable (COS). This is to be expected. There are negative and significant effects for the second efficiency variable (COR), in 1977 and 1978. But COR returns a positive and significant effect in 1979. The two size variables return opposite signs in each regression and both are statistically significant in 1978 and 1979. The WAD variable returns mixed signs and is statistically insignificant in each regression. The coefficients of determination in the DSL-ROI regression are much higher than in the DSL-PMR regression; the range is now .08 to .45.

In order to focus the industry analysis more closely on those industries that might be considered as more concerned with the production and fabrication of aerospace and defense items rather than industries such as agricultural producers from whom the Air Force also buys products, it was decided that an additional series of regressions would be executed. The nature of the refinement was to reduce the number of firms being considered and included only those public aerospace firms which are classified within the Standard Industrial Classification (SIC) 3000-3999 range. These regressions are presented in Table 2. The arrangement of the regressions in Table 2 is identical to the arrangement of the regressions in Table 1: the same dependent variables (PMR and ROI), the same explanatory variables (DSL, COGS or COS, COR, NSALE, ASSET and WAD) and the same special interest in the size, sign and significance of the DSL variable. To repeat, the basic difference is in the type of firms: before all firms were included from whom data were available while the present refinement deals only with such firms as were also in the SIC 3000-3999 classification.

Figures from Table 2 indicate there is no change in the conclusion regarding the impact of DSL on PMR when the more narrow industrial focus is taken: DSL is consistently insignificant. With the exception of an increased R^2 for 1977, decreased R's for 1978 and 1979, and the statistical significance of WAD in two years as opposed to one year, the DSL-PMR results reported in Table 2 are generally the same as those reported in Table 1.

However, the DSL-ROI results in Table 2 are different from those in Table 1 in three important respects. First, the new R^2 values are substantially higher; they now range from .57 to .87 as opposed to the old range of .08 to .45. Second, DSL is now positive and significant in two of the three years suggesting that firms with greater proportions of Air Force sales have higher rates of return on investment. Third, the WAD variable is negative and significant in two of the three regressions implying that WAD defined manufacturers have lower rates of return on investment than WAD defined subcontractors.

As for an overall assessment of the results presented in Table 2 the emphasis is on the impact of industrial structure on the conclusions regarding the effects of DSL on PMR and ROI. Here the new regression results are consistent with the old results with one exception: when the SIC 3000-3999 grouping is employed DSL has a positive and generally significant impact on ROI.

V. SUMMARY AND CONCLUSIONS

The multiple regression analysis for the full sample of firms (the results represented in Table 1) support the conclusion that DSL has no statistically significant impact on the profitability of corporate segments in the aerospace industry. Thus acquisition policies have neither unduly rewarded or unduly harmed those firms who have supplied the Air Force with products. Going one step further, the lack of significant profit effects for Air Force purchases implies that resources are being efficiently allocated between Air Force and commercial markets.

However these conclusions in part are sensitive to the way in which the aerospace industry is defined. When the aerospace industry is restricted to industrial concerns (to firms in the SIC 3000-3999 classifications - the results presented in Table 2), DSL is found to have a positive and significant impact upon ROI in two of the three years under investigation. The DSL-ROI relationship for this group of firms has a number of possible and widely different interpretations. One interpretation is that in the implementation of acquisition policies deliberate preference has been given to industrial firms allowing them to earn extra profits. Such a policy might be justified in an effort to prevent the erosion or to secure the buildup of the military sector of the aerospace industry. Another interpretation is that industrial acquisition is so complex that acquisition officers have been unable to function effectively and Air Force suppliers have been able "to work the system" for extra profits. A third interpretation is that higher ROI for Air Force suppliers results from the fact that these firms are reluctant to invest in defense production facilities. Simply the industrial concerns supplying the Air Force, perhaps because of the one year contracting characteristic of defense acquisition, have invested less in capital equipment. Thus, the higher ROI may be indicative of a defense industrial base which is short of production facilities. The results presented in this study do not provide a basis for selecting between these alternative interpretations. That is a topic for future research.

FOOTNOTES

1. Agapos, A. and Galloway, L. "Defense Profits and the Renegotiations Based in the Aerospace Industry," Journal of Political Economy, Vol. 78, No. 5 (September/October, 1970), pp. 1093-1105.

2. Comptroller General of the United States, Defense Industry Profit Study, (Washington, D.C., Government Printing Office, 1971).

3. Bohi, D. "Profit Performance in the Defense Industry," Journal of Political Economy, Vol. 81, No. 3 (May/June, 1973), pp. 721-728.

4. Weidenbaum, M. "Arms and the American Economy: A Defense Convergence Hypothesis," American Economic Review, Vol. LVIII, No. 2 (May, 1968), pp. 428-437.

5. Logistics Management Institute, Defense Industry Profit Review (Washington, D.C., Government Printing Office, 1970).

6. Department of Defense, Office of the Assistant Secretary of Defense for Installations and Logistics, Profit'76 Summary Report, (Washington, D.C., Government Printing Office, 1976).

7. The WAD is a publication of the Ziff-Davis Publishing Company of Washington, D.C. and is produced annually.

8. Unless otherwise noted statistical significance is evaluated at the 5 percent level.

An Analysis of the Incentives Present in Incentive-type Contracts

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INTRODUCTION

In the early nineteen sixties, the Department of Defense (DoD) began to reduce its reliance upon a mix of Cost Plus Fixed Fee (CPFF) and Firm Fixed Price (FFP) contracts for procurement of weapons systems and began to increase its use of Cost Plus Incentive Fee (CPIF) and Fixed Price Incentive Fee (FPIF) contracts. The motivation for this change was made clear to all participants; the then-prevailing contract forms and practices were not perceived to be providing sufficient incentive for contractors to control their costs. Later modifications of the DoD procurement process, such as Total Package Procurement, were designed to deal with the same general problem. Currently, there exists a great amount of interest in making further changes in the DoD procurement process, [1] for example, the initiation of the use of multiyear contracts. Again, the reason is that the problems which DoD has experienced in controlling the outcomes of contractual arrangements have not abated.

Paralleling these changes in institutional practices was an increase in DoD, "think-tank" and academic studies on the problems and advantages of various contract types. This analytical research, [2] while originally focused on the more general problem, has gradually narrowed its concerns to those problems posed by risk and the consequent issue of optimal risk sharing. While this literature has led to a greater understanding of the role of risk and uncertainty in a contractual arrangement, it has also neglected some other equally important aspects of contractual behavior and outcomes. For example, this research literature has, in general, treated the contract between the purchaser and the supplier as a one-period, one-time relationship. This is an interesting question but does not consider that most major acquisitions are contractual arrangements with contractors having a long history of government work.

The approach suggested in this paper treats as primary determinants two aspects of the contractual arrangement which have not yet been developed in the usual analysis of contracting. The first and more fundamental aspect is, as mentioned, that production contracts for major weapons systems (that area where most cost growth has been experienced) are usually ongoing relationships rather than a one-time relationship. The second, and related, aspect is that there exist links between these ongoing contractual relationships and the Federal budgeting process. This is a recognition that budget appropriations are conditioned by budget requests which, in turn, are conditioned by prior contract experience. [3]

The recognition of these two aspects of the contractual relationship underlies the alleged "buy-in" phenomenon. The claim that contractors "buy-in" is a claim about, first, the relevant time horizon used by contractors in making a decision on a proposed contract. That is, contractors are claimed to have a decision horizon which encompasses more than a single contract. Second, the "buy-in" claim implicitly recognizes differences among proposed costs, actual costs and true (or minimum or competitive) costs for a given contract. This latter aspect includes the process by which the alleged excessive proposed costs are validated within the entire acquisition process.

This paper reports the results of the integration of these two aspects into a model of the government-supplier contractual setting. The results indicate that current institutional arrangements, such as values for cost and profit sharing ratios, create an incentive for government and contractor management to allow excess costs which result in cost growth.

The paper includes a description of the three major elements of the model of the contracting situation: the contractor, the government and the contract. The model presented integrates the long term relationship and budgetary aspects of the contracting relationship with the three major elements of the model. Then some results of the model concerning contractual incentives are presented. Finally, conclusions are drawn and areas for further research are proposed.

AN ANALYTICAL MODEL OF THE PROCESS

There are three major elements in modelling the government-supplier relationship. These are the contract, which codifies the relationship between the contractor and the government and includes the responsibilities and the rights of each; the contractor or supplier and its behavior; and the government and its behavior. Additionally, the links among ongoing contracts and the links between the contracting process and the budgeting process are important aspects of the full model.

The Contract

The contract is assumed to be a general incentive-type contract which provides for production of the desired system. Each contract, upon delivery of the required quantity of the product, requires that revenues be paid to the contractor. These revenues are determined by the actual costs incurred in production of the item, the proposed costs of production and several incentive features. The incentive features of interest here are those of the cost sharing ratio and the incentive or profit fee ratio. The cost sharing ratio determines how the contractor and the government share any cost overruns or underruns. The incentive fee ratio determines the amount of contract revenues which is specifically set aside for profits to accrue to the contractor. Each contract will produce revenues for the firm of

$$R_t = C_t^a + \alpha\left[C_t^p - C_t^a\right] + \gamma C_t^p , \qquad (1)$$

where

R_t = revenues accruing to the firm in year t,

C_t^a = actual cost incurred against the contract in year t,

C_t^p = proposed cost written into the contract in year t,

α = cost incentive share fraction ($0 \leq \alpha \leq 1$), and

γ = contract profit fee fraction ($0 \leq \gamma \leq 1$).

This formulation of contract revenue is the typical analytical one [4] that simultaneously represents the following contract types: FFP (α=1), CPFF (α=0), CPIF ($0< \alpha <1$) and FPIF ($0< \alpha <1$ with a price ceiling added). [5]

The Contractor

The contractor's business objective is assumed to be that of profit maximization over several time periods into the future. This implies that the contractor evaluates alternatives on the basis of the discounted present value of the long-run profit streams resulting from a particular decision. Although there have been criticisms of this profit-maximization decision criterion, recent work [6] indicates that several alternative criteria are nearly equivalent to long-run profit maximization.

The long run profit of a firm is computed by first calculating the profit for a contract in a given year, say year t. The profit in year t is the revenue given by equation (1) less the actual costs, C_t^a, experienced in year t. Thus, profit in year t, π_t, is given by

$$\pi_t = \alpha\left[C_t^p - C_t^a\right] + \gamma C_t^p . \qquad (2)$$

In order to simplify the exposition, assume that the contractor produces only one product and this product is produced for the government. [7] Then equation (2) gives the complete profit picture for the firm in year t. To obtain the present value of the firm's profit in year t, equation (2) is multiplied by the discount factor, $(1+\rho)^{-t}$, to yield

$$\left(\frac{1}{1+\rho}\right)^t\left[\alpha(C_t^p - C_t^a) + \alpha C_t^p\right] \qquad (3)$$

where ρ is the internal discount rate for the contractor. Note that this is a real (inflation-adjusted), pre-tax rate of return.

The Government

The government is treated as an amalgam of various bodies, agencies and departments. Therefore, no single objective is attributed to it and only its procedures and behavior are considered. These procedures and behavior are considered as open, to the extent that, once decisions have been made, the decisions become public knowledge. This last aspect is important in the linkages discussed below.

A primary characteristic of the government's behavior concerns the manner in which purchases are budgeted. The budget appropriation for a particular item in a given year is determined by both the desired quantity of that item for that year and historical unit costs of the item. The appropriation of funds is required each year; however, the desired total quantity to be purchased is considered fixed due to prior, external (to the model) decisions. The effect of having the budget appropriated yearly and a fixed total buy means that the yearly buys can vary in quantity. In order to facilitate the discussion, the yearly quantity purchased is also assumed to be determined by decisions outside the model. Additionally, the yearly buys are assumed to be equal in quantity. Historical unit costs are defined to be the previous year's actual expenditures for this product on a per-unit basis and, thus, have a major effect on appropriations.

The Present Value of the Contract Sequence

Since the government is looking to one firm to provide this product during its production life, the firm can anticipate a series of (usually yearly) contracts, each for the same fixed yearly quantity, until the desired total quantity of the product has been produced. Since the firm is a long-run profit maximizer, it looks ahead over an anticipated T (T>1) years of contracting. The corresponding T contracts, each yielding the yearly profits given by equation (3), combine to obtain, Π, the discounted sum of profits to the contractor of

$$\pi = \sum_{t=1}^{T}\left(\frac{1}{1+\rho}\right)^t\left[\alpha\left(C_t^p - C_t^a\right) + \gamma C_t^p\right]$$

$$= \sum_{t=1}^{T}\left(\frac{1}{1+\rho}\right)^t\left[(\alpha + \gamma)C_t^p - \alpha C_t^a\right] . \qquad (4)$$

Recall that this is a real, before-tax calculation. The firm desires to experience a sequence of contract outcomes that maximizes equation (4).

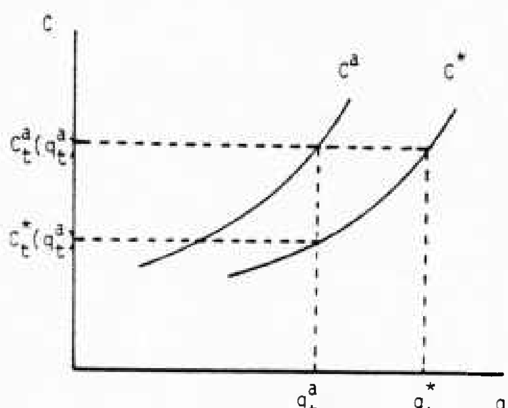
The Structure of Costs

It is hypothesized that there exists some minimum attainable cost level for the production of the desired product. This minimum attainable cost may be taken as that cost which would obtain if the market for these products were organized in a perfectly competitive fashion. Consequently, this minimum cost will be referred to as the competitive cost level.

Observed costs of programs have not usually adhered to this competitive level. Due to various factors such as a bureaucratic environment or managerial slack, costs have risen above this competitive level. The difference between competitive costs and observed costs will be called convenience costs. These convenience costs are a result of both the contractor and the government not enforcing strict cost control. The relationship between the contractor and the government is not of the classic "arms-length" variety, but is more like that of a bilateral monopoly. Therefore, government behavior can strongly influence the occurrence of convenience costs.

Actual costs, convenience costs and competitive costs are illustrated in Figure One.

FIGURE ONE
Actual Costs Versus Competitive Costs



Actual costs, C_t^a, and competitive costs, C_t^*, are, of course, dependent upon the particular quantity, q_t, or lot size of the contract. However, at all quantity levels, convenience costs are defined simply as the difference between the actual costs incurred at a particular quantity and the competitive costs of producing that same quantity. A comparison of C^a and C^* in Figure One is suggestive of another effect; the failure to achieve competitive costs implicitly requires the government to buy fewer units (q_t^a instead of q_t^*) for the same level of expenditure.

One possible reason for the observance of convenience costs is that there exists an emphasis on the technical and scientific aspects of the product to the apparent reduction of interest in the cost aspects. When this occurs, cost implications of alternative solutions to technical problems tend to be considered last, if at all. Pressure for these purely scientific or technical solutions instead of more cost-effective solutions exists on both sides of the contract.

For example, consider the set of alternatives summarized in Table One. The data portray

TABLE ONE
Alternative Technical Solutions

Option	A	B	C
Engineering/ Professional Interest Index	0.5	0.7	0.9
Probability of Success Within Schedule	0.9	0.7	0.5
Cost Index	1.0	1.1	1.2

three alternative approaches to a production modification problem. In such a setting, without active and effective management, the choice could easily be either option B or C while option A is clearly the cost-effective approach. Without an aggressive effort by both government and contractor management to keep cost considerations in a position of at least equal importance, the result is more overhead expense (direct engineering and production labor) and, finally, higher unit costs.

Methods for measuring the magnitude of convenience costs currently exist. These methods generally center around the use of should-cost studies. Such studies have usually shown that there is a nontrivial amount of expenditures which cannot reasonably be considered competitive costs. [8] The difference between contractor proposed costs and should-costs has here been termed convenience costs.

The result of these considerations is that the actual costs experienced on a contract are higher than need be experienced. Realized costs are above competitive costs as shown in Figure One. Analytically, the actual cost experience must track a path bounded from below as

$$C_t^a \geqq C_t^* \geqq 0 \ . \qquad (5)$$

The Links between Budgets and Contracts

The amount budgeted for a contract in year t, B_t, is based on the supporting documentation, testimony, perceived need, and desirability from the points of view of the acquiring agency, the President and the Congress. The budget request is based on the data of prior relevant contract experience and various analytical manipulations of such data. [9] Historical cost experience is extrapolated or projected into the anticipated costs of the contract of year t by means of econometric or engineering cost analyses. The end result is that an amount of dollars is finally appropriated. The outcome of this process can be written as

$$B_t = \beta(1 + \gamma)C_{t-1}^a \ , \qquad t=1,2, \ . \ . \ . \ . \ , T-1 \qquad (6)$$

where γ is the profit fee fraction written into the contract and β ($0 \leqq \beta \leqq 1$) is the parameter representing the proportion of the initiating agency's budget request which is actually budgeted. The parameter β will be referred to as the budget parameter.

The value of β ex post the budgeting process depends upon how strongly the government as a whole needs or desires the product. This is a combination of agency desires, Presidential interest, Congressional interest and even the overall political climate surrounding the defense budget. However, the ex ante value of β must be approximately unity. Viable contracting requires an implicit understanding between the two parties to the contract that allowable costs [10] will, if they are recurring, be covered in subsequent contracts. Thus, β, both ex ante and ex post, represents the transformation of current cost experience into subsequent contract appropriations. Alternative values of β ex post will be discussed below.

The Joining of a Contract

The "price" of a contract is the sum of the proposed-and-accepted costs plus a profit based on the proposed costs or

$$(1 + \gamma)C_t^p \ . \qquad (7)$$

The proposed-and-accepted cost figure becomes the target cost of the contract. An acceptable proposal is one such that

$$B_t \geqq (1 + \gamma)C_t^p \ . \qquad (8)$$

Since the budgeted amount is conditioned by the prior actual cost experience C_{t-1}^a and the budget parameter β, combining equations (6) and (8) yields

$$\beta C_{t-1}^a \geqq C_t^p \ , \qquad t=1,2, \ . \ . \ . \ . \ , T. \qquad (9)$$

Hence, the prior cost experience and the budget parameter combine to form an upper bound for an acceptable contract proposal.

The contractor seeks a contract that fully utilizes the available funds B_t because the higher C_t^p, the higher the base profit fee γC_t^p. Further, the higher the financial flowthrough C_t^p, the easier is internal management of this project. For example, higher manning levels permitted by a higher cost allow management to inventory staff and avoid hard personnel decisions as long as the C_t^p that exhausts the budget ($B_t = (1 + \gamma)C_t^p$) is greater than the competitive cost of performing the contract task.

The formulation of a proposal that exhausts the budget is seldom difficult. If the program is ongoing, the contractor knows C_{t-1}^a. If the program is new, the contractor either has provided some of the research and development work leading to this production contract, or has provided the relevant cost data base. [11] The ongoing two-way traffic of information between the government and contractors, their mutual dependence, contractors' access to and participation (by testimony, lobbying, etc.) in the Congressional budget process, and Congressional district interest in successfully bid and negotiated contracts all combine to ensure that contractors have an accurate perception of the funds available.

Consequently, both the profit and managerial-discretion incentives motivate firms to bid to the funds available and the funds available are typically known with considerable accuracy. This leads to the joining of a contract such that

$$\beta C_{t-1}^a = C_t^p, \qquad t=1,2, \ . \ . \ . \ . \ , T. \qquad (10)$$

For the purposes of simplicity of exposition, it will be assumed that equality holds in (10).

THE FULL MODEL AND ITS RESULTS

Given the above characterizations of the behavior of the contractor, the behavior of the government and their mutual dependence through the linkages of first, budgets that are based on prior cost experience and, second, contracts that exhaust budgets, the formal profit perspective of equation (4) can be rewritten into its operational form. Substituting equation (10), with equality holding, into equation (4) yields the operational profit perspective [12]

$$\Pi = \sum_{t=1}^{T} \left(\frac{1}{1+\rho}\right)^{t} \left[(\alpha + \gamma)\beta C_{t-1}^{a} - \alpha C_{t}^{a}\right] . \qquad (11)$$

Note that if t=1, $C_{t-1}^{a} = C_{0}^{a}$, where C_{0}^{a} is taken to be the past cost base on which the first contract year's funds are established. Then equation (11) may be rewritten as

$$\Pi = \frac{\beta(\alpha+\gamma)}{1+\rho} C_{0}^{a} - \frac{\alpha}{(1+\rho)^{T}} C_{t}^{a} + \sum_{t=1}^{T-1} \left(\frac{1}{1+\rho}\right)^{t} \left[\frac{\beta(\alpha+\gamma)}{1+\rho} - \alpha\right] C_{t}^{a} . \qquad (12)$$

The crucial role of basing future (current) budgets on current (past) cost experience can now be examined. The important point is that for all t=1,2, . . . , T-1 the actual cost experience C_{t}^{a} has the coefficient

$$\frac{\beta(\alpha+\gamma)}{1+\rho} - \alpha . \qquad (13)$$

There are two interpretations of equation (13).

The first interpretation examines each of the terms of equation (13). Whether or not the actual cost is above or below the target cost, so long as it is within the price ceiling range or any other limit placed on cost incentive payments, for every additional dollar of convenience cost experienced in year t, the contractor's profit in year t decreases by α dollars. But the additional dollar of cost in year t leads to β additional dollars occurring in the next year's funding via the budgeting process which is absorbed by the subsequent (optimal) contract cost proposal. These β additional dollars then provide $\beta\gamma$ additional dollars of profit fee in the next year and a potential incentive payment of $\beta\alpha$ dollars by removal of the convenience cost. The present value of these profits in year t are $\beta(\alpha + \gamma)/(1 + \rho)$. So equation (13) is the present value of the potential net profit from an additional dollar of convenience cost experienced in year t. [13]

The second interpretation of equation (13) revolves around its sign. If it is positive, then the net effect of experiencing cost growth via convenience costs in period t is to increase the present value of the prospective profit stream accruing to the contractor. If it is negative, then the present value of the prospective profit stream falls as convenience costs grow.

Alternative Values of the Budget Parameter

Viewing the coefficient in equation (13) arithmetically then, allows a critical value of β to be defined relative to α, γ and ρ. That is,

$$\frac{\beta(\alpha+\gamma)}{1+\rho} - \alpha \gtreqless 0$$

if and only if $\qquad (14)$

$$\beta \gtreqless \frac{\alpha(1+\rho)}{\alpha+\gamma} .$$

The critical value of β, given α, γ and ρ, is the value for which the equality in (14) holds. If the actual value of β is greater than the critical value, the coefficients of C_{1}^{a}, C_{2}^{a}, . . . , C_{T-1}^{a} in equation (12) are positive. Consequently, if the actual value of β is greater than the critical value, the budgeting and contracting processes are linked in such a fashion as to make it profitable to the contractor to experience convenience costs despite the presence of a contractually-based "cost incentive" provision.

To show that the critical value of β could easily be exceeded in actual circumstances, a few sample values of the critical value are given in Table Two for alternative values of α, γ and ρ. These sample values are reasonable from an empirical perspective [14] and result in a critical value of β well below unity for the cases shown. The table suggests that the transformation of current costs into future budgets does not have to be at all generous in order to swamp the "cost incentive" provisions and, therefore, provide a net incentive to experience

TABLE TWO
Critical Values of the Budget Parameter

α	γ	ρ	Critical β
.15	.08	.15	.75
.15	.08	.25	.81
.15	.15	.15	.58
.15	.15	.25	.63
.25	.08	.15	.87
.25	.08	.25	.95
.25	.15	.15	.72
.25	.15	.25	.78

cost growth through convenience costs.

Alternative Values of the Cost Incentive Parameter

Specification of a value for β will, through its relationships with the other parameters in equation (13), permit a determination of alternative values of the cost incentive parameter α. If the hypothesis is accepted that the ex ante value of β has to be approximately one in order for an anticipated contract to be viable, then equation (13) can be used to determine the minimum value of the share fraction α necessary to ensure that the contractor has a net incentive to incur no convenience costs. The minimum or critical value of α, given β, γ and ρ, is provided by

$$\frac{\beta(\alpha+\gamma)}{1+\rho} - \alpha \gtreqless 0$$

if and only if (15)

$$\frac{\beta\gamma}{1+\rho-\beta} \gtreqless \alpha .$$

Table Three provides a list of values of β, γ and ρ and the corresponding critical value of α. If the contract sequence forseen by the contractor has a cost sharing fraction less than the critical value, then the contractor has a positive profit incentive to experience convenience costs.

TABLE THREE
Critical Values of the Cost Sharing Parameter

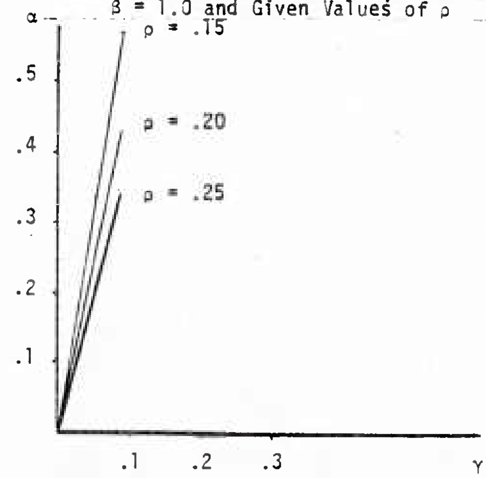
β	γ	ρ	Critical α
1.00	.08	.15	.53
1.00	.08	.25	.32
1.00	.15	.15	1.00
1.00	.15	.25	.60
.80	.08	.25	.18
.80	.08	.25	.14
.80	.15	.15	.34
.80	.15	.25	.27

Combinations of Cost and Profit Incentive Parameters

The cost-sharing ratio, α, and the profit fee ratio, γ, are the only two parameters which can be directly manipulated during the contracting process. Consequently, it is useful to specify values for the budget parameter, β, and the contractor's internal rate of return, ρ, in order to determine which combinations of α and γ yield net incentives to incur convenience costs.

First, the contracting and budgeting process may be viewed in an ex ante or planning aspect. In this case, the contractor seeks to determine his interest in participating in a sequence of contracts as given above. Therefore, the contractor focuses upon the ex ante value of the budget parameter, β, which is one. Figure Two shows combinations of α and γ which result from β = 1.0 and, alternatively, ρ = .15, .20 and .25. Note that all combinations of α and γ which occur to the right of one of the lines results in a net incentive to the contractor to incur convenience costs. Such combinations are relatively more abundant than combinations which do not result in these perverse incentives.

FIGURE TWO
Combinations of α and γ for β = 1.0 and Given Values of ρ

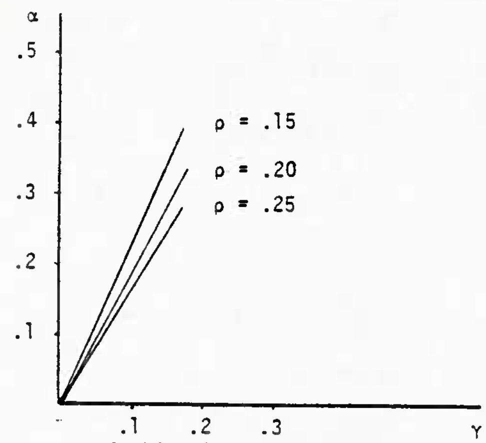


Second, this entire process may be viewed in an ex post or realized budget aspect. The contractor now seeks to determine his interest in undertaking a specific contract, given a particular budget which has evolved from the government decision-making process. Consequently, the process must be evaluated using the ex post value of the budget parameter.

Figure Three shows alternative combinations of the cost-sharing fraction and the profit fee fraction given that the budget parameter has a value of .80 and the same values of the firm's internal discount rate as were used in Figure Two. Again, all combinations which occur to the right of the lines result in perverse incentives to the contractor.

Information from Figure Two and Three may be compared to current practices. Usual observed values from the cost sharing ratio fall between 15 and 40 percent. Observed values for the incentive fee ratio usually fall between 8 and 15 percent. Locating these ranges on the figures indicates that there is a high probability that a particular contract will result in incentives for convenience costs despite the presence of a cost incentive feature in that contract or that sequence of contracts.

FIGURE THREE



Combinations of α and γ for β = .80 and Given Values of ρ

CONCLUSIONS

The model described in this paper has indicated that, by linking the contracting and budgeting processes with a model of the government-contractor relationship, some combinations of the cost-sharing fraction and the incentive fee fraction can create incentives for cost growth. Additionally, these perverse incentives can occur at easily observable values for the contractor's internal discount rate and the budget transformation parameter. This work indicates that, at currently utilized values for the incentive fee ratio, the cost-sharing ratio should be greatly increased to avoid incentives for the contractor to incur convenience costs. Although a similar recommendation has been made earlier in the incentive contracting literature, the present model offers a quantitative evaluation of just how much the cost sharing ratio should be increased.

Necessary extensions of the model should be obvious to the reader. To obtain a more realistic model of the entire process, the model should be expanded to include changing lot sizes over the production period, examination of the effects of a probabilistic interpretation of the budget parameter and the competitive cost level, and the ramifications of progress payments for the model predictions. Additionally, the authors are currently attempting to obtain data in order to empirically test this simple version of the model.

NOTES

[1] See reference [20] and [21] for a series of initiatives for improving the acquisition process.

[2] For example, see [1], [2], [5], [6], [10], [15], [16], [17] and [18] as a partial sample of a lengthy list of references that could be cited.

[3] For a qualitative evaluation of one of the links in this process, see Bryan and Clark [4].

[4] For a formulation of the entire problem addressed in this paper which also includes performance incentives, see reference [3].

[5] Price ceilings will be dealt with implicitly below. Although most contracts are written with a different sharing ratio for cost savings versus cost overruns ("above" versus "below" the line), the analysis below holds for either case.

[6] See [11] and the references therein, for example.

[7] This enables the model to avoid dealing with cross-subsidization between government and private sector contracts. A multiple-product technology for the firm is necessary for analysis of cross-subsidization.

[8] See Fox [8], pp. 333-347 and, especially, Table XVII-1, p. 336.

[9] These are called "end costs" in the terminology of Bryan and Clark [4], p. 112.

[10] That is, those costs which are not challenged and shown to be unreasonably high, i.e., those that pass an audit screen.

[11] See Peck and Scherer [13], p. 241 or Fox [8], p. 101 for confirmations of this process.

[12] A proof of convexity of the objective function as well as an exposition of the (necessary and sufficient) Kuhn-Tucker conditions for an optimum are contained in reference [3].

[13] Because of the assumption of a fixed, equal quantity being purchased each year, the contractor will not realize any of these profits accruing from convenience costs until the last year of the contract sequence. This behavior is forced upon the contractor because of the manner in which budgets are determined.

[14] A reasonable range for the firm's internal discount rate is 15-25 percent, for the cost sharing fraction is 15-40 percent and for the incentive fee is 8-15 percent.

These are ranges which one would expect to encounter in practice.

REFERENCES

[1] Baron, D. P., "Incentive Contracts and Competitive Bidding," American Economic Review, Volume 62, June 1972, 384-394.

[2] Berhold, M. A., "Linear Profit-sharing Incentives," Quarterly Journal of Economics, Volume 85, August 1971, 460-482.

[3] Boger, D. C.; Jones, C. R.; and Sontheimer, K. C., "An Analysis of the Budgeting/Contracting Linkage and Contract Incentives," Working Paper, May 1981, Department of Administrative Sciences, Naval Postgraduate School, Monterey, CA.

[4] Bryan, N. S. and Clark, R., "Is Cost Growth Being Reinforced?," Concepts, Volume 4, Spring 1981, 105-118.

[5] Cross, J. G., "A Reappraisal of Cost Incentives in Defense Contracts," Western Economic Journal, Volume 6, June 1968, 205-225.

[6] Cummins, J. M., "Incentive Contracting for National Defense: A Problem of Optimal Risk Sharing," The Bell Journal of Economics, Volume 8, Spring 1977, 168-185.

[7] Fisher, I. N., "An Evaluation of Incentive Contracting Experience," Naval Research Logistics Quarterly, Volume 16, March 1969, 63-83.

[8] Fox, J. R., Arming America: How the U.S. Buys Weapons, Cambridge: Harvard University Press, 1974.

[9] Gansler, J. S., The Defense Industry, Cambridge: The MIT Press, 1980.

[10] Harris, M. and Raviv, A., "Some Results on Incentive Contracts," The American Economic Review, Volume 68, March 1968, 20-30.

[11] Leland, H. E., "Alternative Long-run Goals and the Theory of the Firm: Why Profit Maximization May be a Better Assumption than You Think," in P. T. Liu, Dynamic Optimization and Mathematical Economics, New York: Plenum Press, 1980.

[12] Moore, F. T., "Incentive Contracts," in S. Enke (ed.), Defense Economics, Englewood Cliffs: Prentice-Hall, 1967.

[13] Peck, M. J., and Scherer, F. M., The Weapons Acquisition Process: An Economic Analysis, Cambridge: Harvard University Press, 1962.

[14] Scherer, F. M., The Weapons Acquisition Process: Economic Incentives, Cambridge: Harvard University Press, 1964.

[15] Scherer, F. M., "The Theory of Contractual Incentives for Cost Reduction," Quarterly Journal of Economics, Volume 78, May 1964, 257-280.

[16] Shavell, S., "Risk Sharing and Incentives in the Principal and Agent Relationship," The Bell Journal of Economics, Volume 10, Spring 1979, 55-73.

[17] Weiner, N. S., "Multiple Incentive Fee Maximization: An Economic Model," Quarterly Journal of Economics, Volume 77, November 1963, 603-616.

[18] Weitzmann, M. L., "Efficient Incentive Contracts," Quarterly Journal of Economics, Volume 94, June 1980, 719-730.

[19] Williamson, O. E., "The Economics of Defense Contracting: Incentives and Performance," in R. N. McKean (ed.), Issues in Defense Economics, New York: Columbia University Press, 1967.

[20] U.S. Department of Defense, Office of the Secretary of Defense Memorandum: "Improving the Acquisition Process," April 30, 1981.

[21] U.S. Department of Defense, Office of the Secretary of Defense Memorandum: "Increasing Competition in the Acquisition Process," July 27, 1981.

SIMULATION MODELING: BRIDGING THE GAP BETWEEN ACQUISITION RESEARCH AND EXPERIENCE

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ABSTRACT

This paper addresses simulation studies in the area of "Government-Industry Interaction." The primary focus of this paper centers around the recent dissertation completed by the author at The Florida State University entitled Design and Analysis of a Simulation Model of the Resource-Acquisition Process for Government Contractors (3). In addition, this paper includes a brief summary of some follow-on acquisition-related research being conducted by faculty and graduate students in the School of Systems and Logistics, Air Force Institute of Technology (AFIT), emphasizing the utility of simulation modeling (i.e., System Dynamics) as a sound research methodology for use in real-world acquisition environments.

BACKGROUND

Present growth trends for the United States aerospace industry in terms of total sales, military aircraft, missiles, space, and commercial transports support a very steep growth forecast for aerospace sales for the next three years (13). A long range strategy of many United States business firms has been one of seeking government contracts to help attain corporate growth objectives.

Uncertainty permeates the entire government weapons acquisition process. Government contractors must often simultaneously contend with varying degrees of uncertainty among different major programs. In the uncertain procurement environment, government contractors must make timely resource acquisition decisions to establish and maintain sufficient production capacity and professional capability to optimize the firm's long range growth objectives.

RELEVANT ACQUISITION RESEARCH

To develop the strategic policy structure for a government contractor, several research studies conducted at the Air Force Institute of Technology (AFIT) were utilized to establish the initial policy structure for the system under study. Elder and Nixon (8) addressed the research and development activity of a government buying activity (i.e., the Aeronautical Systems Division of the United States Air Force Systems Command). Lawson and Osterhus (17) developed a conceptual model of the Department of Defense (DOD) acquisition process for major weapon systems. Kaffenberger and Martin (16) converted Lawson and Osterhus' conceptual model into a System Dynamics model representation of the overall DOD acquisition system. In addition to these three major Air Force studies, the government-industry relationship has been analyzed from several different perspectives (1;12;18;25). The author's research concentrated not only on the overall government-industry relationship but also on the internal strategic policy structure of a single government aerospace contractor in satisfying the needs of the government marketplace.

Several computer simulation models were used in the author's research to obtain a preliminary theoretical framework for a model of the strategic policy structure of a government contractor. This simulation approach to studying complex organizational problems has been proven effective by several authors (4;7;14;19;20). Two major contributors to the field of knowledge related to modeling business firms include Cyert and March (6) and Bonini (2). These early pioneering studies in business simulation led to many follow-on modeling studies that capture the strategic policy structures of firms in a model framework.

The System Dynamics methodology has been used successfully by several researchers to study various organization-related problems. The pioneer in developing System Dynamics as a methodology for studying organizations is Jay Forrester (9). Forrester led the way for the subsequent increase in application of the System Dynamics methodology to many different types of problems experienced by all kinds of organizations. Pugh-Roberts Associates, Inc. (5) is a consulting firm that develops System Dynamics models for strategic policy analysis of organizations. Hall (15) studied the system pathology of one organization using the System Dynamics approach. Goodman (11), in his Study Notes in System Dynamics, presents several examples of the application of System Dynamics to some complex structures. Two examples of special importance to this paper are Meadows' analysis of the commodity production cycle and Patni's analysis of a market growth model (11).

Another major System Dynamics modeling work was conducted by Nord (22), in which the author related capacity-acquisition policies of a firm to the growth of a product in its marketplace. The two major System Dynamics studies that provided much of the preliminary model structure baseline for the research described in this paper were Roberts' (24) study on research and development and Packer's (23) model of the resource-acquisition process for manufacturing firms.

Packer's Resource Acquisition In Corporate Growth. Packer (23) indicated that two resources--production capacity and professional effort--are integral to all manufacturing firms. At the macro-level, Packer examined the interactions between the firm and the market (Figure 1). The firm generates two factors that affect the market--professional activities and product availability. Professional activities create potential customers for the firm, and product availability impacts potential customers through a delay in delivery. As delivery delay increases, more potential buyers tend to turn to alternative sources of supply. So, the order flow to the firm depends on both the firm's professional activities and the availability of products.

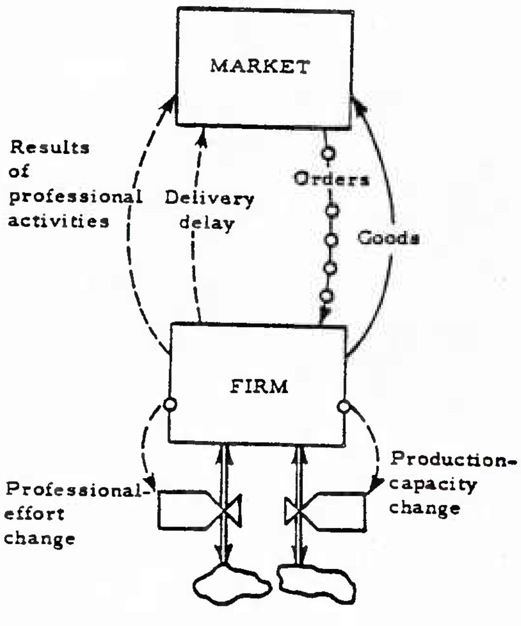

Fig. 1. Market/firm interactions

Packer's Resource Acquisition In Corporate Growth model (23) was utilized as the primary baseline for the development of the contractor model of resource acquisition in support of the government market for major weapon system programs. Packer's model addresses the interactions between a hypothetical manufacturing firm and its market and describes two key policy decision areas (i.e., production capacity and professional effort).

Roberts' Dynamics of Research and Development. Packer's model (23) omits a critical sector of activity that is essential for aerospace contractors to succeed in the government marketplace. Specifically, Packer's model fails to address the research and development sector of activity that characterizes a major portion of government aerospace contractors' operations.

Roberts (24) provides a general theory of research and development utilizing a System Dynamics approach. Roberts emphasizes research and development for military and space purposes, but Roberts also concludes that the approach should be universally applicable to all research and development endeavors. Roberts developed a mathematical model that captured the essence of research and development project life cycles. Roberts utilized the System Dynamics approach to calculate research and development project time histories for stated input conditions. The model equations were developed to describe the relationships that control a typical research and development project. Roberts' (24) study was not focused on any one company. The major emphasis was on broad policy implications for company and government research and development strategic policy structures.

SYSTEM DYNAMICS

One proven analytical methodology for assessing the effects of alternative strategic policies in both hypothetical and real-world organizations is System Dynamics. System Dynamics is an experimental approach to understanding system behavior (9). The most important foundation for System Dynamics is servo-mechanisms (or information-feedback systems). Information-feedback systems underlie the structure for integrating the different facets or sectors of management activity. Forrester (9) defines an information-feedback system as follows:

> An information-feedback system exists whenever the environment leads to a decision that results in action which affects the environment and thereby influences future decisions.

System Dynamics focuses on policy structures and how policy determines behavior. Forrester (10) describes System Dynamics as "a practical profession that starts with important problems, comes to understand the structures that produce undesirable symptoms, and moves on to finding changes in structure and policy that will make a system better behaved." The System Dynamics methodology permits dynamic analysis in evaluating the effects of alternative strategic policies before implementing the policies within an organization.

PURPOSE OF RESEARCH

The government procurement environment is fraught with much uncertainty and a general scarcity of resources that often hamper the planning and operations of government contractors. A System Dynamics study of the government procurement process was conducted to extend theory about strategic policy analysis by government aerospace contractors. The outcome from the research was a framework from which strategic planning guidelines may be derived for use by government aerospace contractors to help attain growth objectives which are congruent with the goals of government buying activities. Government buying activities should also benefit from implementation of the broad guidelines, because the availability of sources of supply for government products should be more firmly established and improved. In addition, the System Dynamics modeling approach could enable both government contractors and buying activities to evaluate the effects of increases or decreases in projected order quantities for major weapon systems.

Specifically, the following questions provided purpose and direction for the author's research effort:

1. What is the strategic policy structure that captures and reflects the behavior of the resource acquisition decision-making process by government aerospace contractors?

2. What are the key effects (or impacts) on the system from the strategic policy alternatives in the resource acquisition decision-making process of a government aerospace contractor?

GENERAL RESEARCH PLAN

The general research plan concentrated on those macro-level issues that government contractors must contend with in the resource-acquisition process in support of government contracts. Strategic planning and decision making were addressed in the author's study. The overall research approach consisted of a macro-level of analysis that utilized the System Dynamics methodology to address aerospace contractors' resource acquisition policy-making activities.

The general research plan for this study was implemented in two phases (See Figure 2): field study research phase (Phase I) and modeling and experimentation phase (Phase II). The aforementioned two research questions were formulated to serve as the overall guide for channeling the author's research project. In response to the two research questions, the research design for the study was structured utilizing the following seven steps to ascertain the strategic policy structure of government aerospace contractors, to produce a policy model of a government contractor's resource-acquisition process, and to evaluate key effects from strategic policy alternatives:

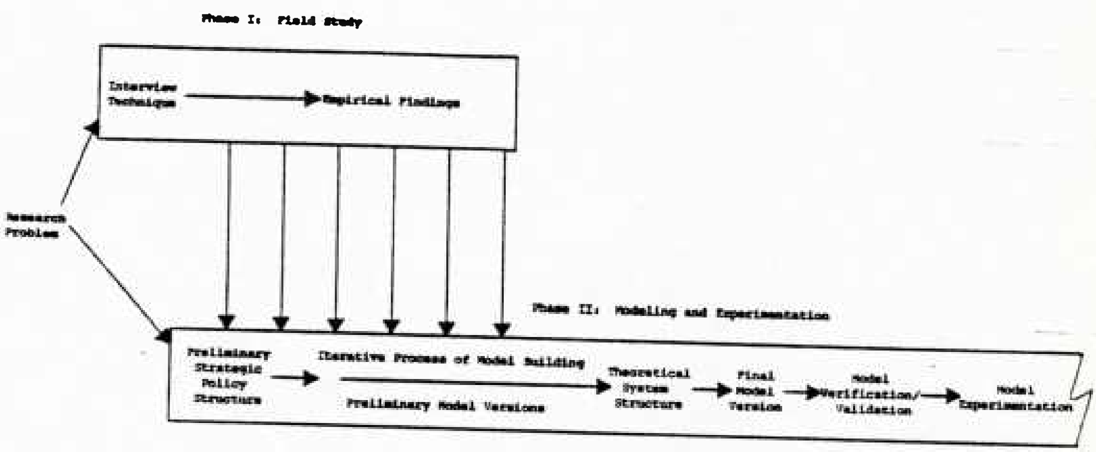

Fig. 2. The Research Flow Process

1. Describe the general system under study by determining boundaries and basic interrelationships between the major system sectors;

2. Develop casual loop diagrams for each system sector in order to show the interaction of system variables;

3. Convert the causal loop diagrams into detailed flow diagrams to show how money, material, and information move throughout the system and decisions are made to regulate the flows;

4. Develop and verify mathematical equations which represent the flow diagram concepts using the DYNAMO simulation language;

5. Validate the model concept to ensure reasonable and logical representation of the real-world system structure;

6. Analyze the system to identify areas sensitive to change and possible system deficiencies; and

7. Recommend changes to the system to improve the structure of information flow and identify areas requiring further study.

In phase I of the author's research, the extensive field study was conducted to gain a better overall understanding of productive systems (i.e., aerospace contractors) that operate within the government procurement environment. The corporate strategic planning process in major manufacturing firms in the aerospace industry was analyzed to determine key policy variables and decisions required for resource acquisition to support government programs. One major aerospace contractor was selected to represent the aerospace industry in the author's research. In the field study, fifty key contractor personnel were interviewed to gain a better understanding of the strategic policy structure of the system under study. The results from the field study research phase were utilized as a foundation for the modeling and experimentation phase.

The modeling and experimentation phase of the research was based on the strategic policy structure that became the output of the field study. The modeling and experimentation phase (Phase II) was used to gain greater understanding of the strategic policy structure of the system under study and to develop a model in which the effects of alternative resource-acquisition policies could be evaluated. Packer's model (23) and Roberts' model (24) served as the initial foundation for representing the strategic policy structure of a government aerospace contractor with respect to the resource acquisition decision-making process. An iterative process of model building was used to obtain an acceptable representation of the system under study. Because of the complex and dynamic nature of the government marketplace, simulation was selected as the appropriate analytical approach for the research. The System Dynamics approach addresses complex structures in a systematic manner using a computer-based simulation language (DYNAMO). In addition, the System Dynamics approach permitted experimental determination of ideas for policy improvements and experimental testing of proposed policy changes within the corporate strategic planning process.

Mode (21) states that System Dynamics provides the manager with a tool that can be used for planning and analysis to gain insight into the cause-and-effect factors that exist within a firm and between a firm and its external environment.

CONTRACTOR MODEL STRUCTURE

The overall model structure for representing the system under study was developed in Phase II (modeling and experimentation phase) of the author's research. The macro structure of the contractor model (See Figure 3) depicts the key sectors of activity included in the model, the nine intersector feedback loops that connect the model sectors, the origins and destinations of critical information that support the firm's decision-making process, and the management response mechanism that reacts to pressures for expanding or contracting operations within the firm. The primary roles and functional operations of each sector within the contractor model are summarized in the following paragraphs.

The market sector generates R&D and production orders to the firm based on the negative market effects created by delays of the firm and positive market effects caused by the firm's professional capability.

The financial sector makes a comparison between the funding available and the funding required (i.e., as determined by the estimated work effort for the next period) for both R&D and production and provides information to the pressure-for-expansion sector when funding levels are too low or too high.

The design (engineering) sector produces the engineering designs that influence the start of work for both the production (manufacturing) sector and the material sector. Without completed engineering designs, hardware cannot be produced internally by the firm or externally by second-tier suppliers of material, parts, and components. Information related to the R&D backlog, engineering design completions, and engineering design changes flows to the pressure-for-expansion sector for appropriate management decisions to expand or contract operations as required.

The production (manufacturing) sector manufactures and assembles the end products that are delivered by the firm to the marketplace. The market relationship between the production (manufacturing) sector and the material sector for material, parts, and components is similar to that market relationship between the government buying activity and the system under study for the final end products. Orders are placed from the production (manufacturing) sector to the material sector for material, parts, and components. The ordered material, parts, and components are shipped from the suppliers within the material sector to the production (manufacturing) sector for incorporation within the final end products. Information related to the production backlog, production finishes, and work-in-process inventory of material, parts, and components maintained within the government aerospace contractor to support the final assembly line influences management's decisions to expand or contract the firm's operations when necessary.

The material sector represents the suppliers that produce material, parts, and components in response to orders from the production (manufacturing) sector as described above.

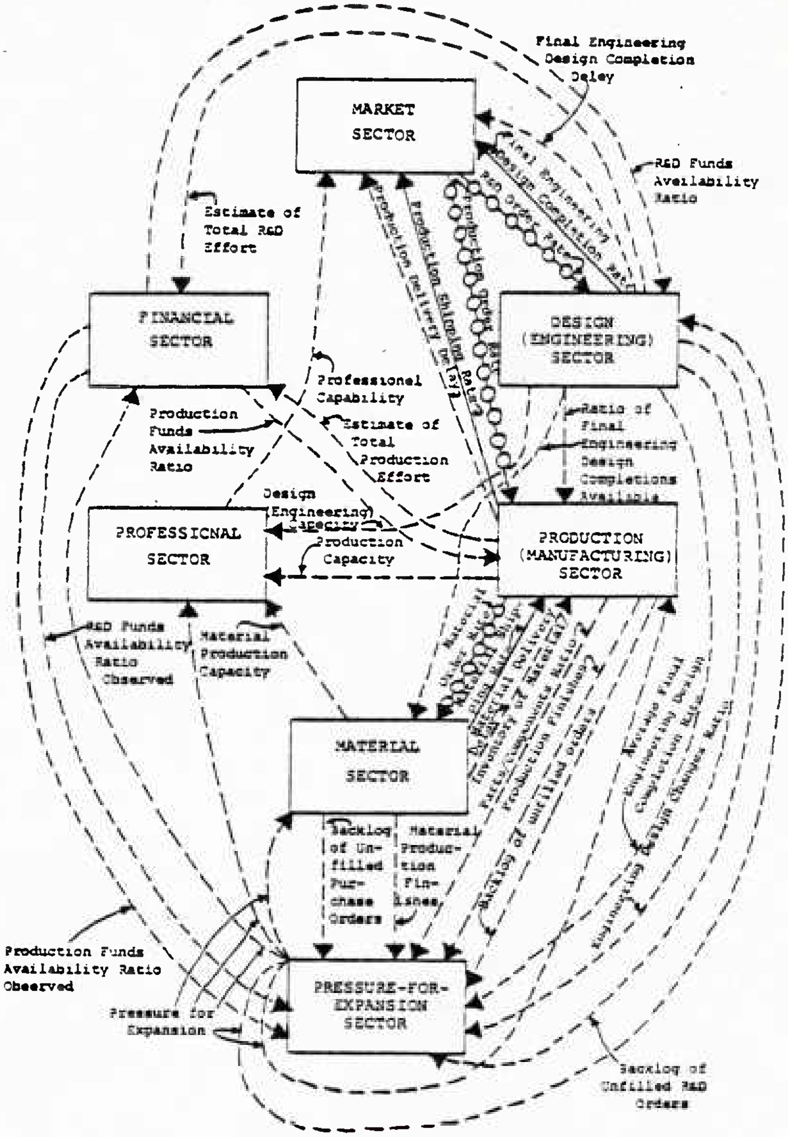

Fig. 3. Macro-level diagram of contractor model--final model version (all nine feedback loops)

The information that influences management's decisions to expand or contract operation levels within the firm includes the backlog of unfilled purchase orders and material production finishes.

The professional sector controls the acquisition of professionals for the firm and the departure of professionals from the firm. Capacity status information flows from the design (engineering) sector, production (manufacturing) sector, and material sector to the professional sector for ascertaining the desired level of professional effort within the firm. Within the professional sector, management's desired ratios of professionals to the three different capacities within the system under study--design (engineering) capacity, production capacity, and material production capacity--determine the level of professionals within the firm. Professional capability represents the level of professional effort that is available within the firm to influence the marketplace and to affect future R&D and production orders to the firm.

The pressure-for-expansion sector receives information that influences the firm's management decision-making process from the other model sectors. The pressure-for-expansion sector serves as the management response mechanism that generates pressures for expanding or contracting the levels of key resources within the firm--professional effort, design (engineering) capacity, production capacity, material production capacity, and R&D and production funding levels--based on the information received from other sectors within the model.

Comparison With Actual Past System Performance

In the author's research project, the specific system under study was a government products division of a major corporation specialized in the development and production of major weapon systems in satisfying the needs of the government marketplace. The strategic policy structure of the government contractor, as captured in the System Dynamics model, was not the result of a momentary situation, but, instead, reflected a long-term perspective of the firm's strategic policy structure established over a period of some twenty to thirty years.

The government contractor model, in its present form, re-creates this historical perspective of the firm's strategic policy structure. This re-creation of the firm (i.e., the system under study) is demonstrated by comparing the actual past system performance with the simulated model output over time. The system under study has historically been a project-oriented (or single product-oriented) firm. Figure 4 depicts the single-product orientation of the

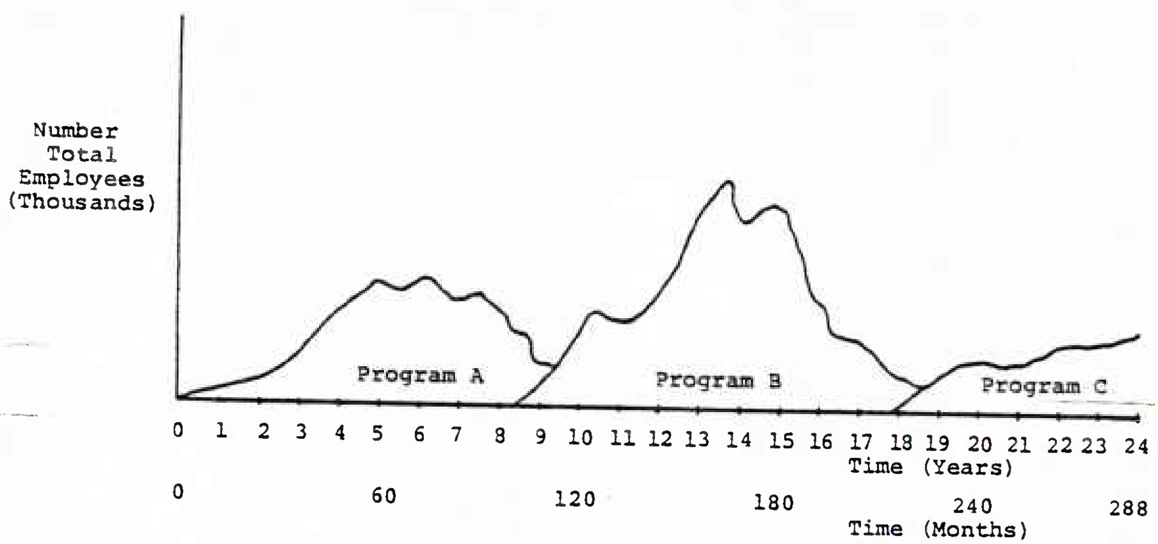

Fig. 4. Total Employment Profile For System Under Study

government contractor in terms of the total number of employees in the firm as associated with three different major weapon system programs--Programs A, B, and C. The manpower levels in the firm were associated with the workload requirements for the respective programs. For example, the peak work requirement (e.g., number of units ordered per period) for Program B occurred during year 14 (Figure 4). To support the peak work requirement (i.e., the higher order rate), the employment within the system was increased to support period of maximum workload. After year 14, the employment level in the firm was reduced because of a reduced order rate to the firm. These same system relationships between employment level and workload were captured in the strategic policy structure of the government contractor model.

The simulated model output does illustrate the above system relationships between employment level and workload. In general, the model structure adequately captures the strategic policy structure of the firm over the period from years 1 to 24 as shown in Figure 4. The simulated model output generally reflects the shapes of Programs A, B, and C. Programs A and B are completed, and Program C is still in its infancy stage as compared to the projected life of that particular major weapon system program. Therefore, as noted previously, model structure was based mainly on experience from Programs A and B rather than C. During the field study, the fifty respondents continually referred to "what happened" in Programs A and B when describing the present strategic policy structure of the firm.

The particular variable in the government contractor model that was selected to represent the program-oriented manpower level in the firm was production capacity. Production capacity is an aggregate measure of the internal productive capability of the firm of which a key component is the direct factory labor associated with manufacturing deliverable end items to the government marketplace. To represent the system's strategic policy structure, the production capacity should re-create the general shape of the historical employment level curve within the firm over time. Figure 5 is the actual simulation run plot for production capacity (C) obtained from the System Dynamics model. As shown in Figure 5, the general shape of the production capacity curve corresponds with the employment level curve depicted in Figure 4. So, on the surface, the contractor model appears to represent system performance characteristics over time.

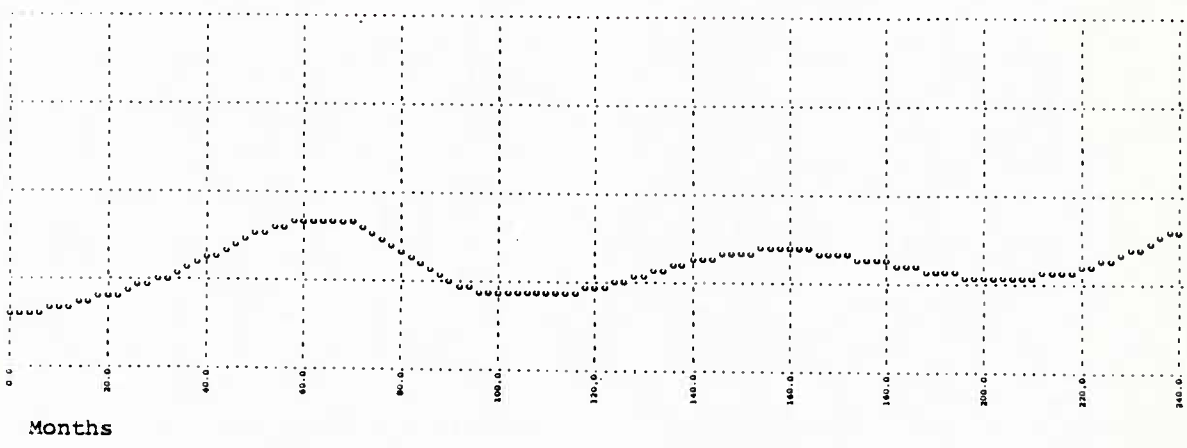

Fig. 5. Employment versus workload-simulated model output for production capacity (C)

The weapons acquisition process may be viewed as a workload measure over time for a single program with design (engineering) effort preceding the receipt of production orders by a government contractor from the government buying activity. As a result, the employment level to support these two categories of work effort--design (engineering) and production (manufacturing)--should correspond to the timing of the different varieties of work. To make an assessment of the proper timing of workload characteristics for a government contractor, the design (engineering) capacity (D) was compared with the production capacity (C) in the firm. The design (engineering) capacity is measured by the number of design engineers within the firm. If the model is a reasonable representation of system characteristics, one would expect a program-oriented design (engineering) capacity level to precede the program-related production capacity measure of work effort. This relationship between design (engineering) capacity (D) and production capacity (C) in the contractor model is depicted in Figure 6. In this graph, the design (engineering) capacity precedes the production capacity within the firm for each of the three programs--Programs A, B, and C. This explainable model relationship between design (engineering) capacity and production capacity lends further credence to the representativeness of the model.

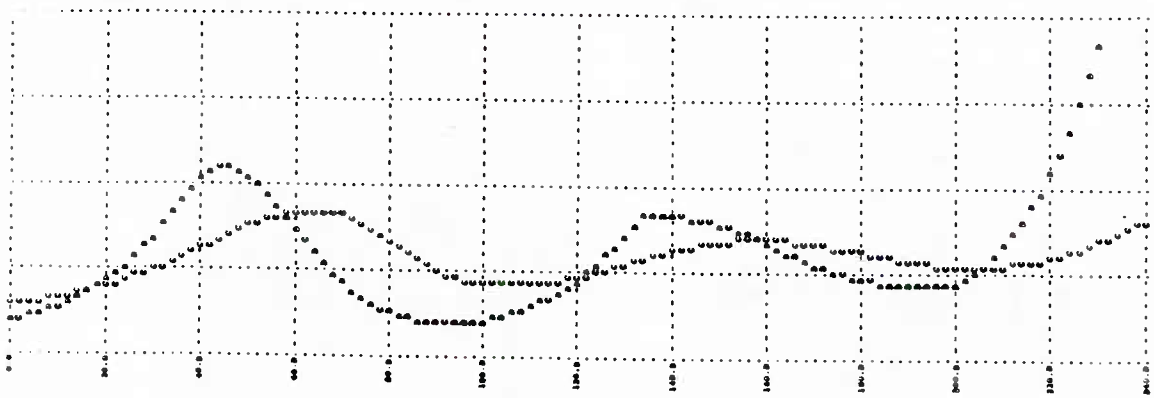

Fig. 6. Workload phasing for design (engineering) capacity (D) and production capacity (C)

STRATEGIC POLICY ANALYSIS

The contractor model developed in this study utilizes a systems approach to the strategic planning and policy formulation activity of government aerospace contractors. The System Dynamics model was developed to capture the essence of the strategic policy structure of a government aerospace contractor and provide a policy-formulation model in which alternative strategic policies of the firm can be evaluated for the effects on the overall objectives of the firm (e.g., growth and stability). Preliminary strategic policy analysis using the contractor model indicated that an aggressive expansion policy allows higher growth at the expense of increased instability. On the other hand, a conservative expansion policy provides a lower growth rate with more stability.

CURRENT AFIT RESEARCH

The use of the System Dynamics technique for analyzing the complex problems related to the government procurement process has been relatively limited to date. As demonstrated in the author's research, the strategic planning and policy formulation process for the acquisition of key resources by government contractors is just one area in which the System Dynamics technique has proven its utility. Much is yet to be learned about the strategic planning and policy formulation process of government contractors and the utility of the System Dynamics approach for analyzing the complex government procurement process in general. With the recent increase in government funding for major weapon system programs, the opportunities for additional meaningful research on the strategic planning process of government contractors will be enhanced.

Faculty Research

In the author's study, preliminary model verification was conducted with the government aerospace contractor model to establish confidence in the model structure. To increase the utility of the model for further usage by management, the author is conducting additional research work with the original aerospace contractor to validate the model concept to ensure a reasonable and logical representation of the real-world system structure. A fully-validated model will increase the "predictive" ability of the government aerospace contractor model, which was not specifically addressed in the author's earlier research.

The alternative strategic policies investigated in the author's original study concentrated on the effects (or impacts) of parameter changes in the original system on overall system performance. Future research studies will address revised strategic policies in applying revised model structures to future major weapon system programs. To provide the government contractor with decision rules capable of creating stable growth expansion at the highest rate feasible, growth rate and stability are being used as criteria to evaluate improvements in the system.

Graduate Student Research

Several graduate students, as part of their master's thesis effort at the Air Force Institute of Technology, are using the System Dynamics modeling approach to address acquisition-related topics.

One thesis team is presently developing a strategic policy model of the overall DOD acquisition system. The primary objective of this thesis effort is to provide a macro policy model of the DOD acquisition system that can be used by DOD acquisition managers and analysts to evaluate the effects of policy changes on the overall DOD system. The researchers are dividing the macro-level system into four primary sectors: Research and Development (R&D), Production, Financial, and Capability.

A second thesis team is conducting an analysis of the predicted benefits of multi-year procurement. There is an absence of empirical data on contractor and cost performance under multi-year contracts. The research project includes the construction of a System Dynamics model of an aerospace contractor to evaluate the anticipated benefits of multi-year procurement. The researchers plan to use their System Dynamics model to demonstrate the impact of multi-year procurement on a contractor's industrial plant modernization, advanced Economic Order Quantity (EOQ) buys, production costs, work force stability, and surge capability.

IMPLICATIONS AND CHALLENGES

After conducting research on the strategic policy structure of major government aerospace contractors, the author concludes that the research design employed in this study of strategic planning has merit for three primary reasons. First, the research design facilitated the tackling of a difficult area of research (i.e., strategic policy structures of organizations) within a very complex organizational setting (i.e., a major government aerospace contractor). Second, the two-phase nature of the research design allowed a structured approach for collecting empirical data in the field study (Phase I) that served as the foundation for Phase II of the research design (modeling and experimentation). In addition, the iterative nature of model building provided feedback from system participants on the representativeness of the model structure. Finally, the two-phase research design produced a contractor model that will meet the immediate strategic planning needs of one major government aerospace contractor and serve as a basis for future research. In the author's study, the two-phase research design facilitated the overall accomplishment of stated research objectives.

While much has been written on the need for government contractors to strategically plan for the successful development and production of major weapon systems to prevent schedule delinquencies, technical problems, and cost overruns, very little research is found in the area of long-range strategic planning and policy formulation for these government contractors. Much of the research is near-term oriented (i.e., the contractor's performance for the next fiscal year). A more systematized strategic planning and policy formulation approach by government contractors will benefit government contractors immediately and, in the long run, benefit the United States taxpayers who pay for the procurement of the major weapon systems. Since there are areas needing additional investigation, it is hoped that this study will serve as a catalyst for further examinations of the strategic planning and policy formulation process of government contractors.

BIBLIOGRAPHY

1. Bickner, Robert E. The changing relationship between the Air Force and the aerospace industry. Santa Monica, Calif.: The RAND Corporation, July 1964.

2. Bonini, C. P. Simulation of information and decision systems in the firm. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1963.

3. Brechtel, Donald L. Design and Analysis of a Simulation Model of the Resource Acquisition Process For Government Contractors. D.B.A. dissertation, The Florida State University, 1981.

4. Clark, Thomas D., Jr. A study and simulation model of decisional and informational structures in public-sector management at the state-government level. D.B.A. dissertation, The Florida State University, 1977.

5. Cooper, Kenneth G. Naval ship production: a claim settled and a framework built. Interfaces, December 1980, 10(6), 20-36.

6. Cyert, Richard M., & March, James G. A behavioral theory of the firm. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1963.

7. Dutton, John, and Briggs, Warren G. Simulation model construction. In John M. Dutton and William Starbuck (Eds.), Simulation of Human Behavior. New York: John Wiley & Sons, Inc., 1971.

8. Elder, Major Jerry L., USAF, & Nixon, Squadron Leader Michael B., RAAF. The application of system dynamics to a managerial model of aeronautical systems division. Unpublished master's thesis. LSSR 22-78A, AFIT/LS, Wright-Patterson Air Force Base, Ohio, 1978.

9. Forrester, Jay W. Industrial dynamics. Cambridge, Mass.: The M.I.T. Press, 1961.

10. Forrester, Jay W. System dynamics--future opportunities. TIMS Studies in the Management Sciences, 1980, 14, 7-21.

11. Goodman, Michael R. Study notes in system dynamics. Cambridge, Mass.: Wright-Allen Press, Inc., 1974.

12. Gorgol, John Francis. The military--industrial firm: a practical theory and model. New York: Praeger Publishers, Inc., 1972.

13. Growth trends: U.S. aerospace industry. Aviation Week & Space Technology, March 1981, 114(10), 16-17.

14. Guetzkow, Harold, Kotler, Philip, & Schultz, Randall L. Simulation in social and administrative science. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1972.

15. Hall, Roger I. A system pathology of an organization: the rise and fall of the old Saturday Evening Post. Administrative Science Quarterly, June 1976, 21, 185-211.

16. Kaffenberger, Susan A., & Martin, Captain David P., USAF. A dynamic policy model of the Department of Defense systems acquisition process. Unpublished master's thesis. LSSR 1-79A, AFIT/SL, Wright-Patterson Air Force Base, Ohio, 1979.

17. Lawson, Diann, & Osterhus, Captain Damond L., USAF A conceptual model of the Department of Defense systems acquisition process. Unpublished master's thesis. LSSR 20-78A, AFIT/SL, Wright-Patterson Air Force Base, Ohio, 1978.

18. Logistics Management Institute. DOD-contractor relationship--preliminary review, task 69-21. Washington, DC: Logistics Management Institute, March 1970.

19. Martin, F. F. Computer modeling and simulation. New York: John Wiley & Sons, Inc., 1968.

20. McLeod, John (Ed.). Simulation: the dynamic modeling of ideas and systems with computers. New York: McGraw-Hill Book Company, 1968.

21. Mode, V. Alan. System dynamics: a tool for management. Academy of Management Review, May 1980, pp. 18-22.

22. Nord, Ole C. Growth of a new product: effects of capacity-acquisition policies. Cambridge, Mass.: The M.I.T. Press, 1963.

23. Packer, David W. Resource acquisition in corporate growth. Cambridge, Mass.: The M.I.T. Press, 1964.

24. Roberts, Edward B. The dynamics of research and development. New York: Harper and Row, 1964.

25. Runkle, Captain Jack R., USAF, & Schmidt, Captain Gerald D., USAF. An analysis of government/contractor interaction as a motivator of contractor performance. Unpublished master's thesis. SLSR 19-75B, AFIT/SL, Wright-Patterson Air Force Base, Ohio, 1975.

LEVERAGE ANALYSIS: THE LINK BETWEEN CONTRACT PLANNING AND CONTRACTOR BEHAVIOR

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INTRODUCTION

In the private sector, the manufacturer, wholesaler, retailer, and other "middlemen" make up a marketing channel intended to get a product to a consumer. This is obviously a coordinated interdependent effort, but experience has shown that each party has its own objectives, and there may be considerable conflict among the parties (including the consumer) in the operation of the channel. This conflict is caused by fact that each party in acting to satisfy its own objectives tends to thwart the accomplishment of the objectives of another party. For example, a wholesaler may be in a dominant position over a manufacturer because there are so many similar products from competing manufacturers and demand a sharp discount in price from the manufacturer. This action will help the wholesaler meet his (or her) profit objective, but jeopardize the manufacturer's profit picture and may lay the groundwork for some future retaliation.

Because of this "natural" behavior in our entrepeneurial culture, each party may tend to try to gain control over some part of or the whole channels to ensure its objectives are accomplished. A manufacturer may differentiate his or her product favorably above others; the wholesaler may offer unique services; the retailer may gain access to a large number of consumers. In effect, each party will try to gain some kind of power, the primary basis for control, for longer term assurance of dominance in the channel.

This goal-seeking-conflict-control-power-seeking behavioral phenomenon is common in industry and is well-discussed in marketing literature (See Stern and El-Ansary, 1977). This behavior is similar to that seen in the Department of Defense (DOD) - defense contractor relationship. This paper will examine this DOD - contractor relationship and concepts of conflict and control in that relationship. The paper will emphasize the purchase of a weapon system (system acquisition) where the phenomenon is most pronounced, although the same kind of behavior is present in varying degrees in all purchases.

Leadership in the DOD-Industry Relationship

DOD has its own marketing channels. Typically the channel is simple and direct - from the firm to the particular service (Figure 1). There are variations however. A broker or other intermediate may be involved.

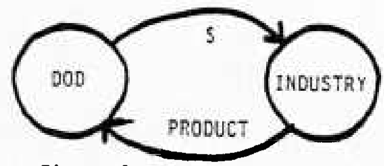

Figure 1 DOD-Industry Channel

DOD may buy parts from a number of firms for assembly into a finished product by itself (an arsenal) or another firm. To make the points of the paper only the simple channel will be pursued.

DOD as a sole consumer (in economic terms, a monopsony) must obtain its good and services from a private firm or firms. In these channels again both parties are trying to get the product to the DOD consumer, but both have their own objectives. When both sets of objectives are accomplished, the relationship is likely to have no problems. When the objectives of one or both parties are thwarted, the result is often conflict, the so-called adversarial relationship.

The reaction to non-accomplishment of objectives and to conflict in this relationshio is the same as in the private sector - the quest for control. A DOD examole is elaborate systems to monitor costs and performance. A contractor example is the attempt to become a sole source or to manage part of a develoo-ment program (e.g., configuration manager).

Obviously a high degree of conflict in any channel is inefficient and can threaten performance. To avoid such dysfunctional behavior channel leadership may be necessary. That is, one of the organizations may have to act to maintain the channel.

The public is generally imoartial (ceteris parabis) as to which party in the private sector gains control in a given channel. In our capitalist society hooefully the most efficient firms will succeed in the marketplace. In the DOD channels, however, other things being equal, the public should not be indifferent. It is in the public's interest that DOD achieves its national defense assurance objectives in order to defend the society. That is, DOD should not allow continued dominance of a channel by contractors.

It should be stressed that this mutual attempt for control is the rational behavior of organizations whose intention is not damage to another organization, although this may be a result. On the contrary, DOD contract control, if it can be attained, must not be exploitative or the mission will be jeopardized not because of a dominant defense contractor but a weakened one.

The DOD buyer, i.e., the contracting officer, unlike the industrial buyer, has the heavy responsibility of attempting to ensure that both sets of objectives are accomplished. However, the importance of DOD's dominant mission accomplishment must be understood by all at the onset of a relationship, as well as DOD's interest in each firm's well-being.

DOD as a contract leader has the following responsibilities in the contract relationship:

1. The roles and duties of both parties must be spelled out completely in the contract and any pre and post-award meetings.

2. Activities during the contract must be coordinated.

3. The firm may have to be controlled to perform through satisfaction of needs and use of power.

4. Conflict must be avoided or minimized. This can be done by understanding each other's role and objectives, avoiding poor perception and dealing with non-performance. Congruence in objectives would, of course, be ideal but difficult to achieve. When one or both of the parties cannot perform to satisfy the other's objectives, the contracting office must react to minimize conflict (e.g., the firm is behind schedule or DOD wants to unilaterally increase the scope of the contract). Many conflict maintenance strategies have been developed. Bargaining on concessions may help. Diplomacy is important. Mutual society membership (e.g., National Contract Management Assn.) and exchange-of-persons programs are a way to exchange views. Conciliations, mediation, and arbritration support from others could be useful. To bring goals more into line, DOD should attempt to make both parties see themselves as part of the same program (e.g., NASA).

5. Communication must be encouraged. Communication is the best way to bring perceptions and expectations in line and give early warning of non-satisfaction of objectives.

This concept of contract leadership does not necessarily mean tight control. A contract may describe a complete "hands-off" development by a firm. DOD must only ensure everyone has realistic expectations, that appropriate activities are coordinated, and that performance progress is somehow known.

Further, DOD contract leadership need not be arbitrary. Existing machinery (e.g., the disputes process) allows opportunity for industry redress.

Systems Acquisition and Implications for Leadership

To better understand contract leadership and control in systems acquisition, the characteristics of that process should be explored. One way to explain these characteristics is to contrast them with those of the private industry buying process.

First, what are we buying? In industry parlance, in systems acquisition DOD is buying new products. Industry typically makes its own new products. DOD makes very little (there are some exceptions) in-house and must go to industry. Moreover these new products involve complex technology and consequently lengthy development. Systems acquisition is unusual if not unique and has no industrial analogy. The requirements for the new weapons are often urgent. The requirements are not stable. Many outside influences (e.g., Congress) lead to the instability. Many fairly autonomous and widely separated government organizations (e.g., project manager, buying organization, headquarters) must coordinate their efforts. The process is heavily constrained by regulations and procedure for getting money from Congress through DOD to the individual firm.

This process obviously requires obtaining firms that are both capable and motivated. DOD has gone through considerable expense to attempt to build a capable defense industry base. The Defense Contract Administration Service (DCAS) and buying organizations themselves investigate firms to find whether they are responsible, i.e., technologically, financially and managerially capable of performing on DOD contracts. Buying organizations also have elaborate source selections on individual contracts to ensure capable firms (sources) are chosen (selected). Source selection involves the detailed (and lengthy) analysis of contractor proposals to make a product by a team of specialists on technical, cost, and managerial issues and the selection of the "best" contractor.

The question of motivation is another story. In the system acquisition process many forces tend to put contract control in the contractor's hands and lessen contractor motivation, i.e., the inclination to satisfy DOD's objectives.

Because investment is high and specialized expertise rare, the later development and the production of a weapon system usually involves one source. Since DOD must have the item, cannot normally terminate a major contractor (Knittle and Carr, 1980), and has no alternative to make the system in-house, this sole source has little to fear for lack of progress. Historically DOD has had difficulty in using past contract performance in the award of future contracts to further weaken DOD's position (Zabel, 1982). The complexity of the acquisition necessitates the use of a cost reimbursable contract (or another non-firm fixed price contract) which heightens the contractor's independence. In view of the factors outlined above, DOD contractors are aware that cost growth in their contract will be usually met with payment (albeit begrudging) and often a reduction in quantity. The complaint often heard from DOD managers is that the only threat they have over a firm is the possibility that higher headquarters or Congress will "kill" their program.

This poor DOD position can often be degraded further by lack of professional respect a firm may have for government technical or buying personnel, the demotivating bureaucratic response of government personnel to a firm's problems, or the perception that the DOD return on investment is too low. Since the firm is perceived as having high paid personnel with a perceived higher level of expertise than its government "opposite numbers", the firm will have a very real expert power over DOD (French and Raven, 1959), and the government may defer to the firm's judgment. Contractor motivation can be reduced by the many requirements for paperwork, socio-economic compliance in their organization, and the slow and formal solution process for problems. Because DOD contracts are not as profitable in terms of sales and investment (Logistics Management Institute, 1977) a firm may be motivated to not work as efficiently on DOD contracts, or defer working on them in favor of more profitable commercial work.

This discussion is not intended to put the blame of today's program difficulties on industry or to show that individual firms are necessarily poorly motivated. The point here is that it is the defense firm who tends to have contract leadership, not DOD, and that this relationship is not in the best interest of systems acquisition.

Leadership in the Individual Contract

One can see now the difficulties for leadership by DOD in systems acquisition. None-the-less the activities that are required for DOD to attain contract leadership have also been suggested.

One basis for deciding leadership strategy is the set of leadership responsibilities spelled out earlier: role and duty specification, coordination of activity, contractor control, conflict avoidance and minimization, and communications. These responsibilities must be carried out over the life cycle of a contract (and beyond). Consequently a contracting officer as contract leader could plan his (or her) activities along the lines of figure 2. For example, the DOD buyer plans for the two parties' roles and duties, specifies them in the contract, and continues to define them throughout the life cycle. Because systems acquisition is a lengthy and incremental process, this planning will actually be for a series of contracts and a shifting of roles (such as the movement of configuration management from the firm to the government). But this larger area of program leadership is beyond the scope of this paper (although perhaps derivative from it). As in

	Role and Duty Specs	Coordination of Activities	Contractor Control	Conflict Management	Party Communication
Planning					
Contract Form					
Evaluation					
Award					
Contract Admin					
Non-Contract Discussion					
Performance Announcement					
Policy Input					

Figure 2 Contract Leader Activity Framework

the role and duty area, the activities to support the other responsibilities can be derived from figure 2.

The emphasis of this paper, however, is on the control of the contract, the column called "contract control" in the figure. Consequently the remainder of the paper will concern the generation of control. Potential control over a contractor is often called leverage. The term leverage analysis will therefore be used to mean the analysis of the factors leading to contractor control and the implementation of the proper activities to optimize control on a given contract.

Leverage Analysis

Leverage analysis can best be described in terms of the life cycle steps of figure 2.

1. Planning:

The system acquisition process can tend, as shown earlier, to give leadership to the firm, so planning for leverage is extremely important. It is hard to add leverage into the contract and actually into the program. To gain program leadership leverage planning must start before the first contract. It must be thoughtfully planned out and implemented. Planning for leverage involves what the government is trying to do, what the conditions of the acquisition are, and what leverage tools are available. It cannot be emphasized enough that planning is the most important step in leverage analysis.

a. Government Objectives

In order to move firms toward the proper performance, DOD must decide what performance it wants, what priority or tradeoff in objectives may be necessary and whether and what kind of incentives will be needed on objectives. Figure 3 lists common contractual objectives.

The buying organization must of course decide which of these objectives are to be pursued on a given contract and the magnitude of each target. Because contracts in systems acquisition are so difficult (see earlier discussion), contractors often cannot simultaneously meet all objectives and the buying organization will have to ascertain what performance requirement may have to be relaxed in order to complete the contract; typically the cost and/or schedule requirement is relaxed to meet the performance requirement. Some objectives are particularly important to DOD or are difficult to achieve. The contracting officer must plan to put more resources on them. DOD often tries to motivate the firm to give attention to these objectives by rewarding the firm with an incentive or award fee.

- Cost Objectives
  - R&D
  - Production
  - Life Cycle
- Performance Objectives
  - Overall
  - Selected
- Schedule
  - Initial Operating Capability
  - Delivery
  - Selected Events
- Other, e.g., Mobilization Base

Figure 3. Typical Contract Objectives

b. Contract Conditions

In order to achieve the objectives for the given contract: what are both parties trying to do, what are they like, and what external factors will affect them. Figure 4 lists these conditions.

(i) Government Objectives

In addition to the considerations in the previous discussion, the contracting officer must determine the criticality of the buy. If we must have the item and cannot terminate the contract, regardless of performance, we are vulnerable to losing contract control.

(ii) DOD Internal Environment

These are the signals available to the DOD organization about what is expected of them (Lorsch and Morse, 1974). These include: the characteristics of the organization (e.g., structure, policy), the management, (e.g., attitude toward contractors), the working personnel (ability and motivation), characteristics of the system (e.g., inherent complexity, condition of technical data package), system requirements (e.g., threat, quantity), and money (budget and type of money).

(iii) DOD External Environment

This environment consists of information about market, technological, economic, political, and scientific factors relevant to the organizations success (Lorsch and Morse, 1974). That is, a DOD's activities (including leverage generation) are affected by

Congress, market place (firms and industry association), other government agencies (e.g., OSHA, EPA, GAO), and academic organizations, among others.

(iv) Contractor Objectives

The fact that these are not the same as the DOD objectives is the problem behind the conflict in the contract, but then this difference is fundamental to our capitalist society. None-the-less DOD must know the contractor's objectives in order to be able to consider motivation and leverage. Short term profit is the first thing that occurs to the average buyer, but this is not the only contractor need (Bilkey, 1972; Hunt, 1971; Fox, 1974; Shetty, 1979; Williams and Carr, 1981). Contractors often act toward long term profit (e.g., expanding markets, developing new skills) at the sacrifice of short term profit on a given contract.

(v) Contractor Internal Environment

This is nearly the same set of analagous variables as in the DOD internal environment. It will be very difficult to ascertain, except for the "track record" of the firm's behavior and Securities Exchange Commission 10K and similar reports.

(vi) Contractor External Environment

Again this environmental list is similar to DOD, except that it includes a firm's competition, other customers and its vendors.

One should observe in figure 4 that these factors affect both the firm and DOD. As mentioned earlier either organization could be the contract leader and in fact inherent system acquisition characteristics favor the firm. Additionally, the party that best "reads" these conditions will more likely lead the other. A buyer is reminded of this when he (or she) awaits a critical proposal from a firm and a critical deadline for the buyer (known to the firm) approaches.

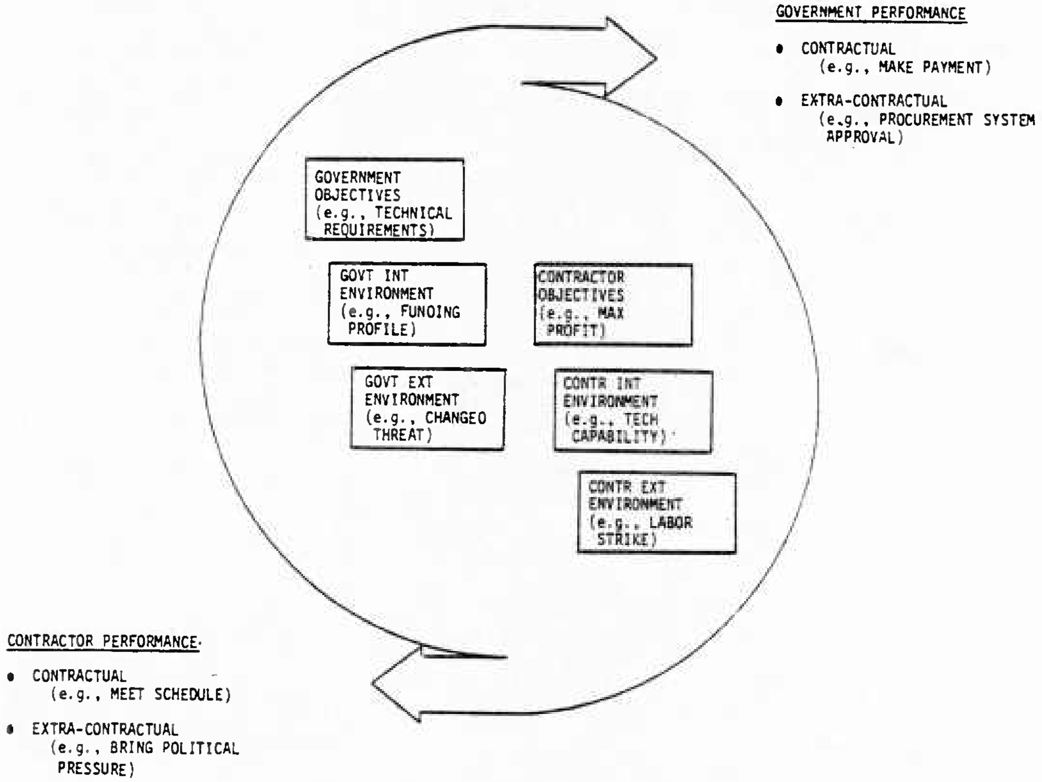

Figure 4. Conditions for Planning Leverage Analysis

c. Leverage Tools

The buying activity has two basic kinds of leverage tools: (1) power, in this paper the tools that do not consider the firm's needs and (2) motivation, the tools that do.

(i) Power

French and Raven in their 1959 study listed five bases of power, each of which is a potential tool for gaining contract leadership.

(a) Rewards. This is the most obvious power a buyer has over a seller. If the firm performs well, the buyer will reward it with money or some other valued consideration.

(b) Coercion. The opposite side of the coin. If the firm does not perform well, DOD will withhold payment or exact some sort of sanction.

(c) Expertness. If the buyer is perceived to have expert knowledge, the firm may defer to his (or her) judgment. As mentioned earlier this power is often in the defense firm's hands. DOD must strive to have its best trained people deal with industry.

(d) Identification. When any organization is attracted to another for some reason (e.g., prestige), the attractive organization has some power over the other. Consequently a firm may grant a DOD buying organization concessions in order to be a defense contractor (or more specifically a Navy, etc. contractor). A buying organization should of course strive to have a reputation worthy of such respect.

(e) Legitimacy. When a firm feels the buying organization "has a right" to be the leader, the buying organization has legitimate power over the firm. The wording of the contract confers some legitimate power (e.g., the government will review the firm's subcontracting plan). The DOD organization must act aggressively and authoritatively to be seen as leader.

(ii) Motivation

These tools are intended to move contractor behavior toward DOD objectives by satisfying the firm's objectives. The most direct approach is to find the needs of the firm and then apply the appropriate tools (as discussed in a later section). One important concept is a firm's expectations. For example, a firm may expect a certain return on its investment based on its company policy or its commercial or other return. If a firm's expectations about its objectives are not met, motivation to perform may suffer. Consequently, the buying office must attempt to (1) meet the expectations if possible and (2) bring expectations in line with reality. Frank communication is obviously the key to motivation. Getting the firm's true expectations is challenging. Communicating the constraints on the government's ability to meet these expectations (e.g., money limitations) is probably more difficult.

2. Contract Formation

After planning for leverage by selecting the right tools to achieve objectives under given conditions, many of these tools must be put into the solicitation and contract.

3. Proposal Evaluation and Award

Those factors that enhance DOD leadershio should be weighted heavily in prooosal evaluation and contract award.

4. Contract Administration

The buying organization should ensure that all other government organizations dealing with a firm under contract (e.g., DCAS, Project Management personnel, contracting officer technical representative) do nothing to jeopardize contract leadership.

5. Non-contract discussion, performance announcement, policy inout.

There are also many non-contractual opportunities for enhancing the DOD position in terms of both power and motivation. Figure 5 depicts the many actions an office might take within and beyond the contract.

Developing Leverage

How does a contracting officer consider the many factors discussed to gain leadershio on his (or her) contracts with a set of actions such as figure 5?

1. General Guidance

a. Assess Leverage Situation - If the DOD office has power over a firm and has effective incentives, then the office should continue the same activity. If, however, the firm has power and DOD cannot incentivize the firm, the office must develop more leverage.

b. Gain Power - The five bases of power discussed are available to each buying office, but will be gained only with effort and planning. Overreliance on rewards and penalties must be resisted. Coercion is typically dysfunctional in the long term.

c. Do Not Give Power Away - The same opportunities for power are available to the

GOVERNMENT INTERACTION WITH CONTRACTOR	EXAMPLES OF POSSIBLE LEVERAGE ACTIONS
PUBLIC DISCUSSION OF PERFORMANCE	ANNOUNCE GOOD PERFORMANCE BY DOD CONTRACTORS.
PROCUREMENT PLANNING	DEFINE GOVT OBJECTIVES AND PLANNING FOR MATCHING WITH CONTRACTOR OBJECTIVES. GENERATE COMPETITION. ASSESS POTENTIAL INCENTIVES.
SOLICITING/DRAFT SOLICITING	GENERATE POSITIVE FEELINGS ABOUT DOD PROGRAM. GATHER INFORMATION OF FIRM'S OBJECTIVES, IDEAS OR PROGRAMS, ETC.
DRAFTING OF PROCUREMENT INSTRUMENTS	
CONTRACT TYPE/CONSIDERATIONS/CONTINGENCIES	OPTIMIZE AMOUNT OF PAYMENT, SCHEDULING OF PAYMENT, CONTINGENCY FOR PAYMENTS
CONTRACT PROVISIONS	E.G., LIQUIDATED DAMAGES, PERFORMANCE BOND, CAPITAL INVESTMENT INCENTIVES
SPECIFICATIONS AND SCHEDULE	ASSURE ADEQUATE SPECIFICATIONS AND FAIR, EQUITABLE SCHEDULE
PROPOSAL EVALUATION/BID EVALUATION	FAIR, EQUITABLE EVALUATION: CONSIDERATION OF ALL WORK CONTRACTORS HAVE (AND, IF POSSIBLE, WILL HAVE)
NEGOTIATION/DISCUSSIONS	FIND CONTRACTOR OBJECTIVES AND TAILOR INCENTIVES TO NEEDS; MINIMIZE ADVERSARIAL ATTITUDES
SOURCE SELECTION/AWARD	USE PAST PERFORMANCE. CONTINUITY IN PROGRAM (MULTI-YEAR, OPTIONS, LARGE QUANTITY). FAIR, EQUITABLE SELECTION.
CONTRACT ADMINISTRATION	
DEBRIEF	INSURE LOSING FIRMS ARE STILL MOTIVATED TOWARD ARMY PROGRAM, ARE CONVINCED PROPER AWARD WAS MADE.
POST-AWARD DISCUSSIONS	ASSURE CONTRACTOR OF FAIRNESS, EQUITY OF DEAL. INSURE CONTRACTOR UNDERSTANDS PROGRAM. ESTABLISH GOOD WORKING RELATIONSHIP. ESTABLISH DCAS, DCAA, ETC. AGREEMENTS.
CORRESPONDENCE	QUICK, RESPONSIVE REPLIES TO CONTRACTOR NEEDS: "NON-BUREAUCRATIC" RESOLUTIONS.
PENALTY/REWARD	MAKE PAYMENTS OR REDUCTION COMMENSURATE WITH GOOD OR BAD PERFORMANCE
NON-CONTRACTUAL DISCUSSIONS/CONFERENCES	GENERATE POSITIVE FEELING ABOUT ARMY PROGRAMS. GATHER INFORMATION ON CONTRACTOR NEEDS AND EFFECTIVENESS OF INCENTIVES
POLICY DEVELOPMENT	WRITE POLICY THAT ACKNOWLEDGES CONTRACTOR OBJECTIVES, NEEDS AND INCENTIVES APPEALING TO THEM. BASE POLICY ON PERFORMANCE FEEDBACK.

Figure 5. Contract Leverage Actions

firm. If the buying office decides a more passive role is appropriate, then at least it should recognize the potential power the firm may gain. Above all, avoid the classic systems acquisition syndrome: the sole source contractor in a cost-environment (and often with a perceived low return) where the government must have the item, cannot terminate, has no prospective alternative, cannot force performance, cannot use performance as threat, and consequently must pay increased cost at the expense of quantity and must endure schedule slippage at the expense of missed critical dates.

d. Motivate - Find the firm's needs and, if possible, satisfy them. But direct the activity toward the contract objectives, particularly the valued and more difficult ones. Recall that money is only one objective, and has more than one dimension; that is in addition to the magnitude of payment, a firm is interested in when it will be paid, and on what basis. Further, a firm will often forego short term profit in the hopes of gaining longer term rewards. The varied interest is seen in the response of a recent sample of defense contractors (Williams and Carr, 1981) who listed the most effective government incentives as: fair and equitable contract, guarantee of future business, program continuity, appropriate contract type, high profit, and improved cash flow.

e. Do Not Demotivate - The government is often seen as a bad buyer (Sales and Marketing Management, 1979). Although the "system" generates a great deal of irritants in its paperwork and regulatory requirements, the individual buying organization should attempt to assist and explain as many requirements as possible. Further, the buyer should not become part of the problem by being bureaucratic, formal and distant in response to industry need.

2. Specific Guidance

Generalizing about firms is risky. Many elude categorization. Firms can change quickly over time. Since firms reflect the abilities and attitudes of their management (primarily), their characteristics change with personnel turn-over. None-the-less intuitively one knows that firms differ in the way they react to various leverage approaches, and that an organization (i.e., DOD) should vary leverage approaches to affect the performance of its contractual partner.

One study (Williams and Carr, 1981) did attempt to find the relative effectiveness of contractual incentives over different types of firms by surveying Army defense firms and Army buying personnel. Figures 6, 7, and 8 summarize many of these findings.

Figure 6 lists likely objectives different kinds of firms might have. For example, small firms are likelier to be concerned with company survival than large firms. Labor intensive firms expressed significantly more interest in making a good product and developing new skills than did capital intensive firms. A buying office can use Figure 6 as the basis for finding the needs of its own firms. It could get better results by making its own contractor survey.

Figure 7 lists effective incentives for different kinds of firms. For example, small firms are likelier to respond to program continuity and the use of past performance and award decisions that are large businesses. Labor intensive firms react more to award and incentive fees than do capital intensive firms. Figure 8 goes further by showing incentives likely to be effective for firms having certain objectives. Once more an office's own survey would give better information about its firms.

Ultimately one must generate this leverage by tailoring the tool to the firm. This will take time and effort, and such analysis will not always be worthwhile. If the effort is not done, however, the buying office should realize that leverage and leadership may be lost to the contractor.

Final Thoughts

In order to bring on desired DOD objectives, DOD must lead the contract relationship. In order to become the leader, DOD must employ leverage analysis. That is, on a given contract, the contracting officer must analyze the factors leading to contract leverage and implement the proper tools to generate that leverage.

These tools are (1) power, the ability to influence the contractors behavior without considering his needs and (2) motivation, the ability to influence the contractors behavior by considering his needs. These tools must be planned for early on and employed before, during, and after the contract award to maintain leadership.

The reality of systems acquisition today is that leadership tends to be in the contractor's hands (DOD must have the system, has no alternative, cannot terminate, etc). Consequently, leverage will have to be strived for and attained against considerable odds.

Another reality is that contract leadership is only one part of the solution to cost growth and other undesirable outcomes. Technological complexity and environmental uncertainty (e.g., Congress, threat) will continue to lead to problems regardless of how hard we and the best-intentioned contractor work as partners.

	Provide Good Product	Company Survival	Company Growth	Return on Invested Capital	Public Image	Develop Skilled Workforce	Utilize Excess Capacity	Develop New Capab	Long-Term Relation	Improve Cash Flow
SMALL FIRM		X								
LABOR INTENSIVE	X	X						X	X	X
HIGH GOVT BUS (FIRM)		X	X							X
HIGH GOVT BUS (DIV)		X	X			X		X	X	X
CLOSELY HELD		X			X	X				
PRODUCTION-ORIENTED							X			
HIGHLY TECH COMPETI				X	X					

Figure 6. Likely Objectives for Different Kinds of Firms

	High Profit	Award Fees	Incentive Fee	Multiple Incentive Fee	Cash Flow	Program Continuity	Long-term Contract	Past Performance	Capital Investment	Non-Monetary Awards	Government Investment	Competition	Withholding Future Business	Performance Bonds	Good Relationship	Appropriate Contract Type	Fair & Equitable	High-Level Management
SMALL FIRM						X		X										
SMALL DIVISION	X										X				X			
LARGE DIVISION							X				X							
MED-LOW TECHNOLOGY								X							X			
MATURE			X		X													
LABOR INTENSIVE		X	X	X	X		X	X		X	X		X					
HIGH GOVT BUSINESS (FIRM)													X					
HIGH GOVT BUSINESS (DIVISION)		X	X	X						X			X			X		X
CLOSELY HELD OWNERSHIP					X	X							X	X	X		X	
HIGH TECHNICAL COMPET									X			X						

Figure 7. Most Effective Incentives for Different Kinds of Firms

	HIGH PROFIT	INCENT FEES	CASH FLOW	CONTINUITY	FUTURE BUS	PAST PERFORM	CAP INVES PR	NON-MONETARY	COMPETITION	DENY FUTURE BUS	POOR PERF LOSS	TERM FOR DEF	PERFORMANCE BONUS	THREAT OF COMP	GOOD RELATION	APPROP K TYPE	FAIR/EQ CONT	JAWBONING
GOOD PRODUCT						X	X	X	X	X					X			
SURVIVAL			X	X		X	X			X	X	X	X					
GROWTH				X	X		X			X	X							
PROFIT	X		X							X	X							
ROI			X				X			X								
IMAGE				X			X	X	X	X								
SKILLS										X					X			
EXCESS CAPACITY				X		X	X	X	X	X		X	X				X	
NEW CAPABILITY						X	X		X					X	X	X	X	
CONTIN RELATIONSHIP		X		X	X	X	X	X	X	X					X	X	X	
DOMINANT POSITION					X													X
CASH FLOW			X				X			X						X		

Figure 8. Most Effective Incentives for Various Firm Objectives

Nonetheless contract leadership is a necessary condition for OOD in order to retain control of a contract and a program. Without it, complexity and uncertainty become unmanageable.

REFERENCES

Bilkey, W.J., "Empirical Evidence Regarding Business Goals," in J.L. Cochrane and M. Zileny (Eds), Multiple Criteria Decision Making, University of South Carolina Press, Columbia, SC, 1973.

Fox, J.R., Arming America, Harvard, Boston, 1974, pp. 309-310.

French, John R. P., and Raven, Bertram, "The Bases of Social Power," in Dorwin Cartwright (Ed), Studies in Social Power, University of Michigan Press, Ann Arbor, MI, 1959, pp. 150-167.

Hunt, R.T., et. al., "Federal Procurement: A Study of Some Pertinent Properties, Policies and Practices of a Group of Business Organizations," National Contract Management Assn., Vol. 6, No. 2, (Fall 1970).

Knittle, O.D., and Carr, D.M., "Improved De-Fault Procedures," Army Procurement Research Office, Ft. Lee, VA, 1980.

Logistics Management Institute, The Defense Industrial Base, Washington, DC, 1977.

Lorsch, T.W., and Morse, J.J., Organizations and Their Members, Haroer and Row, NY, 1974.

"Out of the Maze - Selling to the Government", Sales and Marketing Management, Aoril 9, 1979, pp. 44-52.

Shetty, Y.K., "New Look at Corporate Goals," California Management Review, Winter, 1979.

Stern, Louis W. and El-Ansary, Adel I., Marketing Channels, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1977.

Williams, R.F., and Carr, O.M., "Contractor Motivation Theory & Applications," APRO, Ft. Lee, VA, 1981

Zabel, Wayne, "Consideration of Past Performance in Source Selection," APRO, Ft. Lee, VA 1982 (Draft).

PANEL K

ACQUISITION WORKFORCE

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IDENTIFYING AND DEVELOPING CIVILIAN ACQUISITION MANAGERS IN THE NAVAL MATERIAL COMMAND

Gerry S. Buck

In 1974, the Secretary of Defense mandated that each service component institute a weapon system acquisition management development program for its military and civilian personnel. The purpose of this directive was to improve, through better selections and training, the overall quality of the personnel responsible for procuring DOD's increasingly complex and expensive weapon systems.

In Navy, the military established the Weapon System Acquisition Management Career Management Program, WSAM for short. The WSAM program identified military billets within the organization considered to be critical to the acquisition process. The program also defined the type of education and/or experience an officer would need to perform satisfactorily in the identified positions. These program requirements, were, and still are, used by Navy detailers to make assignments into acquisition-oriented positions. Using this approach, the Navy military WSAM program has been quite successful in identifying, developing and utilizing qualified military personnel in Navy's acquisition management structure.

During the 76-77 timeframe, efforts were made to incorporate civilians into a program similar to the military one. This attempt failed primarily because management did not properly recognize or address the differences in the roles of civilian and military personnel in the Navy organization.

The civilian version of WSAM attempted to categorize the acquisition work force into three groups, WW, WP, and WT. Simply, the WW job was the primary-decision maker, responsible for managing a major acquisition effort and served as the coordinator for several smaller acquisition projects. Jobs identified as WW had to be filled with an employee with WW or WP experience.

The WP job represented the next echelon down in the decision-making process and was responsible for managing smaller acquisition programs. Jobs identified as WP had to be filled with someone with a WP or WT background. The WT job provided support to a WP job and covered a wide-range of acquisition and functional elements. Incumbents of WSAM positions received experience which could be used in qualifying for other WSAM positions.

Under this program each activity was permitted to identify its own civilian WSAM designated positions using these broad definitions. Initially there was much confusion about how broad the WSAM coverage could be. In some instances, clerk-typist positions were identified at WT simply because they were located in an acquisition office. After the dust settled, there appeared to be a high correlation between those positions identified as WSAM and those positions in the organization's management structure identified as supervisor, manager, and executive.

Navy's problem was, and still is, how to implement a WSAM program for civilians. The military WSAM program works well and the temptation is to transfer the successful elements from that program to the civilian side. Experience indicates that this approach will not work. I disagree. Admittedly, the past attempt did not succeed, but I maintain that this was due to the lack of understanding of the roles of the military and civilian work force.

The civilian personnel system relies upon the classification standards to define the type and value of a certain position or set of duties. These standards reward technical excellence by granting more credit and thus higher grades. The length of experience in that series also has a positive influence on the grade. To move outside the individual's designated series could lead to delayed promotions and loss of productivity. Thus, civilians are encouraged to specialize in one series and/or discipline. This situation is excerbated in a military organization. The military officer is perceived as being the management official. This system tends to reinforce the perception that civilians need to be technical experts.

The civilian WSAM program elements, designed in this environmental context, gave rise to the belief that what was needed was a multi-discipline technical expert. This was to be accomplished through increased job rotations at the lower grade levels and new performance rating tools. Identification of the skills, knowledge and abilities needed for this multi-disciplinary technical expert would be generated through the performance rating system as the program went along.

It was in this interpretation on how best to implement the WSAM program that the civilian WSAM program erred. Acquisition management, for military and civilian alike, is a management function, not an accumulation of different technical skills. For this reason, I am proposing that future efforts to develop a civilian WSAM program be established as a subset of a broader executive/management development effort. This viewpoint is supported by the correlation of civilian WSAM positions with the existing management structure found in the past efforts to identify WSAM positions.

This awareness can be used to greatly simplify the WSAM program and procedures. If we agree that WSAM positions are a special category of management positions then it is possible to use the supervisory, managerial, or executive experience as a selection tool for filling a given acquisition job. A specific skills mix, identified by line management, can be used to refine a list of qualified candidates and develop a certificate of highly qualified applicants. This skills mix would be determined by the phase of the project and the organizational environment.

This approach is also useful and economical in developing employees for future acquisition positions. Activities are required to have some form of XD/MD program. If the civilian WSAM program is made a part of this effort then it can share management training resources. It also helps redirect the development of WSAM participants toward broadening their perspectives and teaching integration skills rather than layering discipline upon discipline.

In reality this approach will bring the civilian WSAM closer to the military program by redefining the program audience. The military officer in the SYSCOMs is a member of the management structure. This is a given. The military WSAM program was built upon that assumption. The civilians on the other hand, have no such ready grouping. By refocussing on the management population of the organization, it is possible to identify a similar civilian population. Once done, the program development should be able to readily borrow elements from the military program and be implemented in a cost-effective fashion.

In conclusion, if the proposition to view the development of civilian acquisition management personnel as part of the broader executive/management development effort is accepted, I feel that the results will be better identification, development, and utilization of the personnel involved. This will lead to a better match of personnel to jobs, improved productivity, and ultimately provide better control of the total acquisition process.

Acquisition Workforce Research

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ABSTRACT

The present Acquisition Workforce at Oklahoma City Air Logistics Center is composed of men and women with varied education levels, grades and training. Through Acquisition Workforce Research, we can better determine education requirements, grade structure and the type of training required. This will enable management to meet our workforce objective of a highly trained and educated group of personnel. Through Acquisition Workforce Research, tomorrows workforce can be developed today.

PURPOSE

This paper presents a view of todays acquisition work force at Oklahoma City Air Logistics Center. The paper depicts problems as we see the them and problems as management sees them. We will also present our concept of tomorrows work force and what we anticipate will have to happen to arrive at the proper mix of education, training and grade structure.

TODAYS WORKFORCE

Education

The Directorate of Contracting and Manufacturing at Oklahoma City Air Logistics Center is composed of approximately 526 persons with education equal to or greater than the following percentages:

Doctorate Level	1%
Masters Degree	6%
Bachelors Degree	27%
High School & Some College	65%*
Less than High School	1%

*More than 50% of those in this category have some college.

Emphasis is placed on education at OC/ALC. To provide employees with educational opportunities, several colleges and universities offer bachelor degree programs and advanced programs on base. Several of these same schools are within commuting distance and offer a wide variety of education programs.

The Oklahoma City Air Logistics Center in cooperation with Oscar Rose Junior College has developed a Purchasing and Contracting Associate Degree Program. Oscar Rose is a Junior College located within three miles of the ALC.

The curriculum consists of sixty-two college hours. There are 23 hours of General Education Requirements, 30 hours of Program Speciality courses and 9 hours of Program Support/Related courses.

This type of education program not only improves the Acquisition Workforce on board but it provides the local community a means of becoming educated to qualify for Acquisition positions both with the Federal and Local Governments.

Training

Training as it now exists begins upon initial assignment to the Directorate of Contracting and Manufacturing. The training continues in stages through out an individuals career as they advance in grade. There are four methods of providing training for Acquisition personnel. They are, formal schools at various training bases, class-room instruction provided by the same schools here at the ALC, correspondence courses and on-the-job one on one training.

Some problems encountered are lack of training positions at schools, shortages of training funds, and unexpected vacancies. Projections can be made to a certain degree of accuracy concerning retirements; however, personnel who quit or change jobs that takes them out of the Acquisition Career Field cannot be projected with much degree of accuracy.

With reduced budgets, training funds are expected to become harder to obtain. This will in turn reduce the training capability of the ALC Acquisition Workforce.

Grade Structure

The Acquisition workforce at OC/ALC is composed of 526 persons in grades GS-2 through GS-15. The average grade is 7.49 and the average salary is $20,327. There are 45.1% of the Acquisition Workforce in grades 9 through 15 and 54.9% of the workforce in grades 2 through 7.

There is a more rapid turn over of those persons in grades GS-2 through GS-7. This is related to acceptance of other positions, lack of promotion potential, transfers, pay and promotions. Fewer persons retire at the GS-2 through GS-7 grades than they do at the GS-9 through 15 grades.

It is possible to enter at the GS-2 level and advance to the GS-15 level within the Directorate of Contracting and Manufacturing. Advancement is through training, experience and education. The entrance into the professional acquisition series is at the GS-5 level. One may enter through the PACE or equivalent evaluation criteria or the upward mobility program.

Automation

Automation is rapidly changing the way we do business at the Oklahoma City ALC. The word processing systems and other computerized storage and tracking systems are taking away the routine clerical duties of the contracting person. We are rapidly approaching what appears to be "super clerks" highly trained in computer and word processing systems.

The small dollar and routine acquisitions are processed by trainees and lower grade personnel. The large dollar and highly technical acquisitions are normally processed by skilled, highly qualified, educated and trained personnel. However, due to a rapid turnover in recent years and the promotion criteria, less qualified and educated individuals are handling some of the major acquisition programs.

Computerized word processing systems are programed with routine repetitive form letters, forms, contracting documents and various reports. The only effort of acquisition personnel that is required is for them to fill in the blanks. This allows the buyer more free time for more technical work.

TOMORROWS WORKFORCE

Education

The education levels will have to be increased at all levels of the workforce. We conceive managers with degrees at the doctorate level, all those in grades GS-5 through GS-9 with bachelors degrees. Clerical Grades GS-2 through GS-5 will have to have special training or at least Associate degrees.

Incentives for improving one's education at this ALC are:

A. Advancement to the Copper Cap program or Management Intern.

B. Entrance into the Acquisition career field through the PACE or Equivalent Evaluation Criteria.

C. The Upward Mobility Program.

D. Promotions and higher pay.

More emphasis is already being placed on improving education levels and providing personnel with education opportunities. We anticipate and recommend that entry requirements for entry into the Upward Mobility program to be a minimum of two years college. Progression to the GS-6 upon completion of 75 hours, the GS-7 with 90 hours, GS-8 with 105 hours and to the GS-9 with a bachelors degree is recommended.

Training

Present formal training programs will have to be compressed into a tighter schedule due to more advanced training being required by the workforce. Training will have to begin at all grade levels immediately after entering the acquisition career field. Those persons administering training will be required to do more with less resources.

If local colleges and universities continue to adapt programs to the acquisition career field, less emphasis can be placed on formal training programs. Those individuals possessing associate degrees or degress in acquisition will have more of the general acquisition knowledge that has to be presently taught in government provided training schools.

Grade Structure

We do not anticipate any large and fast changes to the present grade structure. However, to compete with private industry and recruit the best educated and skilled individuals, pay and grades will have to be appropriately structured. Problems already exist in some geographical areas where positions are currently hard to fill with skilled and highly educated personnel.

Automation

Automation will continue to absorb more of the repetitive routine transactions of acquisition personnel. We do not anticipate a slowdown in Automation advancement in the near future. Emphasis is highly placed on automation at the Oklahoma City, ALC. Changes and improvements in our systems are a continous operation.

Social Expectations

Management should encourage the workforce to become involved in community affairs. Employees should be encouraged to participate in professional organizations such as National Contract Management Association, Air Force Association, Tinker Management Association at Tinker Air Force Base and other on base organizations. Employees should be encouraged to belong to Civic Clubs such as Chamber of Commerce, Lions Club, Kiwannis Club, etc.

With active participation in on and off site organizations, the citizens outside of the Government acquisition community will have a better understanding of government officials. In addition the employee gains valuable insight about leadership, local problems and attitudes, and interchange of ideas.

RESEARCH PROPOSAL

Extensive exit interviews should be conducted to find out why acquisition personnel quit or transfer from the Contracting and Manufacturing career field. This would provide management with statistics for planning, recruiting and motivational tactics. For all practicable purposes, the only question now asked one upon departure is a statement as to why they were leaving.

Periodic interviews should be made by personnel either through the placement specialist or the local personnel specialist. Selected non-supervisory acquisition personnel could also be used to fill an extra duty assignment as retention counselors. Unsigned questionaires could be used to gather data. Things to be considered in interviews could be, but not limited to are:

a. Job satisfaction

b. Morale

c. Pay

d. Promotion Opportunities.

e. Reasons for Quitting or Transferring.

f. The amount of training expended.

g. The amount of the individuals education.

The individuals that quit or transfer are either clerical GS-2-5 personnel or GS-5-9 trainees. Whenever we lose the GS-5-9 trainee, we are of the opinion that the reasons are; better conditions, more pay or lack of job satisfaction. The GS 5-9 trainee is most likely to have entered through the off base PACE and is an individual with at least a Bachelors degree. On base PACE or equivalent evaluation entrants usually have a degree, however they are normally more career oriented employees. The upward mobility entrants have some college and are working toward a higher level of education.

CONCLUSION

If we are going to develop an Acquisition Workforce to meet tomorrows needs; Acquisition Workforce Research must continue at a more rapid level. Our workforce must be better educated, trained and provided with incentives that they will have a strong desire to improve their own capabilities.

MANPOWER PLANNING FOR THE ACQUISITION PROCESS: Current Status, Issues and Constraints, Challenges

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Manpower planning is an activity of critical importance for an organization which is constrained by such factors as manpower availability, funds, and objectives relating to efficiency, effectiveness, and cost. The Department of Defense and the services manage multiple programs in the acquisition process and function in an environment in which numerous constraints operate which demand that manpower planning and resource allocation be performed as effectively as possible. A similar situation exists for product divisions and program offices, although the dimensions differ.

Commanders at all levels express the need for decision tools to help them allocate scarce resources effectively among competing programs, in addition to planning (budgeting) for future time periods. Program managers and manpower analysts continually seek effective ways to plan manpower requirements for the programs. Functional and staff managers need tools to assist them in planning their manpower requirements and allocating those resources in support of multiple activities, especially acquisition programs.

This paper presents the results of a research study of the status of manpower planning for the acquisition process, identifies problems associated with it, and suggests needs, challenges, and research directions for effective manpower planning.

MANPOWER PLANNING DEFINED

Definitions of manpower planning are varied. Some refer only to managerial manpower; others exclude forecasting as part of the planning process; still others include programming as part of the planning process. In the Air Force, manpower refers to manning spaces, and personnel deals with people. The definition used for this study was all-encompassing but did not include programming.

Manpower planning is the process of determining manpower requirements for carrying out the integrated plans of an organization to accomplish certain specific objectives. It includes determining types and numbers of skills and knowledge and the timing of their assignment to the organization (Human resources planning and personnel requirements planning are names for the same activity.) Manpower programming consists of determining the action plans for achieving the manpower plan objectives.

COMPLEXITIES OF ACQUISITION MANAGEMENT

Manpower planning within the acquisition process is a highly unstructured, decentralized, complex task affected by multiple levels of authority, responsibility, and action; by multiple sources of authority and responsibility (program, functional and staff); and by variations in program organization, size, and management. It operates within an environment of structural constraints which include relationships between program and functional managers in matrix organizations; the origin and interface of funding for programs and manpower; the separation of financial, manpower, and personnel systems; and the nature and integration of data and information retrieval systems.

The program manager is responsible for staffing the program office over its life. Under the matrix system, however, functional and staff units are responsible for providing manpower to the program office in support of specific activities. In addition, the environment, size, and structure of program offices vary. The major variables affecting the program office and its manpower requirements include: dollar value, size, type of contract, length, degree of engagement, amount of government furnished equipment (GFE), foreign military sales (FMS), acquisition strategy, complexity, organization structure, priority, national importance, scope, and management philosophy.

THE RESEARCH PROJECT

Objective

The purpose of the research was to identify concepts, methodologies, and techniques applicable to manpower planning in the acquisition process and, based upon that definition of a "state of the art," to identify possible research directions for the application or development of concepts for manpower planning, human resource allocation, and productivity studies. Specifically, attention focused on manpower decisions at four levels: 1) command and 2) product division for manpower planning and resource allocation, 3) program office for manpower planning for all relevant phases of the acquisition process over the life of the program, and 4) functional units and staffs for manpower planning for inputs into program operation under the matrix and functional structures.

Methodology

An extensive search of defense-related, business, and other literature was conducted. Sources searched included the following:

1. Defense Logistics Studies Information Exchange (DLSIE).

2. Defense Technical Information Service (DTIS) and Defense Documentation Center (DDC).

3. National Technical Information Service (NTIS).

4. ABI/INFORM (index of business publications).

5. Hospital administration bibliographies.

6. Regulations, instructions, studies, and other information from the Air Force Systems Command (AFSC), Aeronautical Systems Division (ASD), and Air Force Business Research Management Center (AFBRMC).

7. Michigan State University libraries and personal knowledge of the researcher.

The sources searched generated over 4000 titles, of which approximately 450 appeared relevant. Microfiche or hard copies were obtained and analyzed for their contribution to the research objective.

No preconceived or predefined limitations were imposed regarding origin or application of studies, e.g., a Navy study of shore manning requirements or a study of scientists in the pharmaceutical industry. As the research progressed, two major types of studies became repetitious and consequently were deleted from further consideration because their approach and application had been clearly defined. These were macro-manpower studies at the Department of Defense (DoD) and service levels and personnel requirements studies for manning and maintaining advanced systems by operating units.

Several studies, especially within the Air Force Institute of Technology (AFIT), dealt with organizational factors in the systems program environment. Those studies focus on the effects of such variables as organization size, organizational climate, role stress, tenure and level of bureaucracy on the job of the program manager. While such factors influence the managing of the program office and indirectly affect issues of manpower planning, they were not included in this study directly.

Obviously, not all literature has been searched. Time limitations mandated a reasonable stopping place. Other countries, particularly Britain, have been researching manpower planning. While some British and NATO data were included in this study, the search was not exhaustive. Furthermore, new studies are continually coming to fruition.

Results

The literature sources were classified by scope of coverage, function, and methodology. The specific classifications were: macro-aggregate models, micro-organizational and functional models, acquisition-oriented models, general conceptual models, and other techniques. There was overlap among classifications and, consequently, there was double coverage of some studies.

A description of contributions within classifications follows. In most instances, only reference is made to the source and the topic it covered; in a few instances, a more detailed description of the study is provided when it is considered particularly relevant.

Macro-Aggregate Models

The vast majority of manpower models are those which attempt to analyze personnel requirements from a supply viewpoint with the objective of determining adequacy of resources for policy making. In general, they are quite broad in scope, yield gross, or aggregate, manpower figures and do not contribute to the manpower planning decisions investigated in this project. Illustrative of these regression models are a long-range active and reserve Army planning model (16), a civilian manpower model (31), and university and general military planning models (15).

Micro-Organizational and Functional Models

Another group of models, which also deal with supply, have a less broad scope and focus on organizations and specific types of manpower skills. These, too, provide little contribution because of their macro orientation. The Air Force Project PIEMAN uses a regression technique to forecast manpower for material management, maintenance, procurement and production, and distribution functions within the Air Force Logistics Command using aircraft inventory or flying hours as the causal variable (8). Other studies deal with production in a Navy Rework Facility (5), maintenance in the Navy (23) and Air Force (3), a Naval maintenance division (27), and a Naval medical center (9). The Navy corrective maintenance study (23) uses PERT and task analysis. The Air Force study of maintenance manpower requirements for aircraft units uses a time-oriented, events-recording data system and proports to permit allocation of manpower to a particular shop or work center (3).

Acquisition-Oriented Models

Franke and Morris (14) conducted a study of manufacturing personnel for a major fighter program office in ASD. Using a multiple regression technique, they analyzed factors in all stages of the acquisition cycle up to IOC (initial operating capability) under the matrix system. They found a high degree of validity in their model and suggest that it is applicable to forecasting requirements for similar fighter aircraft programs.

The distinctive features of their study are the variables analyzed and the analysis of the stages of the acquisition process from conceptual through production. The variables include four functions common to all major programs (manufacturing engineering, manufacturing management, special reviews, and government furnished equipment [GFE] management); four internal factors (technical manufacturing risk, co-production, subsystem integration, and program director's philosophy); and four external variables (urgency of need, contractor capability, contract administrative services [CAS] manning/support, and foreign military sales [FMS]).

Several studies (30, 22, 2) within the Air Force Contract Management Division (AFCMD) for Air Force Plan Representative Offices (AFPRO) provided useful inputs for this study. The Turner and McQuire report (30) contains: 1) a framework for demand forecasting for the manning of the total of each AFPRO in AFCMD giving total AFPRO standards, and 2) functional manpower guides for AFPRO managers including the use of judgment, to aid the AFCMD commander in allocating manpower to AFPROs. Management Engineering Team (MET) 25 developed manpower standards (manning equations) for the AFPROs (22), which functioned as macro models for the AFCMD. The equation factors include a logarithm of total contractor manning, and the total number of separate contractors business segments. The Barney, et al. study (2) focuses on the quality assurance (QA) function within the AFPRO with the aim of improving the ME standards for AFPRO QA functional manpower models by analyzing contractor QA manning.

Management Engineering (ME) constructs mathematical equations for organizational units using workload elements (drivers) to calculate man years needed to accomplish a unit's tasks. These standards include micro elements for individual categories of functional effort directly related to mission accomplishment (plus overhead factors). The value of the ME standards for manpower planning lies not in the standards themselves as accurate predictors but in the process and information obtained in formulating the standards. The process identifies factors which determine (drive), or correlate closely to, manpower requirements and may be the most useful basis for manpower planning. A second value is that a valid historical standard may be useful for initial forecasting for similar programs.

The Air Force Systems Command (AFSC) has a Systems Acquisition Manpower (SAM) model for the product division within the command (21). The SAM model identifies 17 complexity factors (drivers) within five major categories (engineering/technical, management/finance, procurement, production, and test/development) which influence the manpower requirements of a program as it progresses through the acquisition life cycle. For each driver, there are five incremental definitions of workload complexity. Each factor is ranked in complexity and, within each category, its relative influence on manpower requirements is determined. Two models exist--one for single product SPOs and one for basket SPOs. In 1981, the SAM model was undergoing revision to increase its validity and applicability, including increasing drivers (from 17 to about 40), obtaining a more precise definition of programs, and tailoring the model to unique characteristics of product divisions.

Other studies contributed concepts which may be useful to portions of the manpower planning process for the acquisition process. Malone, et al. (20) identifies concepts appropriate to stages of the acquisition process for deriving personnel requirements. Norden (26) presents a conceptual work on relating the life-cycle method to manpower and schedule estimates. Coleman describes manpower planning for R & D personnel in pharmaceutical firms (12) and aerospace firms (10). Most other business-oriented studies are of two types: 1) simple correlation models relating manpower requirements to activity levels, i.e., sales personnel to sales levels, etc., and 2) managerial manpower models.

General Conceptual

General conceptual approaches and models for manpower planning come primarily from academicians. Burack and Walker (7) is a comprehensive but general approach, including discussion of forecasting, manpower models, and information systems. Burack (6) contains a general framework for manpower planning (pp. 9-14) and some emphasis on computer-based personnel information systems. Two other references contain general, but useful approaches (13, 11). The value of these sources is in their broad conceptual analysis of corporate manpower planning, much of which can provide valuable background for manpower planning in the acquisition process.

Techniques

Techniques applied to manpower planning problems are varied. Sources identified here describe different techniques and models, evaluate them, and apply them in particular situations.

Mitchell, et al. (25) describes various techniques of forecasting (including qualitative ones), and some of the techniques are applicable to manpower. Grinold and Marshall (15) describes and discusses a variety of techniques and models for manpower planning. Hutchins, et al. (17) describes computer models with emphasis on Navy macro manpower planning. All of these reports are quite comprehensive.

The Aerospace Corporation study (1), although dated, does an excellent analysis of the validity of manpower prediction techniques at various stages of weapons development in the acquisition process. It is applicable for systems, but not for acquisition management or for performing the program. The most recent analytical review of personnel models is in the Rand study (18). It discusses types of models as well as methodological approaches, and several of its conclusions are worth highlighting.

1. Non-optimization models are useful for incorporating different sets of assumptions and simulating the effects of alternative policies, then enabling the user to exercise judgment (p. 27).

2. Optimization models are of little use as yet, but have potential (pp. 27-28).

3. Manpower models have not yet contributed to efficient manpower management (p. 28).

The following are additional sources using methodologies not described elsewhere or consisting of specific applications of relevance to this study. The Norden (26) and Malone (20) studies have already been cited. Milkovich, et al. (24) employes the Delphi procedure in predicting professional manpower (sales) requirements; their study concludes that Delphi works better than regression analysis equations for that type of manpower skill. Sauer and Askren (28) utilize an expert estimate technique for predicting manpower, maintenance, and training requirements for proposed Air Force systems and found the method to be valid. Johnson (19) describes a method based on the probability of uncertain events to determine manpower requirements for an Army R & D organization and includes tradeoffs and least-cost analyses.

Resource Allocation

The allocation of resources among competing programs is of major interest at command and product division level, but was not a part of this study unless a specific manpower-oriented source was located. None was. Two studies by the Institute for Defense Analysis, however, are cited here for their possible value to those wishing to pursue that direction. Trozzo (29) describes and critiques quantitative methods for the allocation of DoD exploratory development resources, and Berinati, et al. (4) focuses on the allocation of funds to individual project tasks using "military value" as the principle criterion. The latter study summarizes methods for resource allocation (pp. 57-59).

Conclusions

In view of the objectives of the research study and the environment of the acquisition process, the following conclusions were made.

1. There is no single framework applicable to all stages of the acquisition process nor to command decisions for resource allocation among competing programs. There are, however, concepts, techniques, and tools appropriate for portions of the problems.

No model deals with the qualitative aspects of manpower planning nor are the qualitative aspects well delineated in the literature. While no quantitative model can deal with the qualitative manpower planning considerations in managing a program office, these factors must be documented and researched.

2. At command and product division level, macro manning models can be constructed, but in my judgment would be of little practical use for decision purposes related to planning of activity levels or resource allocation. Such a macro inventory of skills could represent a measure of acquisition program capability on a broad scale, and that knowledge might be useful for personnel planning purposes (e.g., training, recruiting, etc.).

It would be possible, at significant cost, to construct a model using simulation techniques based perhaps on Delphi technique inputs for evaluating alternative resource allocation decisions under various scenarios in order to project probable outcomes. A technique of this nature would serve as an analytical aid to commanders. Whether the cost-benefit ratio would be sufficient to justify such a technique is debatable because of the many variables operating in each program and among programs and because of the risks of misuse (for example, over simplifying assumptions upon which the models are based or placing improper weight upon the assumptions when decisions are made).

3. There is no concept or technique applicable to program offices in general because of the variability among programs which was discussed earlier. Several models could be constructed to serve as decision guides for classifications of programs. The classifications might be based on size and scope, for example, with modifications for degree of foreign military scales (FMS). Thus, a model could be designed for very large, complex, high-priority programs, another for medium-sized, less complex programs; and another for small programs or for program offices responsible for several

small programs. Models of this type would likely be general in nature and largely conceptual.

4. Many models have been developed and applied to different types of manpower planning. The following appear to hold the most promise for manpower planning in the acquisition process:

a. Delphi forecasting and expert estimate techniques for professional/scientific manpower.

b. Simulation techniques for manpower allocation analysis and manpower loading analysis for all program manpower.

c. Regression models for functional (production-type) and some staff activities.

5. Mathematical models appear to have had limited use in the manpower-planning decision process; the judgment of managers has prevailed. Nonoptimization models have served as computational and educational tools helping the manager in analysis prior to exercising judgment. Optimization models have not been developed to the point of providing the manager with a sufficiently high confidence level to rely upon them. It does seem apparent that the models do have great potential to be a valuable aid to decision making.

6. There are useful concepts and techniques for specific functional areas that are production oriented. Linear regression models have aided manpower planning and show promise for more sophisticated development and application. Despite their tendency to be macro approaches, they do serve to aid decision making.

7. The work of Management Engineering in developing multivariate statistical models for application to program office manpower requirements has provided useful knowledge and should be continued for greater refinement. Inclusion of qualitative criteria would undoubtedly enhance the usefulness of the models.

RESEARCH DIRECTIONS AND CHALLENGES

Because of the relatively undeveloped state of manpower planning concepts and techniques for the management of the acquisition process, there are many opportunities for research which can help commanders, program managers, and functional and staff managers make operational decisions. These research directions include modification and refinement of existing techniques, application of existing techniques to acquisition-process manpower planning, and new directions. Some suggested approaches follow.

1. Build conceptual decision models for classifications or types of program offices. Models could be constructed for variations in program office size, complexity, and scope (single program office or "basket" program office).

2. Develop decision models and refine manpower planning tools for each stage of the acquisition process for specific types of skills.

3. Refine and apply regression and other types of models for production-type manpower skills, i.e., staff units and units utilizing specific disciplines of skills.

4. Develop and test allocation and simulation models for command and product division decision making employing different sets of assumptions of cost, time, and priority.

5. Study past and current program office manpower planning and allocation to document the experience of program managers in order to identify relevant variables in the decision processes with special attention to qualitative factors. The identification and effect of those variables may also provide useful insight into major factors which influence manpower utilization in program offices.

6. Study procurement productivity through resource allocation and use compared to an efficiency/effectiveness measure on programs. Investigate such questions as: What manning levels were used and what levels of "success" were achieved? What other factors contributed to "success?" What factors constrained "success?"

In addition to the need for further research, there are a number of other challenges and opportunities for coping with the constraints operating on manpower planning decisions at all levels and for improving the efficiency and effectiveness of the total system. Several are highlighted here.

1. The division of authority and responsibility between program and functional/staff managers for manpower planning and staffing of the program office. This may hinder effective and efficient utilization of program manpower and program management.

2. The origins of funding for programs and manpower are separate. Funding cycles differ. The interface of the systems in all likelihood does not enhance optimal manpower decision making.

3. Financial, manpower, and personnel systems are separate. Further, the nature of the data in each differs and each is incompatible with the others for effective manpower planning and allocation. And finally, because of this incompatability, the data in each are not integrated and cannot be retrieved for manpower planning and assignment purposes.

CONCLUDING COMMENTS

The state of the art of conceptual approaches and models for manpower planning for the acquisition process in the DoD and services can be characterized as being in its infancy and highly fragmented. The acquisition process and its management are complex and influenced by formidable constraints. Despite this, there are a great many opportunities for developing more useful models for manpower decision making for acquisition-oriented activities and for coping with the constraints operating on the systems.

This paper has been an attempt to document the state of the art as it exists in the literature and to evaluate concepts, models, and techniques in their contribution to manpower planning decisions. In addition, research directions and challenges have been suggested for developing a stronger manpower planning capability.

REFERENCES

1. Aerospace Corporation, The Comparative Validity of Manpower Prediction Techniques. (Prepared for Air Force Systems Command, Ballistics Systems Division), El Segundo, CA, June 1963.

2. Barney, L. K., D. W. Carpenter, and O. D. Samuels, Criteria for Predicting Manpower Required for the AFPRO Contractor Quality Assurance Function. Master's Thesis, Air Force Institute of Technology, September 1976.

3. Bell, C. F., and J. P. Stucker, A Technique for Determining Maintenance Manpower Requirements for Aircraft Units. The Rand Corporation, Santa Monica, CA, May 1971

4. Berinati, V. J., W. S. Payne, and C. L. Trozzo, Quantitative Methods for the Allocation of DoD Exploratory Development Resources. Institute for Defense Analysis, Science and Technology Division, Arlington, VA, May 1972.

5. Bres, E. S. and R. J. Niehaus, An Integrated Workload and Manpower Planning System for the Naval Air Rework Facility, North Island. Office of Naval Research, Washington, DC, November 1974.

6. Burack, E. H., Strategies for Manpower Planning and Programming. Morristown, NJ: General Learning Corporation, 1972.

7. Burack, E. H. and J. W. Walker, Manpower Planning and Programming. Boston: Allyn and Bacon, Inc., 1972.

8. Carlburg, R. E., R. H. Freeman, and H. W. Utter, Project PIEMAN: Persistent Indicators for Estimating Manpower Needs. HQ AFLC, DCS for Plans and Operations, Wright-Patterson Air Force Base, OH, October 1974.

9. Chipman, M., Analysis of Demands on Naval Regional Medical Center, San Diego. Navy Personnel Research and Development Center, San Diego, CA, April 1977.

10. Coleman, B. P., "Corporate Strategy and Manpower Planning." Chapter 14 in N. H. Cuthbert and K. H. Hawkins, Industrial Relations Policies. London: Longmans, 1973.

11. Coleman, B. P., "An Integrated System for Manpower Planning." Business Horizons, October 1970, pp. 89-95.

12. Coleman, B. P., "Research Manpower Resources Planning." Research Management, July 1973.

13. Department of Employment and Productivity, Company Manpower Planning. London: Her Majesty's Stationery Office, 1968.

14. Franke, F. A., and M. B. Morris, A Technique for the Determination of Manufacturing Personnel Requirements within the ASD. Masters Thesis, Air Force Institute of Technology, September 1978.

15. Grinold, R. C., and K. T. Marshall, Manpower Planning Models. NY: Elsevier North-Holland, Inc., 1977.

16. Holz, B. W., et al., Manpower Planning Models: COMPLIP and CHAMP. Office of the Assistant Secretary of the Army—Manpower and Reserve Affairs, Washington, DC, January 1972.

17. Hutchins, E. S., et al., Computer Models for Manpower and Personnel Management: State of Current Technology. Navy Personnel Research and Development Laboratory, Washington, DC, April 1973.

18. Jaquette, D. L., G. R. Nelson, and R. J. Smith, An Analytical Review of Personnel Models in the Department of Defense. The Rand Corporation, Santa Monica, CA, September 1977.

19. Johnson, L., Probabilistic Manpower Planning for the R & D Organization. U. S. Army Missile Command, Research and Engineering Directorate, Redstone Arsenal, AL, November 1969.

20. Malone, T. B., et al., Human Factors Techniques Employes in Deriving Personnel Requirements in Weapons System Development. The Matrix Corporation, Alexandria, VA, October 1967.

21. Management Engineering Division, HQ AFSC, Systems Acquisition Manpower Models: Multivariate Statistical Models for Program Office Manpower Requirements, Andrews Air Force Base, MD, April 1977.

22. Management Engineering Team (MET) 25, AFSC, Manpower Standards Study Final Report. Kirtland Air Force Base, NM, July 1980.

23. Manheimer, B. H., S. R. Goldberg, and G. L. Pfeiffer, Predicting the Corrective Maintenance Burden. Bureau of Naval Personnel, Washington, DC, April 1963.

24. Milkovich, G. T., A. J. Annoni, and T. A. Mahoney, The Use of the Delphi Procedures in Manpower Forecasting. Office of Naval Research, Washington, DC, 1972.

25. Mitchell, et al., Handbook of Forecasting Techniques. U. S. Army Corps of Engineers, F. Belvoir, VA, December 1975.

26. Norden, P. V., "Applications of the Life Cycle Model to Project Manpower Planning and Control," In W. N. Jessop, Manpower Planning. NY: American Elsevier Publishing Company, Inc., 1966.

27. Rudevich, B. H., et al., Manpower Planning Handbook, Volume II, NavCommSta Electronics Maintenance Division, Office of Naval Research, Washington, DC, August 1975.

28. Sauer, D. W. and W. B. Askren, Validation of an Expert Estimate Technique for Predicting Manpower, Maintenance, and Training Requirements for Propcsed Air Force Systems. Air Force Human Resources Laboratories, Brooks Air Force Base, TX, May 1978.

29. Trozzo, C. L., Description and Critique of Quantitative Methods for the Allocation of Exploratory Development Resources. Institute for Defense Analysis, Arlington, VA, May 1972.

30. Turner, G. L. and R. McQuire, A New Model for Forecasting Air Force Plant Representative Office Manpower Requirements. Air Force Contract Management Division, Kirtland Air Force Base, NM, June 1975.

31. Watt, R. and G. R. Fitzpatrick, Civilian Manpower Projection Methodology. General Research Corporation, McLean, VA, December 1974.

DoD'S PROCUREMENT WORKLOAD VERSUS WORKFORCE -- A GROWING IMBALANCE

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Between 1975 and 1980 DoD's procurement workload increased significantly in both size and complexity. Individual procurement actions were larger and more complex, requiring more effort as well as higher degrees of skill and judgment from procurement personnel. At the same time, the total number of people in the procurement workforce increased. However, the increase in personnel was uneven and did not keep up with the increase in workload at all procurement activities. There were excessive personnel losses, especially at activities that were already understaffed, and these losses lowered the skill levels of the workforce.

WORKLOAD

The total number of procurement actions completed by the four major DoD components (Army, Navy, Air Force, and Defense Logistics Agency) during FY 1980 was 13% greater than that completed during FY 1975 (11.4 million versus 10.1 million). Total dollars, adjusted for inflation, increased by 24% over the same period. An upward trend in the dollar value of individual actions had a significant effect on workload during this time. Simplified purchase procedures followed in transactions of less than $10,000 could not be used in buys over $10,000. Once that $10,000 threshold was breached, additional requirements became applicable. The number of actions of $10,000 or more in FY 1980 was 41% greater than in FY 1975. The increase in the small purchase threshold to $25,000 will grant some measure of relief. However, the number of actions of $25,000 or more in FY 1980 was 56% greater than in FY 1975. Still other requirements, adding both time and complexity, apply to procurements of $100,000 or more, and the number of those actions increased by 63% from FY 1975 to FY 1980.

COMPLEXITY

Many requirements that add to the complexity of procurements result from legislative and administrative requirements introduced or emphasized in the past 10 years and the technical, fiscal, and economic factors which, together, have brought the acquisition process to its current state of complexity.

1. Renewed emphasis on contracting out
2. Preference for small and disadvantaged businesses
3. Increased concern for cost and readiness of systems
4. Cost accounting standards
5. Commercial products
6. Cost of capital
7. International cooperation and foreign military sales
8. Source selection
9. Increasing production lead times
10. Increasing technical sophistication
11. Declining size of the defense industrial base
12. Inflation
13. Aging weapons
14. Modifications to the Buy American policy
15. Large number of dollar thresholds in DAR

Renewed emphasis on contracting out

It has been and continues to be the general policy of the Government to rely on competitive private enterprise to supply the products and services it needs. This policy was stated as early as 1955 and later prescribed in Circular A-76, issued in 1966 and revised and reissued in March 1979.

The revised circular reaffirmed the general policy of reliance on the private sector for goods and services, while recognizing that certain functions were essentially governmental in nature and must be performed by Government personnel. It also reaffirmed that relative cost must be considered in decisions between in-house performance and reliance on private commercial sources.

A decision for in-house performance based on economy must be supported by a comparative cost analysis. This in-house cost estimate is compared with a contract cost figure based on a binding firm bid or proposal. While the procedures and the participants vary among organizations, buyers and the procurement office usually are deeply involved in the analysis. One irony is that a decision to contract out a function previously done in-house often leads to an across-the-board reduction in personnel authorizations including the procurement office which gains, rather than loses, workload from contracting out.

Preference for small and disadvantaged businesses

The amendments to the Small Business Act legislated by P.L. 95-507 have had a twofold effect on the procurement process. One major provision of the legislation is that, with some exceptions, all purchases of $10,000 or less which are subject to small purchase procedures are small business-small purchase set-asides. In FY 1980, more than 10.8 million DoD transactions met the dollar limits of the small business-small purchase set-aside criteria.

Most procurements suited to automation are for $10,000 or less and, therefore, subject to these set-asides. DoD activities have had to screen all computer programs to ensure removal of large businesses from bid lists, basic ordering agreements, and indefinite quantity type contracts which are now reserved for small businesses.

These amendments have had several results:

1. Many no-bids or rejections of orders have been encountered. Purchasing activities have found that many small concerns which had requested inclusion on bidders' mailing lists are not able to supply the particular product.

2. By restricting sources to small businesses, purchasing offices frequently must deal with distributors rather than manufacturers. These distributors often may be unable to deliver on time, their prices are higher, and they may not pass on warranties offered by the manufacturer.

3. There are varying degrees of understanding as to what documentation is needed to support a contracting officer's determination that there is no reasonable expectation of receiving competitive quotations.

4. When no quotes or no competitive quotes are received, the resolicitation on a non-restrictive basis is duplicate work and takes extra time.

The second major provision of P.L. 95-507 requires the successful offeror to submit a separate plan for subcontracting with small business concerns and with small disadvantaged business concerns whenever the proposed contract is expected to exceed $500,000 ($1 million for construction contracts). The contract specialist must determine the adequacy of the subcontracting plan before the contract can be awarded. It requires extra effort to obtain, evaluate, and negotiate these subcontracting plans and adversely affects procurement workload and administrative leadtime. In FY 1980 DoD awarded 14,821 contracts in excess of $500,000.

The Federal preference for small and small disadvantaged businesses includes a program to foster business ownership by socially and economically disadvantaged individuals. The program is authorized by Section 8(a) of the Small Business Act. Under the program, the Small Business Administration (SBA) may select firms to perform DoD contracts as subcontractors to the SBA. Any costs that the proposed subcontractor may anticipate in excess of the current fair market price are identified as business development expenses and must be borne by the SBA. The contracting officer must make arrangements with the SBA to reimburse DoD for such expenses before the procurement can be awarded. In addition to these unusual arrangements, the proposed subcontractor usually is not familiar with DoD contracting procedures and requires extensive explanations and advice. Each DoD procurement activity has goals, established by negotiation between DoD and the SBA, for specific dollar amounts to be awarded annually under this program.

Increased concern for cost and readiness of systems

In the past 10 to 15 years, DoD has started several different programs to contain the cost of developing and operating weapon systems. The programs include direct attempts at predicting and influencing costs such as life cycle costing, design to cost, reliability improvement warranties, and value engineering. There also have been programs that seek to control and reduce overall costs by reducing the frequency of failures and the time it takes to get a failed item back in use, as well as by improving the front end logistics planning.

All of these efforts are implemented as contract requirements and, as such, require extra effort in the planning, negotiation, and performance stages. Any such program new to either contracting officials or contractors, or both, requires extra effort. Even after both parties are familiar with a program, the process is complicated by added variables and work required over and above that necessary for any variation of the straight "you perform, we pay" contract.

Cost accounting standards

The Cost Accounting Standards Board (CASB) was created by Congress in 1970 to promulgate cost accounting standards designed to achieve uniformity and consistence in the cost accounting principles followed by defense contractors and subcontractors under Federal contracts. The standards are used by all relevant Federal agencies and by defense contractors and subcontractors in estimating, accumulating, and reporting costs in connection with the pricing, administration, and settlement of negotiated national defense prime contracts and subcontracts in excess of $100,000. Excepted are contracts and subcontracts where the price negotiated is based on (1) established catalog or market prices of commercial items sold in substantial quantities to the general public, or (2) prices set by law or regulation.

The CASB developed and issued, in the period 1972-1980, 19 cost accounting standards as well as regulations dealing with the disclosure of cost accounting practices and the application of standards in the procurement process.

The principal burden of compliance with the standards, rules, and regulations of the CASB is borne by the companies who hold defense contracts and subcontracts and who meet the dollar thresholds. Although a CAS clause is included in most negotiated defense contracts and subcontracts exceeding $100,000, the CASB eased the burden somewhat by establishing (in 1974) a $500,000 threshold to activate the provisions and (in 1977) a $10 million ceiling for a modified contract coverage.

Within DoD, the principal burden for administration of CAS requirements is carried by the contract administration activities of DLA and the military services and the auditors of the Defense Contract Audit Agency. For the most part, contract specialists in procurement activities have the lightest burden. In almost all cases, their involvement begins with insertion of appropriate provisions in solicitations and ends with negotiation of the appropriate clause or clauses for the contract.

Commercial products

DoD Directive 5000.37, issued in September 1978, renewed emphasis on use of commercial, off-the-shelf products and commercial distribution channels in supplying commercial products to users.

While these practices can clearly benefit the Government, they nonetheless create additional workload for the procurement activity. The contract specialist becomes involved at two points in the acquisition of commercial products. The first involvement may be peripheral, in selecting or developing the commercial specification to replace the MILSPEC. The second is in determining whether the tendered product will meet the user's requirements. The contract specialist no longer can rely on the MILSPEC to provide this assurance. In the absence of a Government specification for a product, many suppliers can offer different products, all of which may, or may be claimed to, meet the Government's requirements. Assurance that a commercial product will meet the need is accomplished by the requirement that it have a commercial market acceptability. This procedure requires a review and analysis of the sales history of the offeror's product, adding to the overall procurement workload.

Cost of capital

The introduction of Cost Accounting Standard (CAS) 414 in 1976 led to revised DAR weighted guidelines for determining profit objectives on negotiated procurements and added a new complication to the contract specialist's work — the recognition of return on facilities capital as part cost and part profit.

Weighted guidelines are used by contracting officers to determine a profit objective on negotiated contracts over $100,000. If a contractor claims cost of facilities capital under CAS 414, the contracting officer must reduce that portion of the profit objective based on contractor effort by applying an offset factor of 0.7. On the other hand, to determine that portion of the profit objective based on a contractor's use of facilities capital, the contracting officer applies a rate of 16 to 20 percent to the estimated facilities capital allocated to the contract.

International cooperation and foreign military sales

New and complex factors are introduced when contracting pursuant to international cooperative arrangements. The controlling mechanism in such arrangements usually is a memorandum of understanding (MOU). This document delineates areas of agreement on assignment of authority and matters relating to items such as finance, security, intellectual property rights, quality control, management structure, trade agreements, taxes, duties, sales, and transfer. Many, if not all, affect the contracting process to some degree.

Foreign firms often are involved either in development and production of discrete parts of programs or are linked in joint ventures with domestic firms for the whole program. Complexities, resulting from differences in language, laws, monetary systems, accounting practices, and ownership of special tools and facilities, must be dealt with.

Many of the factors present in dealings involving international cooperative agreements also may be present in contracts for military equipment to be sold to foreign governments. In addition, issues may be introduced because the foreign purchaser is bearing the ultimate cost and hence has a strong proprietary feeling about matters in the contracting process. If the foreign purchaser lacks clear understanding of U.S. procurement laws, regulations, and practices, enormous complications may be introduced and often slow the entire process.

Source selection

DoD has adopted a formal four-step source selection procedure for competitively negotiated research and development acquisitions, and the procedure may be used for any other acquisition. The four steps are submission and evaluation of technical proposals, submission and evaluation of cost proposals, establishment of the competitive range and selection of the apparent successful offeror, and negotiation of a definitive contract.

This formal procedure differs from the procedure it replaced largely in the provision for sequential, rather than simultaneous, submission and evaluation of technical and cost proposals. Written or oral discussion with all offerors in the competitive range, required by law, are constant features of procurement by negotiation. Source selection, if judged by the outline in the Defense Acquisition Regulations, is a logical means for making the ultimate selection from among competing offerors. However, the implementation of the DAR requirement in major program competitions typically uses a source selection official, a board that makes recommendations to the selection official, and separate teams of experts that evaluate the technical and cost details of all proposals and report their findings to the board. The complete process requires large amounts of time and human resources to help reach a decision as to which proposal is most advantageous to the DoD.

Increasing production lead times

The span between authorization to begin work on a product and the time of delivery is increasing for several reasons. Limitations on productive capability, shortages of critical materials, contractors' preferences for commercial work, and the increasing technical sophistication of DoD's programs contribute to this condition.

The practical effect of longer lead time on contracting shows in two ways. In some cases, the challenge is to price the contract at a realistic level. Increased lead time makes forecasting contract costs and reaching agreement on contract price and other terms and conditions more difficult. This can result in the greater use of fixed-price incentive contracts or fixed-price contracts with provision for economic price adjustment, either of which adds work over and above that required for a firm fixed-price contract.

In other cases, notably in airframe, aircraft engine, and missile procurements, contractors must be authorized to begin work on planned programs years before the final congressional approval of the programs is received. Under special conditions, contractors are authorized to place orders for specified long lead time items and reimbursement provisions are established. These arrangements give contractors somewhat of a "blank check," which contract specialists limit by constructing safeguards on a contract-by-contract basis. The problem grows more acute as the lead times increase. Currently, some airframe and engine parts have as much as a 50-month production lead time.

Increasing technical sophistication

With continuing rapid advances in many technologies, the promise of greatly increased capabilities can lead planners to specify more complex defense weapons. It is more difficult to specify the contract requirements for such weapons and consequently to estimate the costs of contract performance. It frequently takes more time and greater skill to establish contract procedures for measuring weapon system performance and to negotiate reasonable contract pricing arrangements. These conditions have resulted in development and use of should cost studies, performance and delivery incentives, life cycle cost estimates, design to cost goals and incentives, and reliability improvement warranties. This, in turn, means extra work for many in all phases of the acquisition process because use of any of these devices must be tailored to the circumstances of the particular acquisition.

Declining size of the defense industrial base

A combination of factors is causing a continued shrinking of the number of companies available for contracting with DoD and making it more difficult to conclude mutually satisfactory agreements with those still in the base. Findings cited in the Summer 1980 Defense Science Board task force report include:

- Productivity in the defense sector has been lagging, in large part because of low levels of capital investment compared to U.S. manufacturing in general.
- The larger defense firms are now part of multi-market corporations. In the competition for capital, the return on investment for defense markets is not favorable.
- Cash flow problems, tax policies, high interest rates, and inflation have all tended to discourage needed investment.
- The instability of defense programs has made the business less attractive, and has led to low investment in productivity.
- Unrealistic inflation factors are being used in DoD planning and budgeting.
- Lead times have increased markedly in the last three years, leading to higher costs.

- The subcontractor and supplier bases have decreased. The factors for the loss in the lower tier base include small quantities, annual buys, DoD contracting requirements, high cash requirements, and returns not consistent with risks.
- Prime contractors do not routinely "flow down" beneficial provisions of their contracts to subcontractors and suppliers.

Cost accounting standard requirements have been cited as major factors causing companies in certain industries to reassess continued participation in defense business. Large companies, such as U.S. Steel and Alcoa, which, in relative terms, sell little to DoD and its prime contractors, have viewed CAS requirements with ill-disguised antipathy. Oil companies, large and small, have expressed considerable opposition to the application of CAS to their industry, and CAS has been cited as one reason many specialty manufacturers, both prime contractors and subcontractors, have left the defense industrial base.

A reduced base makes it necessary to spend more time finding suppliers and the new suppliers are unfamiliar with the rules governing DoD procurement. If they must be dealt with on a noncompetitive basis, contract specialists will spend more time evaluating responses and negotiating agreements with them. For larger buys, these problems may be transferred to the prime contractor lining up subsystem, component, and materials suppliers, and may result in longer lead times. The longer the time span, the more difficult it may be to come up with a realistic estimate of costs and a suitable contractual arrangement for shifting or reducing the risks of inflation.

Inflation

Inflation makes the procurement function more complex and time consuming. The persistence of high inflation has increased the use of economic price adjustment (EPA) clauses and reduced the acceptability of firm fixed-price contracts. Use of an EPA clause means extra work for contract specialists. Although the DAR contains model EPA clauses, each must be customized for a contract, so that movement in the index will approximate that expected of the contract cost elements to be covered.

Further, inflation pushes a greater proportion of contracts over established dollar thresholds, thereby triggering additional reviews, clearances, and other requirements.

Aging weapons

The DoD operational inventory, as well as the inventories of nations which have bought or were given U.S.-made weapon systems, contain some old, out-of-production weapons. Procurement support of these older systems is made difficult by a number of factors:

1. technological obsolescence and small quantity purchases which individually or together effectively reduce the number of companies able or willing to do the work,
2. lack of specifications and detailed drawings needed to manufacture certain components and subsystems, and
3. relatively high unit cost of items procured in this kind of market.

Older systems are not always phased out as new systems move through to full-scale development and then to production and into the operational inventory. Frequently, the older systems are modified or modernized to improve performance or adapt to new missions. This can strain the resources of the system acquisition activity which must continue to staff and support old program offices, even as developing systems create the need for a contracting capability in new program offices.

Modifications to the Buy American policy

The Buy American Act generally provides that only domestic end products shall be acquired for public use in the United States. One of the exceptions to the Act applies when the Secretary concerned determines that the cost of a domestic end product would be unreasonable.

Historically the determination as to reasonableness of cost of domestic end products was made by adjusting foreign offers by stipulated amounts and evaluating the competing offers as adjusted. As closer cooperation has developed between the U.S. and its allies, and as agreements have been implemented to relax trade barriers, numerous modifications have been introduced into the Buy American policy.

There are "defense cooperation countries" for which the Buy American Act restrictions have been waived for certain items. There are "FMS/offset arrangement countries" for which waivers of Buy American Act restrictions are dealt with on a case-by-case basis. There are "participating countries" for which a blanket waiver of Buy American Act restrictions has been made. Finally, there are "designated countries" under the Trade Agreements Act of 1979 from which certain designated non-defense end items in procurements of more than $196,000 (since adjusted to $182,000) can be made without regard to the restrictions of the Buy American Act. DoD also has implemented its Balance of Payments program which essentially applies the same evaluation criteria to procurement of goods and services for use outside the United States.

The net result is an extremely complex set of circumstances under which contracting officers must determine the status of the country of origin of the products offered, the status of the items being procured, and the appropriate factors to be applied in the evaluation process, in order to structure the request for bids or proposals, and to establish the acceptable low proposal.

Large number of dollar thresholds in DAR

Indications as to the relative complexity of a procurement also can be derived from analysis of regulatory requirements activated at specific dollar levels. As of 1 May 1981, there were 317 special requirements in the DAR activated at one of 49 dollar thresholds, as summarized in the following table. (Provisions of the FY82 DoD Authorizations Act (P.L. 97-86) raised, but did not remove, certain thresholds.)

DAR DOLLAR THRESHOLDS REQUIRING OR PERMITTING SPECIFIC ACTIONS
(AS OF 1 MAY 1981)

Dollar Threshold	Number of Actions	Dollar Threshold	Number of Actions
$25 or less	3	More than $250,000	3
$50 or more	1	Not less than $300,000	1
$100 or less	3	$350,000 or less	1
$150 or less	1	More than $350,000	1
More than $250	1	$500,000 or less	3
$500 or less	2	More than $500,000	10
More than $500	2	$1 million and less	2
$1,000 or less	7	More than $1 million	13
$1,000 or more	8	$2 million or less	2
$2,000 or less	1	More than $2 million	3
More than $2,000	8	$3 million or less	2
$2,500 or less	8	More than $3 million	2
More than $2,500	11	$5 million or less	2
More than $5,000	6	More than $5 million	3
$10,000 or less	39	$10 million or less	1
More than $10,000	63	More than $10 million	1
$25,000 or less	8	$15 million	1
More than $25,000	13	$20 million or less	1
$50,000 or less	9	$25 million or less	1
More than $50,000	10	More than $25 million	2
$100,000 or less	13	More than $35 million	1
More than $100,000	36	More than $50 million	1
More than $196,000	1	More than $100 million	1
More than $200,000	3	More than $200 million	1
$250,000 or less	1	Total actions	317
		Total thresholds 49	

WORKFORCE

The civilian procurement workforce, measured by the Office of Personnel Management's contract and procurement occupational series, GS-1102, increased by 14.5% between FY 1975 and FY 1980, although the increases were not uniformly distributed among or within the DoD components.

Skill levels, judged by length of service and separation rates decreased significantly. The average length of service for GS-1102s dropped significantly in several purchasing activities in those six years. The separation rates for GS-1102s were significantly higher than those for all DoD administrative personnel (which includes the GS-1102 series).

Excessive backlogs, increased investments in inventories, and increased use of unpriced contractual instruments are evidence of imbalances, as are excessive personnel loss rates, extensive use of overtime, use of less experienced personnel in negotiating major procurements, and inability to recruit applicants (even for higher grade vacancies).

Individual procurement activities compensated in various ways for the shortage of personnel. Several increased productivity by use of computers and word processing equipment. Many central procurement activities devised systems to identify and expedite the procurements that were most important to their customers. Some activities used upward mobility and other training programs to provide more stability to the available workforce.

SUMMARY

In summary, there is an imbalance between workload and staffing at many DoD activities, and where such imbalance exists, there is, to varying degrees, a degradation in the performance of the procurement function. This problem will be magnified as the DoD procurement budget increases. The solution is neither simple nor easy to attain.

Some relief from the increased complexity of individual procurement actions will result from recent legislative action to raise the dollar thresholds at which certain requirements apply. Increased use of computers and word processors should increase the productivity of the present workforce. Better records of work in process and on hand at each procurement activity and major command should allow more equitable distribution of available personnel and serve as a necessary first step to ensuring adequate staffing. DoD-wide use of work measurement and manpower utilization and projection systems should permit systematic assessment of the adequacy of the procurement workforce and document the need for adjustments.

These remedies are promising, but an increase in the number of people assigned is the only way to bring immediate help to procurement operations.

This article is based on Report, Procurement Workload Versus Workforce — A Growing Imbalance (AD No. A099-922), Robert S. Young, R. P. White, Thomas M. O'Hern; May 1981; LMI, 4701 Sangamore Rd., Washington, D.C. 20016.

PANEL L

COMPETITION

PANEL CHAIRMAN

Mr. J. Alan Muller
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COMPETITION OF DEFENSE PROCUREMENTS: EVIDENCE, THEORY, AND APPLICATION

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FOREWORD

This paper presents the results of acquisition research and analyses undertaken by the authors and their colleagues at The Analytic Sciences Corporation. Recent research efforts have concentrated on the development and refinement of a cost estimating model that incorporates consideration of production quantity, variations in production rate, and the impact of competition. This paper briefly describes the general model, presents empirical evidence of the impact of competition, discusses the implications of cost growth on the selection of an acquisition strategy, and concludes with an illustrative example.

1. INTRODUCTION

The use of competition as a means of reducing weapon systems acquisition cost is an often studied, yet still controversial area. Reasons for the contentious nature of the subject are numerous, and frequently involve one or more of the following:

- Differing data analysis procedures
- Differing interpretations of results from prior competitive programs
- Conflicting personal experiences
- Vested interests
- Political considerations.

The authors have conducted research and analysis in this area for some time. We have developed an analytic methodology, based upon empirical evidence, that incorporates the interrelationships of cost improvement curves, production rate variations, and competition on weapon systems' production costs. This methodology is explained in a paper recently published in CONCEPTS, the Journal of Defense Systems Acquisition Management (Volume 4, Number 4, Autumn 1981). In this paper, we summarize the methodology and present highlights of our more recent analyses.

First, the significance of production rate variations is discussed and our analytic (macro-level) methodology described. Results from a recent micro-level analysis of the impact of production rate variations are presented and compared to the macro-level methodology. Next, historical evidence is presented to demonstrate the positive impact on contractor cost behavior of competition during production. Our analytic methodology which captures this behavior is explained and documented. Results from a preliminary examination of potential cost growth is presented, and its relation to alternative acquisition strategies is explored. Finally, an example is presented which illustrates how these factors interact when applied to a hypothetical, yet realistic, tactical missile program.

2. THE RELATIONSHIP BETWEEN UNIT COST, PRODUCTION QUANTITY, AND PRODUCTION RATE

Analyses of weapon system acquisition costs often employ the concept of a cost improvement or learning curve as a cost estimation technique. In its simplest form, the cost improvement curve presents the percent reduction in unit cost as production quantity doubles. Thus, an 80 percent cost improvement curve presents a reduction in unit cost of 20 percent as production quantity is increased from N^{th} to the $2N^{th}$ unit.

The major shortcoming of this approach is that there is no reference to the rate at which this quantity is produced. The authors have developed a methodology that considers both production quantity and rate in predicting unit cost trends. The methodology involves a three-dimensional surface represented graphically in Figure 2-1.

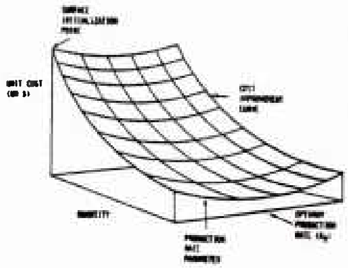

Figure 2-1 - Combined cost Improvement and Production Rate Effects

This general form of the unit cost surface has been developed based on detailed analysis of historical cost data and as such is a macro-level methodology. The methodology assumes a fixed production capacity and the existence of a most cost efficient or optimum production rate (denoted R_O in Figure 2-1). The initial reduction in unit costs as production rate increases results primarily from amortization of fixed costs, both direct and indirect, over an increased number of production units. The tendency of unit costs to increase after some optimal production rate is exceeded can be attributed to production inefficiencies that may arise from tooling or plant capacity limitations, excessive overtime or multi-shift operations, work flow bottlenecks or other diseconomies of scale.

The nature of these diseconomies will vary from program to program. For the sake of simplicity, we have assumed that the trend in unit cost increases beyond the optimum rate is opposite in slope to the unit cost decreased which occur below the optimum rate. This assumption, consistent with traditional economic theory, yields a uniform u-shaped curve expressing the relationship between unit cost and production rate.

The true shape of the production rate curve is an area of great theoretical contention. Several shapes of the curve beyond the optimum have been postulated. In reality, the effect of production rate on unit cost may take several forms, depending on the pecularities of an individual production line. However, with no justification to favor one formulation over the other, the symmetric curve chosen appears reasonable for the general case.

The general cost improvement curve and production rate surface can be projected using a basic formula which predicts unit production cost as a function of the cumulative quantity produced and the current production rate. Mathematically, this is expressed as follows:

$$Z = AX^BY^C.$$

where

Z = unit cost of the X^{th} item produced

A = constant referred to as "first unit cost" or surface initialization point

X = cumulative quantity produced

B = coefficient which describes the slope of the quantity/cost curve (ln cost improvement rate/ln 2)

Y = (proxy) production rate in effect defined as

- R if $R \leqq R_O$
- $2R_O - R$ is $R_O < R \leqq 2R_O - 1$

where R is the production rate in effect for a given lot and R_O is the optimal production rate.

C = coefficient which describes the slope of the rate/cost curve (similar to the cost improvement curve).

Production rate and cost improvement rate parameters for a particular weapon system are derived by detailed micro-level analysis of program specific cost estimating relationships. These relationships predict trends in specific categories of direct, indirect, fixed, and variable costs for a specific weapon system. A computer-based production cost model has been developed which incorporates these cost estimating relationships. The production cost model can be used to derive a series of lot cost/lot quantity projections from a number of hypothetical production schedules. These cost/quantity data sets are then analyzed using multi-variate regression techniques to derive production rate and learning rate parameters for the macro-level model which best characterize the unit production cost trends for an individual program. This process is graphically displayed in Figure 2-2.

This technique has been applied for a major missile program now entering production. The production rate and learning rate parameters derived for this program were consistent with values which had been derived from historical production cost data for other tactical missile programs. The consistency between the two approaches demonstrates the validity of the macro-model. The macro-model, based upon historical data, is supported by actual detailed contractor cost relationships. Thus, the macro-model is an accurate representation of contractor cost behavior.

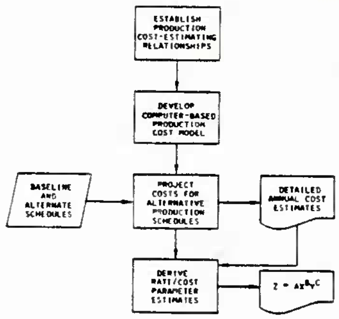

Figure 2-2 Process for Deriving Production Rate and Cost Improvement Rate Parameters

Furthermore, the micro-level analysis forms the foundation of a methodology that can be used in a predictive manner for an individual program. This predictive methodology is consistent with empirically demonstrated cost behavior.

A representative sample of production rate and cost improvement rate parameters derived from historical data is presented in Table 2-1. Both producers' cost parameters are presented for prior competitive programs where adequate data was available to undertake detailed analysis.

TABLE 2-1

PRODUCTION RATE PARAMETERS EVIDENCED ON PRIOR PROGRAMS

System	Producer	Unit Cost Improvement Rate	Unit Cost Production Rate Parameter
BASIC HAWK	RAYTHEON	.834	.969
SPARROW AIM-7F	RAYTHEON	.87	.985
	GENERAL DYNAMICS	.84	.923
BULLPUP AGM-12B	MARTIN	.82	1.004
TOW	HUGHES	.98	1.007
SIDEWINDER AIM-9L	FORD	.910	.754
	RAYTHEON	.870	.851
SIDEWINDER AIM-9B	GENERAL ELECTRIC	.900	.819
STANDARD	GENERAL DYNAMICS	.8019	.9555
MAVERICK	HUGHES	.857	.877
REDEYE	GENERAL DYNAMICS	.925	.790
MEAN VALUES FOR THIS SAMPLE		.873	.903

3. COMPETITION DURING PRODUCTION

Numerous studies have attempted to estimate the impact of competition on weapon systems acquisition costs. The results of some of these prior studies are presented in Table 3-1.

TABLE 3-1

RESULTS OF PRIOR STUDIES

Sponsor	Year	Number of Systems	Average Savings (%)
IDA	1979	31	31
APRO	1978	11	12
ARINC	1976	13	47
IDA	1974	20	37
LMI	1974	1	22
LMI	1973	NA	15-20
JNT ECON COMM	1973	20	52
ECOM	1972	17	50
BMI	1969	20	32
RAND	1968	NA	25
McNamara	1965	NA	25

The results of these aggregated studies show a large range of average net savings, varying from over 50% to 12%. By their very nature, these prior studies are historical and not directly applicable to a specific weapon system acquisition. They are relevant in that they empirically demonstrate that savings due to competition have been realized on prior programs.

A review of 45 individual programs using a common analytic framework indicates that potential savings are unique for each particular program. The common framework used cost improvement curves to assess the impact of competition on contractor cost behavior. The results, shown in Table 3-2, reflect calculation of percent savings based upon remaining production quantities. Percent savings represent the difference between projected single source costs and realized competitive costs. Costs incurred prior to competition were considered as sunk costs.

TABLE 3-2

PRODUCTION COST SAVINGS FROM COMPETING PREVIOUSLY SOLE SOURCE CONTRACTS

Programs	Savings (%)	Programs	Saving (%)
AN/APM-123	67.7	USM-181 Telephone Test Set	36.3
MK-980/PPS-5	66.5	Standard Missile, ER RIM 67A	34.0
AN/ARC-54	63.1	AN/SGS 23 208A Transducer	32.3
MK-48 Torpedo - Test Set	61.8	Tow Launcher	30.2
MK-48 Torpedo - Exploder	61.2	TD-660 Multiplexer	28.4
AN/GRC-103	60.1	BULLPUP 12B Missile	26.5
Standard Missile, MR RIM 66A	59.2	APX72 Airborne Transponder	23.3
AN/ARA-63 Radio Receiver	57.9	FAAR TADDS	18.2
TD-352 Multiplexer	55.6	FAAR Radar	16.6
60-6402 Electric Control	52.7	TOW Missile	12.3
MD-522 Modulator-Demodulator	51.9	Dragon Tracker	12.3
Hawk Motor Metal Parts	49.9	UPM-98 Test Set	11.5
MK-48 Torpedo - Warhead	48.6	AN/ASN-43	10.7
MK-48 Torpedo - Electric Assembly	47.0	SPA-25 Radar Indicator	10.7
CV-1548 Signal Converter	45.4	SHILLELAGH	9.4
AN/FYC-8X	43.2	Dragon Round	2.8
TD-204 Cable Combiner	42.0	Sidewinder AIM-9D/G	.7
AN/PRC-77 Radio	41.9	PP-4763/GRC Power Assembly	.5
AN/GRC-106	41.8	SPA-66 Radar Indicator	-3.4
TD-202 Radio Combiner	40.2	Rockeye Bomb	-4.5
FGC-20 Teletype Set	39.9	Sidewinder AIM-9B	-5.6
TALOS Missile	39.8	AN/ARC-131 Radio	-16.1

AVERAGE PRODUCTION COST SAVINGS FOR 45 PROGRAMS: 33%

The average savings of 33 percent, demonstrated by the 45 programs, is within the range of the prior studies. The review demonstrates that there are potential cost benefits associated with competition and that these potential benefits are determined by program specific characteristics.

Expressing savings as a percent of total program recurring costs for the same programs results in an average savings of 16 percent. These results demonstrate the large discrepancy that may arise strictly from employing different techniques in estimating potential savings due to competition.

Both estimating techniques were based upon changing cost behavior due to competition as evidenced by contractor cost improvement curves. Detailed unit cost analysis of prior competitive missile programs has demonstrated that competition results in:

- An instantaneous reduction in the original producer's unit cost, evidenced by a downward shift in the producer's cost improvement curve
- A steepening of the original producer's unit cost improvement curve, evidenced by a rotation of the producer's cost improvement curve
- A lower first unit cost for the second producer
- A steeper initial cost improvement rate for the second producer.

These impacts can be graphically presented as shown in Figure 3-1.

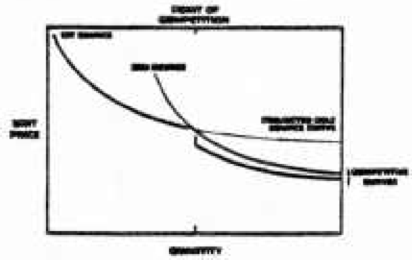

Figure 3-1 The Impact of Competition

Table 3-3 presents empirical evidence of second source behavior on prior tactical missile programs.

TABLE 3-3

THE IMPACT OF COMPETITION: SECOND SOURCE COST BEHAVIOR

Program	Cost Improvement Rates: First Source	Cost Improvement Rates: Second Source	Difference (%)	% First Unit Cost Reduction
SPARROW	.87	.84	3	14
BULLPUP	.82	.80	2	46
TOW	.98	.89	9	20
SIDEWINDER AIM 9B	.90	.83	8	17
SIDEWINDER AIM 9L	.91	.87	4	18
Average			5.2	23

In addition, similar behavior has been observed on other types of systems such as electronics and ships. The empirical data suggests a relationship between the cost and complexity of a system and the nature of the cost improvement curve of a second source. For less costly and complex systems, a second source can be competitive from the outset. As cost and complexity increase, more time is required for a second source to be competitive. Furthermore, in all cases where there was sufficient data to permit analysis, the slope of the cost improvement curve of the second source was steeper than that of the original producer.

This cost behavior by the second source applies competitive pressure to the original producer. His reaction to this pressure can be viewed as a shift and rotation of his cost improvement curve. Figure 3-2 graphically portrays this behavior using a log-linear formation of the cost improvement curve. The figure has been enlarged to dramatize the effects of competition on the original producer's unit costs. Table 3-4 presents observed shifts and rotations on prior missile programs.

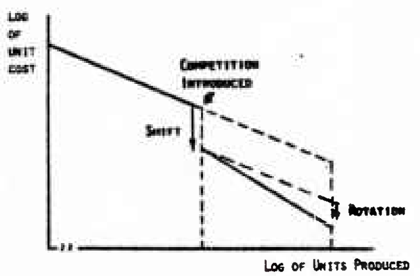

Figure 3-2 First Source Reaction to Competitive Pressure

TABLE 3-4

OBSERVED SHIFTS AND ROTATIONS ON PRIOR MISSILE PROGRAMS

Program	Contractor	(%)	(%)
SPARROW	Raytheon	8	10
BULLPUP	Martin	14	13
SIDEWINDER AIM 9B	General Electric	9	16
TOW	Hughes	15	32
SIDEWINDER AIM 9L	Raytheon	10	7

The historical data demonstrate the impact of competition on the original producer's cost improvement curve. The data also reveal that the magnitude of the shifts and rotations vary significantly. The concept of a "best competitive" cost improvement curve was developed to explain this variation, as shown in Figure 3-3.

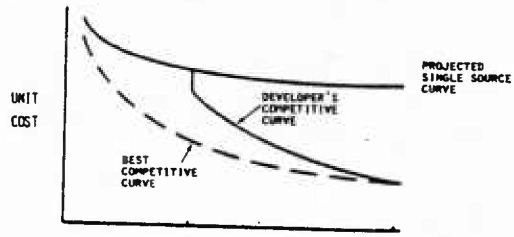

Figure 3-3 Best Competitive Curve

This curve represents the continuous cost improvement curve which begins with the historically derived, non-competitive first unit cost and achieves parity with the last competitive unit cost. It represents what "might" have happened had the original producer been under continuous competitive pressure from the outset.

Comparing the slope of the hypothetical "best competitive" curve with the slope of the historical single source curve reveals a statistically significant relationship displayed in Figure 3-4.

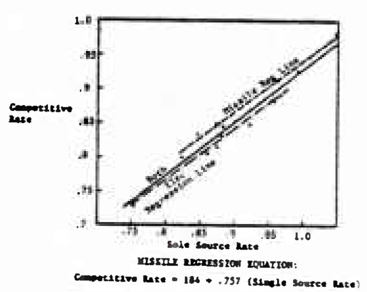

Figure 3-4 Correlation Between "Best Competitive" and Single Source Curves

The "best competitive" curve provides a consistent explanation of the observed cost behavior or the original producers. The observed shifts and rotations (of varying magnitudes) of the original producer's cost improvement curve can be characterized as "making up" for earlier cost improvements which were possible, but were unrealized in the absence of competition. Furthermore, the slopes of the hypothetical "best competitive" curves correspond well with the slopes of the competitive second source curves. In other words, the second producer, who is attempting to be competitive from the outset, follows a (historically derived) cost improvement curve very similar to the "best competitive" cost improvement curve calculated for the original producer. In addition, unit costs for the flatter portions of both curves are comparable.

Combining the empirically observed impact of production competition with the production cost surface results in a predictive methodology that incorporates consideration of competition, total quantity and production rate. This methodology, graphically displayed in Figure 3-5, can be used to assess alternative acquisition approaches for future production programs.

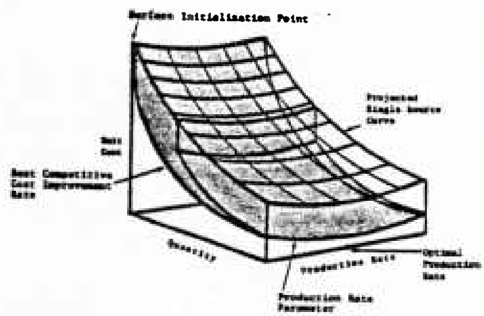

Figure 3-5 The Integrated Model

4. COST GROWTH AND COMPETITION

Cost growth, as measured by actual costs compared to a baseline cost estimate, is a continuous problem for most major weapon systems. Norman Augustine reported in a recent issue of Government Executive (Vol. 14, No. 2, February 1982) that he has evidence that shows (after eliminating the effects of inflation and after adjustment for changes in procurement quantity):

- The chances of a major program being completed within its initial cost estimate is about 9%
- The chances of a major program being completed with no more than a 50% cost overrun is no more than about 70%

- The median overrun is about 32%
- The average overrun is nearly 52%.

The authors examined the subject of cost growth and how it varies for competitive versus non-competitive programs for programs which submit Selected Acquisition Reports (SARs). Data for the analysis were obtained from the SAR Program Acquisition Cost Summaries spanning the period December 1975 through June 1981.

Table 4-1 displays the growth in total program cost estimates during FSD for the programs included in the SAR data. Table 4-2 displays the additional cost growth during production for the SAR programs.

TABLE 4-1

TOTAL PROGRAM COST GROWTH DURING FSD

NON-COMPETITIVE FSD

PROGRAM	COST GROWTH (%)
Sidewinder AIM-9L	89.8
SPARROW AIM-7F	38.2
Patriot	20.8
M-1	80.5
Roland	55.2
Copperhead	21.7
M-198	38.4
Hellfire	54.0
CH-47 Mod	12.5
B-1	12.2
F-16	26.8
E-4	52.0
EF-111A	60.0
AEGIS	27.8
Captor	87.7
Condor	29.5
Harpoon	12.8
Trident	6.5
PHM	20.1
F-18	58.2
Average	40.2

COMPETITIVE FSD

PROGRAM	COST GROWTH (%)
UH-60A (Black Hawk)	-8.5
ALCM	14.4
DIVAD Gun	0.2
Average	2.0

TABLE 4-2

TOTAL PROGRAM COST GROWTH DURING PRODUCTION

NON COMPETITIVE PRODUCTION

PROGRAM	COST GROWTH (%)
UH-60A (Black Hawk)	22.5
M-198	-16.0
F-16	22.4
E-3A	5.3
Captor	38.0
Harpoon	25.2
Trident	5.8
PHM	-1.3
Average	12.7

COMPETITIVE PRODUCTION

PROGRAM	COST GROWTH (%)
SIDEWINDER AIM-9L	19.0
SPARROW AIM-7F	9.4
SSN-688	-3.6
FFG-7	13.8
Average	9.65

Although the quantity of data in each category is too limited to obtain statistical confidence, the implications are clear. As shown, a significant portion of the growth in total program cost estimates occurs during FSD. Furthermore, the presence of competitive pressure during Full-Scale Development greatly reduces cost growth compared to a non-competitive environment. Competition during production also appears to suppress cost growth, but not as dramatically as competition during FSD. None of the programs in the data sample maintained competition during both FSD and production.

Historical evidence indicates that competition is an effective means of suppressing cost growth. Additional funds are required to maintain competitive pressure, and the program office must assume additional managerial responsibilities. For many programs, these additional costs may be justified solely on the basis of suppressing future cost growth.

5. EXAMPLE CASE

This example case is intended to provide illustrative results for a hypothetical missile Full-Scale Development and Production program. This hypothetical case is representative of recent research performed by the authors on several tactical missile programs. Program specific model parameters are derived, recurring production costs are estimated, and sensitivity analyses are conducted to identify key program cost factors.

Recurring production cost estimates are assumed to be provided by the Program Office (see Table 5-1). As such, these estimates represent a consolidation of an independent government estimate and the contractor's bid estimate for a single source FSD and production program.

TABLE 5-1

PROGRAM OFFICE PROVIDED RECURRING COST ESTIMATES (80$)

LOT NO.	LOT QUANTITY	RECURRING COST (MIL. $)	AVG. UNIT COST ($)
1	836	206	245,957
2	2224	361	162,316
3	3000	409	136,410
4	3000	377	125,650
5	6000	701	116,742

Fitting the average unit costs by lot to the single source surface results in the program unique parameters shown in Figure 5-1.

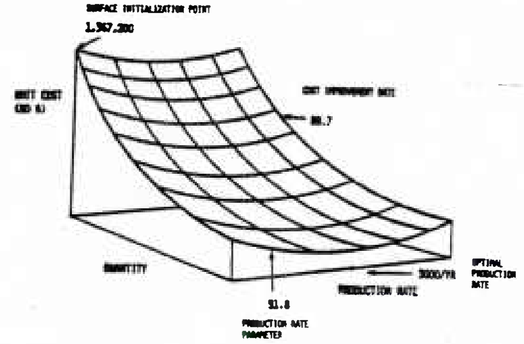

Figure 5-1 Single Source Surface Parameters

Table 5-2 presents the error terms associated with these parameters in predicting recurring costs. As shown, the model parameters, and thus the model surface, accurately reflect single source program costs.

TABLE 5-2

RECURRING COST BY LOT
MIL. 80$

LOT#	PROGRAM OFFICE ESTIMATE	MODEL ESTIMATE	DIFFERENCE (%)
1	205	205	0.0
2	361	362	-0.3
3	409	409	0.0
4	377	377	0.0
5	701	700	0.1

The surface predicts single source recurring costs accurately. Based on the observed empirical impact of competition, cost estimates for two alternative competitive approaches have been calculated.

The first competitive approach involves the second producer in a competitive development effort during the first half of FSD. At the midpoint, a design is selected and the losing contractor becomes a follower of the system developer in a leader/follower arrangement. Competitive awards begin with lot three. The second approach brings the second producer into the program in lot two through a technical data package transfer. Competitive awards do not begin until lot four.

Estimated recurring production costs for the various approaches are presented in Table 5-3. The associated non-recurring costs for each alternative approach are also shown. Non-recurring costs were estimated based upon hypothetical contractor and program office provided data.

TABLE 5-3

REPRESENTATIVE COST ESTIMATES FOR
ALTERNATIVE STRATEGIES
(MIL. 80$)

COST ELEMENT	SINGLE SOURCE	COMP. FSD PRODUCTION	SECOND SOURCE
FSD	425	455	425
NON-RECURRING PRODUCTION	90	145	165
RECURRING PRODUCTION	2053	1781	1848
TOTAL	2568	2381	2418

The two competitive approaches demonstrate potential recurring cost savings of $272 million for the leader/follower approach and $205 million for the second source approach. These represent a return on investment of 3.2 to 1 and 2.9 to 1, respectively. Given the baseline program, there are significant cost benefits associated with competition. The cost estimates shown in Table 5-3 do not include potential cost growth. Potential cost growth is considered following some representative sensitivity analyses.

Variations in the baseline program parameters may have a significant impact on the estimated recurring costs. Prior research has indicated that three key factors are major determinants of recurring costs:

- Timing of competition
- Second source cost improvement rate
- Production rate parameter.

Variations in these key parameters are briefly investigated.

Figure 5-2 presents the impact of delaying competition on recurring production costs. As shown, the earlier competition can be held, the greater the potential costs reductions. Potential savings are greater, the earlier competition is held, because the original producer begins to move toward his best competitive curve sooner.

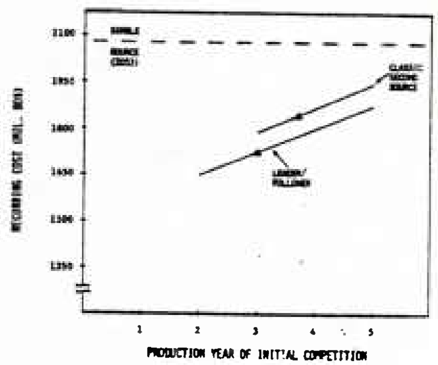

Figure 5-2 Timing of Competition

Potential savings are also sensitive to the second producer's cost improvement rate. Figure 5-3 demonstrates this sensitivity in terms of recurring production costs.

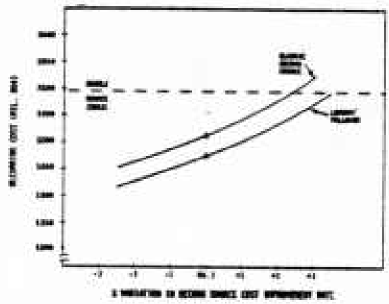

Figure 5-3 Second Source Cost Improvement Rate

The second source's cost improvement rate drives not only the second producer's cost but also the competitive pressure that results in the original producer's reaction. Fortunately, this is a variable that the government can influence. By developing and implementing a good technology transfer program the government can enhance the second producer's cost improvement rate, thus influencing his costs. Recurring costs are also affected by the production rate parameter as shown in Figure 5-4.

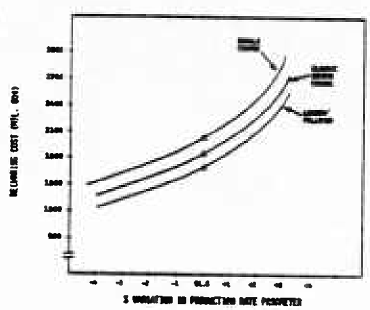

Figure 5-4 Production Rate Parameter

Variations in the production rate parameter results in exponential variations in recurring costs. Clearly the parameter is a significant determinant of cost; however, since all alternatives evidence the same impact, it is not a key factor in the dual source/single source decision.

Another key factor that must be addressed is the relative ranking of the alternatives when considering potential cost growth. Figure 5-5 presents a range of toal program cost estimates for each alternative based upon a reasonable range of potential cost growth during development.

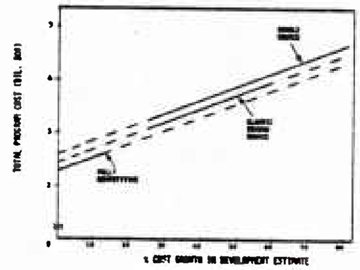

Figure 5-5 The Impact of Cost Growth

As discussed, the significant portion of growth in total estimated program costs on prior programs occurred during the development phase. The high variance in cost growth between competitive and single source development results in the leader/follower approach being vastly preferred over the other alternatives. The difference is highlighted by the numerical example shown in Figure 5-6.

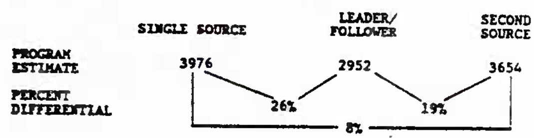

Figure 5-6 Cost Estimates Including Potential Cost Growth (Mil. 80$)

Clearly one of the greatest benefits of competition is the control of cost growth. Often, acquisition strategies are developed based upon suppressed baseline cost estimates. When consideration of potential cost growth is incorporated, the benefits of competition are clear. The additional initial funding is more than recovered.

This example, although representative, is based on actual program experience. The example has served to demonstrate:

- The predictive capability of the analytic model
- The potential cost benefits of competition
- The importance of early planning and the timing of competition
- The criticality of technology transfer and the second source cost improvement rate

- The need for detailed study of the impact of production rate factors on unit cost
- The significant benefits of competition in controlling cost growth.

ECONOMIC ANALYSIS OF A PROPOSED USE OF SECOND SOURCING

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ABSTRACT

This paper discusses a predictive model designed to facilitate economic analysis of second sourcing. The model is based in part on previous second source experience in tactical missile procurement and was developed to evaluate second sourcing of the imaging infrared (IIR) Maverick missile (AGM-65D).

First, a probable sole source progress curve was constructed using data from both the earlier TV Maverick and the current AGM-65D programs. Then consideration was given to the probable nonrecurring start-up costs of qualifying and equipping a second source for production. Finally, previous second sourcing experience in tactical missile procurement was reviewed to quantitatively measure the impact of competition on sole source progress curves and on the resulting second sourcing acquisition cost. After extending previous experience in similar systems to the systems at hand, the nonrecurring start-up costs were subtracted from the difference between sole source and second source acquisition costs to get a net savings (loss).

This predictive model differs from previous second source models by the construction of a composite progress curve for split-buy competition awards. The composite curve predicts competitive cost without predicting how individual contractors would fare in a succession of competitions for part or all of the production. Still, the composite progress curve formulation permits sensitivity analysis for the purpose of determining how program savings change with changes in total quantity produced, the timing of initial competition, and the sole source and competitive progress curve parameters.

This paper was prepared for presentation at the 1982 Federal Acquisition Research Symposium, May 5-7, 1982, held in Washington, D.C. The views expressed in this paper are the authors' own and are not necessarily shared by ANSER or its research sponsors. The paper is based on research performed in partial fulfillment of Contract F49620-82-C-0003. This subject is covered more fully in a briefing provided by the authors to the research sponsor [Ref. 1].

OVERVIEW

Although competition is less common in the production phase of military systems acquisition than it is in the R&D phase, competition for production is generally considered to be beneficial for system performance, system availability, total program cost, or the health of the industrial base. In this context, we were tasked to determine whether financial savings might be realized if the Air Force was to establish a second production source for the imaging infrared (IIR) version of the Maverick air-to-surface missile.

The purpose of this paper is to present our approach to the well-known problems [Ref. 2] associated with secondary sourcing analysis. Because certain quantitative aspects of this ongoing program are competition-sensitive, we fictionalized certain aspects of the analysis while faithfully demonstrating our procedures.

Second sourcing can of course take many forms. A <u>given</u> for our analysis was that the second sourcing approach contemplated by the System Program Office (SPO) was via a technical data package (TDP). More specifically, for the purpose of this analysis, second sourcing was defined to be a procurement strategy whereby the SPO 1) obtains and validates a technical data package, 2) selects a second source contractor, 3) manages a second source qualification program, and 4) conducts subsequent competitions between two producers.

Our basic approach to determining probable savings or loss in second sourcing the missile is represented in the following relationship:

$$NS = RC_A - NC_B - RC_{A/B}$$

where,

NS = Net Savings

RC_A = Probable recurring cost of the total AGM-65D buy from the developer (Contractor A) on a sole source basis,

NC_B = Probable nonrecurring cost to qualify and equip a second source (Contractor B) for production,

$RC_{A/B}$ = Probable recurring cost of the total AGM-65D buy from Contractor A and Contractor B in competition.

PROBABLE SOLE SOURCE COST

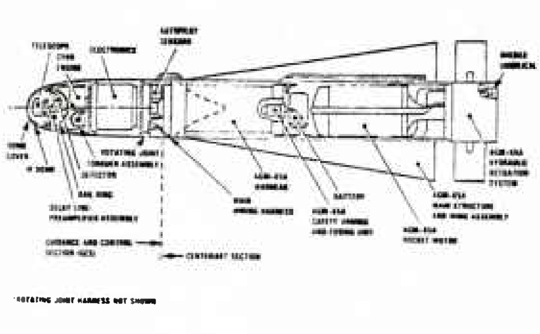
The Maverick missile consists of two sections as shown in Figure 1, the guidance and control section (GCS) and the center-aft section. The center-aft section is common to all versions of the Maverick. Since more than 26,000 TV Mavericks were built, developing a cost estimate for an additional 60,000 copies of the CAS was a distinctly different problem than developing a cost estimate for the same number of newly developed IIR GCSs.

We elected to base our determination of the IIR Maverick sole source costs on cost experience with the TV Maverick, making two assumptions:

1) The sole source cost of the CAS of the IIR Maverick would be an extrapolation of the cost of the CAS of the TV Maverick, with appropriate allowances for a production interruption in the 1978-1981 period.

2) The sole source cost of the GCS of the IIR Maverick would be a function of a system program office projection of the average unit cost of the IIR Maverick GCS in the second year of production (Segment II), coupled with a progress curve slope from the TV Maverick GCS production.

FIGURE 1
AGM-65D MAVERICK MISSILE



Accordingly, it was necessary for us to review TV Maverick production cost data and compute the

1) TV Maverick CAS progress curve slope

2) TV Maverick CAS first unit cost

3) TV Maverick GCS progress curve slope.

The TV Maverick was developed and produced originally under a total package procurement (TPP) contract—reportedly the only weapon system successfully developed and fielded with the use of a TPP contract [Ref. 3]. Production options were exercised in quantities of 2,000, 5,000 and 10,000 for a total of 17,000 missiles produced under the TPP contract between 1972 and 1975. These three quantities are known as lots A, B, and C. An additional 6,000 missiles were bought under a firm, fixed-price contract; they are known as lot D and were produced in 1975-76 at a monthly rate of less than half that achieved in the latter days of the TPP contract. The data on the cost to the Air Force of these missiles have costs broken out by production lot for the GCS and CAS. Both GCS and CAS unit costs show a downward trend for the first three lots (within the TPP Contract), and a jump upwards for lot D on the follow-on contract. In computing progress curve slopes for the GCS and the CAS, and a first unit cost for the CAS from this data, we made a 10 percent reduction to the average unit cost for lot D to remove a presumed cost increasing effect of the lower production rate.

For the purpose of this demonstration of our approach, we substituted fictional numbers for the numbers we found in our research of the TV Maverick cost history. We represented the CAS slope and first unit cost from the TV Maverick production as 90 percent and $40,000, respectively, and represented the GCS progress curve slope as 85 percent.

We then computed the sole source cost of the CAS for the IIR Maverick, having accounted for the effect of previous production. More than 26,000 TV Mavericks were produced in the 1972-1978 period, but production was interrupted from 1978 to 1981. We assumed that there was a loss of learning due to this interruption such that learning, in effect, resumed in 1981 at quantity 3,000. The current production is for foreign military sales of 2,650 missiles. Therefore, CAS production prior to production for the IIR Maverick would be effectively a quantity of 5,650.

Table 1 is a fictional production profile —the 60,000 total is similar to a frequently quoted planned quantity for the program.

We now have the data necessary to define the CAS progress curve but insufficient

TABLE 1
ASSUMED IIR MAVERICK PRODUCTION PROFILE

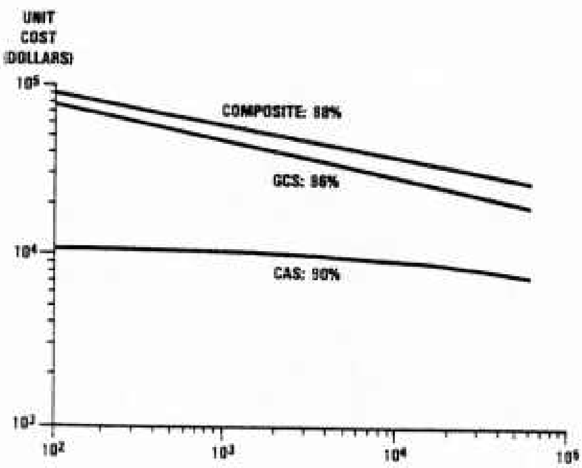
PRODUCTION SEGMENT	FISCAL YEAR	SEGMENT QUANTITY	CUMULATIVE QUANTITY
I	1982	200	200
II	1983	1,300	1,500
III	1984	3,000	4,500
IV	1985	4,500	9,000
V	1986	6,000	15,000
VI	1987	9,000	24,000
VII	1988	12,000	36,000
VIII	1989	12,000	48,000
IX	1990	12,000	60,000

data to define the GCS curve. Although a slope is known for the GCS progress curve, additional information is needed to "peg" this progress curve at some point, so that we can determine the theoretical first unit cost and find the unit cost at additional points of interest. We decided to "peg" our 86 percent slope at lot segment II since this is the first production buy of substantial quantity. The average unit cost for lot segment II, which we used in our original analysis, was provided by the SPO. However, in our example we used a fictional figure of $50,000 for lot segment II average unit cost and projected back on the 86 percent slope to obtain a first unit cost.

Next we summed the CAS and GCS costs for each of the nine production segments and performed a least squares regression, which yielded a missile progress curve with a slope of 88 percent.

Figure 2 shows the progress curves for the CAS, GCS, and complete missile.

FIGURE 2
DERIVED AGM-65D PROGRESS CURVES



PROBABLE COST TO QUALIFY AND EQUIP A SECOND SOURCE

Insight to the probable cost to qualify and equip a second source production contractor (i.e., start-up costs) came from the following three separate sources:

1) Costs for TV Maverick implementation, including vendors

2) The nonrecurring costs incurred for second sourcing in earlier missile programs

3) Current plans for implementing the IIR Maverick developer for production.

The start-up costs included contracted production engineering, special tooling, test equipment, and qualification missiles, and USAF in-house costs to cover second source selection and contract management, TDP validation, and first-article inspection and test. Since the SPO is about to conduct a competition among would-be second source contractors, we introduced another fictional number for our example. We represented the cost of second source qualification and implementation as an obviously low $20M, to be spent as follows: $8M in FY82, $6M in FY83, $4M in FY84, and $2M in FY85.

A PROGRESS CURVE FOR COMPETITIVE REPROCUREMENT

In doing an analysis relative to a tactical missile, we limited our historical look to what we called "tactical missiles and similar or related equipment." After finding 15 such systems (Table 2) we consulted the more readily available literature [Refs. 4-8] with respect to these procurements.

Several of these histories were not amenable to our analysis, but others yielded useful results. As an example we will describe the SPARROW AIM-7F data as we found and interpreted it and show how we extracted a useful indicator from it. The AIM-7F cost data is shown in Table 3.

The data was divided into four sets, sole source and competitive for each of two contractors, to examine the apparent impact of competition on each contractor. However, at this point the procedure we used departs somewhat from previous analysis of this kind. We created an additional data set by combining the competitive procurements for FY 77-80, as shown in Table 4.

We then used the Raytheon FY 72-76 sole source data and the FY 77-80 composite competition data to construct a two-part progress curve shown in Figure 3.

TABLE 2
MISSILE SYSTEM COMPETITIVE REPROCUREMENTS

SYSTEMS	CONTRACTORS
BULLPUP G&C	MARTIN, MAXSON
DRAGON ROUND	McDONNELL DOUGLAS, RAYTHEON
SHILLELAGH	PHILCO-FORD, MARTIN
SHRIKE	TEXAS INSTRUMENTS, SPERRY RAND
SIDEWINDER AIM-9B	PHILCO-FORD, GENERAL ELECTRIC
SIDEWINDER G&C, AIM-9D/G	RAYTHEON, PHILCO-FORD
SPARROW, AIM-7F	RAYTHEON, GENERAL DYNAMICS
STANDARD MISSILE	GENERAL DYNAMICS, SOLE SOURCE AND COMPETITION
TALOS	BENDIX, SOLE SOURCE AND COMPETITION
TOW MISSILE	HUGHES, CHRYSLER
WALLEYE	MARTIN, HUGHES
DRAGON TRACKER	McDONNELL DOUGLAS, KOLLSMAN INSTRUMENT
MK-46 TORPEDO	AEROJET, HONEYWELL
MK-48 TORPEDO	DELCO, GOODYEAR AEROSPACE
TOW LAUNCHER	HUGHES, EMERSON ELECTRIC

TABLE 3
SPARROW AIM-7F COST DATA

FY	RAYTHEON		GENERAL DYNAMICS	
	QUANTITY	UNIT COST	QUANTITY	UNIT COST
72	100 SS	$291,339		
73	225 SS	162,065		
74				
75	600 SS	94,721		
76	880 SS	79,337	70 SS 210 SS	$187,970 113,261
77	1,110 SA	63,194	210 SA	90,598
78	1,398 SA	55,369	750 SA	65,921
79	900 SA	48,900	1,310 SA	44,588
80	1,144 SA	40,814	300 SA	57,964

SS - SOLE SOURCE; SA - COMPETITIVE, SPLIT AWARD

TABLE 4
SPARROW AIM-7F COMPOSITE COST DATA

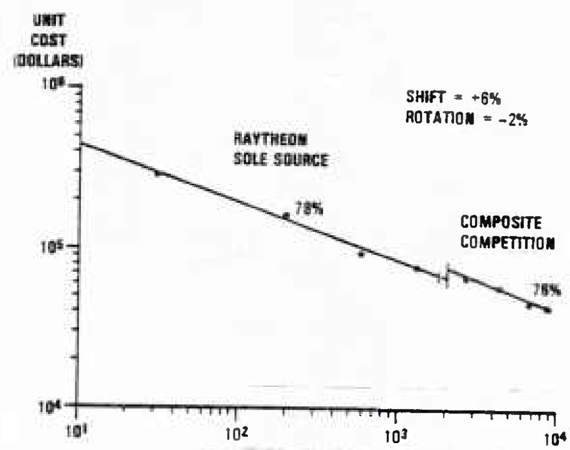
FY	RAYTHEON		GENERAL DYNAMICS		COMPOSITE	
	QUANTITY	UNIT COST	QUANTITY	UNIT COST	QUANTITY	UNIT COST
72	100 SS	$291,339				
73	225 SS	162,065				
74						
75	600 SS	94,721				
76	880 SS	79,337	70 SS 210 SS	$187,970 113,261		
77	1,110 SA	63,194	210 SA	90,598	1,320	$67,553
78	1,398 SA	55,369	750 SA	65,921	2,148	59,053
79	900 SA	48,900	1,310 SA	44,586	2,210	46,343
80	1,144 SA	40,814	300 SA	57,964	1,444	44,377

SS - SOLE SOURCE; SA - COMPETITIVE, SPLIT AWARD

Much in the manner suggested by other researchers [Refs. 9, 10], we defined shift as the percent change from the sole source unit cost at the point competition is initiated and rotation as the change in progress curve slope. Both the shift and rotation occur on the log-linear unit progress curve at the cumulative quantity prior to the initiation of competition, which includes the sole source quantity of the original contractor plus any learning or directed buy quantity of the second source. Both rotation and shift can be either positive or negative.

We attempted to operate on the data from all fifteen programs previously mentioned but were able to use only five of the systems for our analysis. The predominant reasons for not including a previous program in the analysis were insufficient and conflicting data; in one case there was only one competition conducted and in other cases time simply did not allow us to dig deeper and resolve some data questions. Table 5 lists the fifteen systems and brief remarks on each situation. Table 6 shows the results for the five systems that did yield useful results.

FIGURE 3
SHIFT AND ROTATION OF THE AIM-7F PROGRESS CURVE WITH COMPETITION



Based on the results shown in Table 6, an average rotation of -10 percent and an average shift of +5 percent, we constructed the projection shown in Figure 4 for the probable IIR Maverick progress curve in a competitive reprocurement.

At this point it is useful to offer additional comments on our reasons for adopting the composite competition progress curve. There are many benefits of using a shift and rotation of a sole source progress curve to depict an expected composite progress curve. We found that while the unit prices of sole

TABLE 5
UTILITY OF HISTORICAL MISSILE PROCUREMENT INFORMATION

SYSTEMS	REMARKS
BULLPUP G&C	INCLUDED
DRAGON ROUND	CONFLICTING DATA
SHILLELAGH	INCLUDED
SHRIKE	DATA NOT SUITABLE
SIDEWINDER AIM-9B	CONFLICTING DATA
SIDEWINDER G&C, AIM-9D/G	INCLUDED
SPARROW, AIM-7F	INCLUDED
STANDARD MISSILE	CONFLICTING DATA
TALOS	ONLY ONE MULTIYEAR BUY
TOW MISSILE	INCLUDED
WALLEYE	INSUFFICIENT INFORMATION
DRAGON TRACKER	CONFLICTING DATA
MK-46 TORPEDO	INSUFFICIENT INFORMATION
MK-48 TORPEDO	INSUFFICIENT DATA
TOW LAUNCHER	CONFLICTING DATA

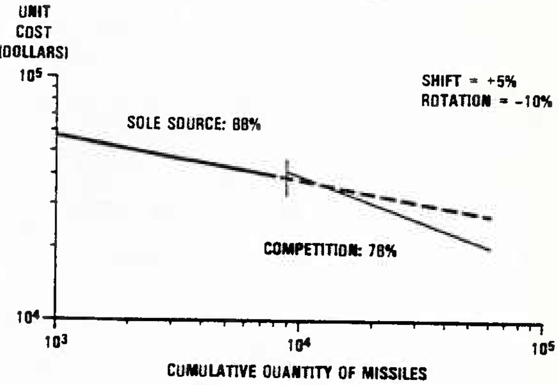
TABLE 6
ROTATION AND SHIFTS OF COST-IMPROVEMENT CURVES

MISSILE PROGRAM	1ST CONTRACTOR (SS CURVE SLOPE)	2ND CONTRACTOR (IN COMPETITION)	COMPOSITE 1ST/2ND CURVE	
			ROTATION	SHIFT
BULLPUP G&C	MARTIN (81%)	MAXSON (WON)	-16%	-11%
SHILLELAGH	PHILCO-FORD (76%)	MARTIN (LOST)	- 7%	+19%
SIDEWINDER G&C AIM-9D/G	PHILCO-FORD (93%)	RAYTHEON (WON)	-16%	+ 7%
SPARROW	RAYTHEON (78%)	GENERAL DYNAMICS (CO-PRODUCER)	- 2%	+ 6%
TOW	HUGHES (86%)	CHRYSLER (LOST)	- 8%	+ 2%
AVERAGE	81%		-10%	+ 5%

source contractors followed a log-linear unit progress curve, once competition began their unit costs tended to be more erratic. We speculate this was due to the inherent gaming of bids being conducted in each competitive bidding. The composite curve formulation tended to balance this gaming and give a fairly smooth log-linear composite progress curve.

A composite curve formulation also allows one to bypass the question of competition strategy in regards to split award allocations to each contractor. Previous work [Refs. 9, 10] used shift and rotation of the progress curves of the individual contractors. This required an estimate of the projected split of the total buy between contractors, which is not known until after competition has been conducted.

FIGURE 4
SHIFT AND ROTATION APPLIED TO THE AGM-65D SOLE SOURCE PROGRESS CURVE



Projecting the shift and rotation based on the progress curves of the individual contractors also required an estimate of both the original source's and second source's sole source and competitive progress curves. We could not find enough information on which to project a competitive progress curve for the second source and felt uneasy projecting the second source's curve using data based mostly on the original contractors' shifts and rotations.

PORTRAYAL OF SAVINGS

Second sourcing means putting money at risk in the near term with expectation of a future payoff. In our example, $20 million is spent for start-up costs in FY 82-85, and an additional $21 million is spent in FY 85-86 as a premium for the missiles produced by the second source. Over the last 5 years of the program, competition was conducted for 41,000 missiles (68 percent of the total buy). The annual savings (loss) is depicted in Figure 5. By putting the same information on a cumulative basis we see from Figure 6 that, for the example we developed, second sourcing did in fact realize savings. Remembering that several of the inputs are fictitious relative to the Maverick program, our example shows a net savings of $179 million. The net savings are about 12 percent of the cost of the missiles procured competitively. When balanced against the amount and pattern of upfront costs for second sourcing, the amount and temporal pattern of savings in the latter part of the production period constituted an internal rate of return of about 40 percent.

FIGURE 5
SECONO SOURCING ANNUAL SAVINGS (LOSS)

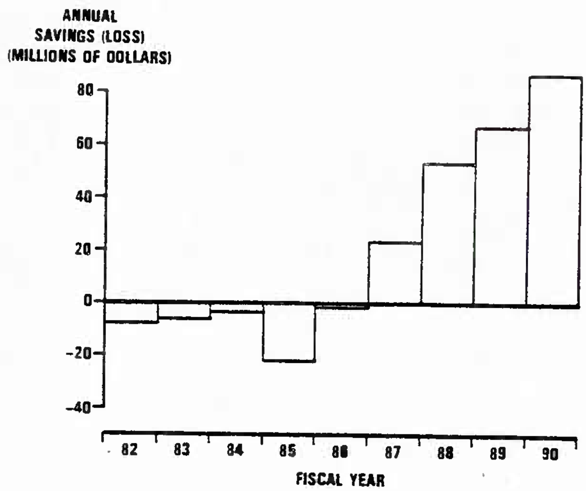


FIGURE 6
SECOND SOURCING CUMULATIVE SAVINGS (LOSS)

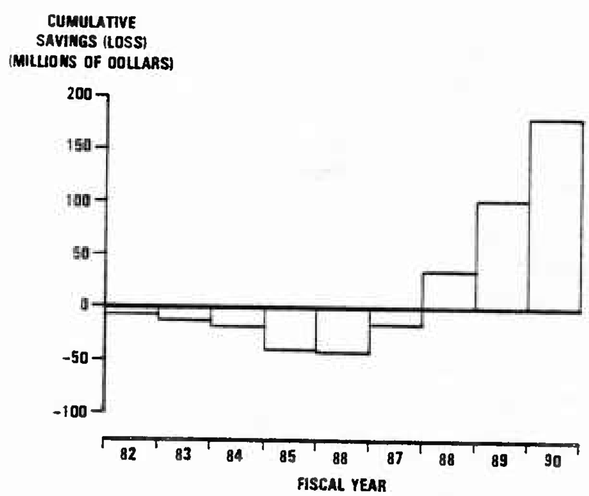


FIGURE 7
SENSITIVITY OF SAVINGS TO CHANGES IN SHIFT AND ROTATION

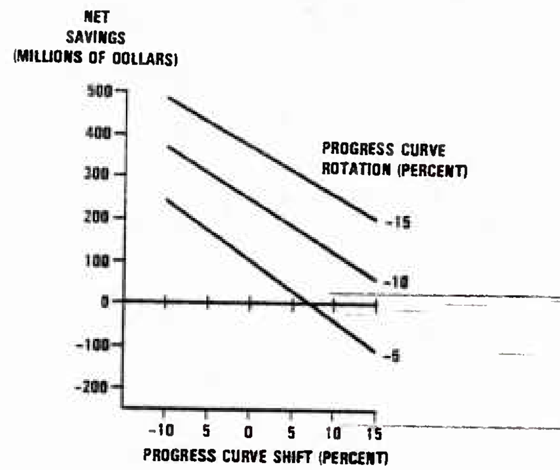
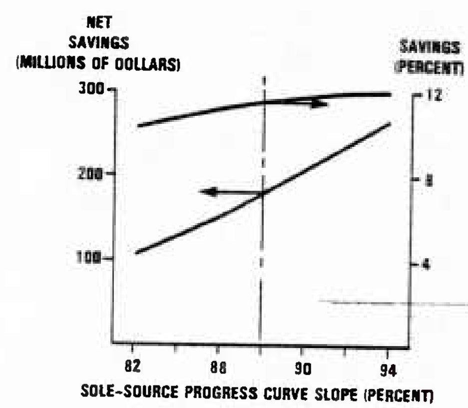


FIGURE 8
IMPACT OF SOLE SOURCE PROGRESS CURVE SLOPE ON SAVINGS



SENSITIVITY ANALYSIS

The composite curve formulation lends itself well to sensitivity analysis. As was shown in Table 6, the variance in shift and rotation is large, and therefore parametric analysis on this aspect would be desired. Also the estimated sole-source slope is a major parameter, which with small variation, can result in large changes in overall program cost and resulting net savings from second sourcing. The timing of introducing a second source can also affect the quantity of missiles competed and change the resulting savings. Many other factors including changes in the first unit cost of the sole source progress curve and changes in the second sources start-up costs can affect second sourcing savings. For this analysis we considered only the following key parameters and their effect on second sourcing savings:

1) Shift and rotation of the composite progress curve

2) Sole source progress curve slope

3) Timing of introducing second sourcing.

As shown earlier in Table 6, the shift for previous competitions varies from -11 percent to +19 percent and the rotation ranges from -2 percent to -16 percent. The average shift of +5 percent and rotation of -10 percent are therefore only rough approximations; nevertheless they provide a more accurate estimate of second sourcing savings than a speculation or estimate based on even narrower experience. It is therefore important to ascertain how other shift and rotation values would impact the savings from second sourcing. For our sample problem we show in Figure 7 the second sourcing net savings that result from various combinations of shift and rotation.

Figure 8 shows the impact of changes in the sole source progress curve slope on second sourcing total and percent savings. Percent savings is based on savings relative to the cost of competed missiles. If they were procured on a sole source basis. The flatter the expected sole source progress curve, the more savings can be realized through second sourcing. However, it should be kept in mind that the flatter the progress curve slope, the more the total program cost will be. As a consequence, the percent savings does not rise nearly as sharply as net savings the flatter the progress curve slope.

The earlier competition can be introduced the better, as long as system design is fairly well stabilized. In our example we have seen that a net savings of 12 percent or $179M results from initiating competition in 1986. If the qualification program could be compressed and the competition could be initiated in 1985, savings would nearly double due to the greater quantity of competed missiles. If competition were delayed a year until 1987, only $54M or 4 percent would be saved. In each case, we assumed that the Air Force would procure the same number of missiles each year regardless of whether or not second sourcing is introduced.

REFERENCES

1. James W. Dwyer, and James F. Kerr, *The Economic Aspects of Second Sourcing The IIR Maverick*, ANSER, April 1982.

2. K. A. Archibald; A. J. Harmon, M. A. Hesse, J. R. Hiller, and G. K. Smith, *Factors Affecting the Use of Competition in Weapon System Acquisition*, RAND, R-2706-DR&E, February 1981.

3. Geneese G. Baumbusch, and Alvin J. Harman, *Appendixes to the Report on the Peacetime Adequacy of the Lower Tiers of the Defense Industrial Base: Case Studies of Major Systems*, RAND, R-2184/2-AF, November 1977.

4. Arthur J. Kluge, and Richard R. Liebermann, *Analysis of Competitive Procurements*, Tecolote Research, Inc., TM-93, August, 1978.

5. Edward T. Lovett, and Monte G. Norton, *Determining and Forecasting Savings From Competing Previously Sole Source/Noncompetitive Contracts*, U.S. Army Procurement Research Office, APRO 709-3, October, 1978.

6. Larry Yuspeh, *The General Advantages of Competitive Procurement Over Sole Source Negotiation in the Defense Department*, Study for a subcommittee of the Joint Economic Committee of the U.S. Congress, November, 1973.

7. Morris Zusman, et al, *A Quantitative Examination of Cost-Quantity Relationships, Competition During Reprocurement, and Military Versus Commercial Prices for Three Type of Vehicles*, IDA, S-429, March, 1974.

8. George C. Daly; Howard P. Gates and James A. Schuttinga, *The Effect of Price Competition on Weapon System Acquisition Costs*, IDA P-1435, September, 1979.

9. Lou Kratz, Bruce Dembroski and Paul Martin, *Analysis of AMRAAM Acquisition Alternatives*, TASC, TR-3277, October, 1980.

10. J. W. Drinnon, "Assessing the Effect of Competition In Weapon System Acquisition," *Defense Management Journal*, Vol. 18, No. 2, Second Quarter 1981, pp 29-31.

PLANNING FOR COMPETITIVE PROCUREMENT: TECHNIQUES, PERCEPTIONS AND STRATEGIES

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ABSTRACT

This report concerns the means by which procurement managers carry out their responsibility to secure the benefits of competition. It begins by comparing four recent books dealing with industrial and government procurement. This part of the report is intended to set the stage for consideration of purchasing manager's criteria for selection of sources and their techniques of securing competition. It is followed by discussion of a sample survey conducted by the author During March, 1982. The survey sought information on source selection criteria, solictation techniques and planning activities of contracting officers and purchasing agents. Preliminary analysis indicates the buying community, particularly in government, does inadequate long range planning, adversely affecting competition.

LITERATURE REVIEW

The purpose of this study is to suggest that the adoption of practices that secure the benefits of competition is feasible for government provided there is recognition of the many forms by which those benefits may be achieved. To date, government has so structured its systems that it has frequently denied to itself the advantages to be gained from a true competitive procurement process.

This report begins with a discussion of four previously published works which address the issues of competition in procurement. The objective is to compare government and industry perceptions of the competitive process and the mechanisms by which it may be effected. First to be discussed is the treatment by Corey of strategic planning for major procurement by large corporations.[1] Second will be a summary of sourcing models used by government as explained by Sherman.[2] Third will be a commentary on certain of the criticisms by Gansler of the approach to its industrial support system of the Department of Defense.[3] Fourth, we will review the approach to competition contained in the Federal procurement system proposal submitted to the Congress on February 26, 1982 by the Office of Federal Procurement Policy.[4] Finally, the results of a recent survey conducted by the author concerning planning for competitive procurement will be summarized.

That competition is beneficial to buyers and a stimulus to sellors is an article of faith in the procurement community. It is also a foundation stone upon which our free enterprise system is based. The validity of those perceptions is not challenged in this work. Instead we shall challenge the practical implementation of competitive concepts by the procurement manager. Though limited in terms of his total economic influence as an individual decision maker, the buyer in an industrial or governmental setting can adopt practices that secure most of the benefits of competition, both for his employer and for the benefit of the economy's productivity.

Perhaps the most recent public pronouncement on this subject is contained in President Reagan's Executive Order 12352 titled <u>Federal Procurement Reforms</u>, dated March 17,1982. The order directs executive agencies in (paragraph (d)) to: "Establish criteria for enhancing effective competition and limiting noncompetitive actions..." This statement strongly supports the concept of competitive procurement and differs from past public issuances in being a part of the highest level legal policy of the executive branch. Support of the concept of competition is consistently found in public documents, but presidential action directing agency heads to bring about effective competition is new and important, since it conveys the message that judgment is required in this matter. It is no longer to be assumed that adherence to a traditional policy and practice is equivalent to effective use of competition.

Corey's research into the procurement management practices of six large industrial corporations[5] produced several new insights into the competitive practices of the private sector. They clearly differ from those of the federal government in terms of the methods used and probably differ in terms of results--the companies appear to achieve the substantive objectives of competition to a greater degree than does the government.

Three strategy models are developed by Corey which he contends are illustrative of corporate strategies for securing procurement sources. His common denominator for analysis is the approach to pricing, and he illustrates the variations in technique for setting prices associated with each model. The cases he has developed amply demonstrate that price is approached after the fundamental qualification of potential sources has been achieved. Thus he illustrates the cost-based price model, the market-price-based model, and the competitive bidding pricing model.

While the cost-based price model is in many respects similar to that used in government procurement for new technological products, it differs in a substantial way because of reduced formality, more intensive examination of alternative sources by a team of the buyer's key personnel, and decison as to source prior to detailed negotiation of the purchase. This model is useful when unique or specially designed products are desired for which intensive interaction between buyer and sellor is essential.

Corey's market-price-based model is distinguished from government practice because it involves allocation of quantities (proportions) of annual requirements to supply sources as a reward or recognition of the supplier's performance in the immediate past and of commitment by the supplier to the needs of the buyer. This model is applicable when the supplier market is made up of oligopolistic basic materials producers. In this situation, price is not considered to be directly negotiable but may be influenced by actions that encourage or discourage the supplier's behavior.

Pricing by competitive bidding, when practiced by the large companies studied by Corey, was based on competitive price bidding but only after selected bidders had been prequalified through solicitation, expression of their interest in the buyer's business, review of their service record, and a decision as to the number of suppliers to be brought on board. A purchase objective of insuring that suppliers are given enough business to be attracted to the buyer, but without creating a sole source is practiced. This approach results in the internal decision of how many suppliers to invite. This type of judgment is not ordinarily considered in government procurement because it results in limitation, for individual purchases, through exclusion of potential sources at time of solicitation.

Sherman's treatment of procurement strategy differs from Corey's in using, as its foundation, the source selection process rather than price determination. It asserts that the choice of strategy depends on the type of competition the world presents with respect to the particular need that must be fulfilled. It is based upon techniques developed in government procurement. There are four types of strategy in Sherman's treatise; price-directed, classical- competitive, limited source, and technological/conceptual.

Price-directed procurement strategy seeks to cause the market to determine price by tying source selection directly to price—with the low bid winning the award. This technique is analogous to Corey's competitive bidding model, except that government implementation of it is so highly structured that selection of an appropriate number of bidders for solicitation is constrained, and prior standing of sources as suppliers is not considered--each purchase stands on its own. This strategy is normally associated with the traditional formal advertising procedure of government. It's practicability is severely limited for today's procurement of sophisticated products and services.

Classical-competitive sourcing strategy is rooted in the government concept of negotiated procurement. It seeks proposals that are evaluated in light of a number of criteria in addition to (but including) price. This strategy is distinguished because it presumes that an adequate definition of the procurement objective has been made, in advance of solicitation, for proposals to be addressed to the specific requirement of the buyer. This approach could involve pricing that is cost-based, market-based, or competitively bid as discussed by Corey, but does not fit the procedural concepts that Corey found in the industrial setting. Within this strategy, a life cycle costing basis for source selection may be employed.

Limited-source strategy is embraced in numerous specific situations. It implies that only one source will be considered for the purchase. Effort ranging in complexity from purchase of utility services to purchase of advanced technological systems can fall under this strategy. Cost-based pricing is generally applicable to this model, since the normal pressures of the competitive marketplace are perceived to be absent. However, included within this model is procurement based upon "unsolicited" proposals, the fundamental mechanism by which the competition of ideas and the advancement of innovation can be marketed to government and to industrial buyers. This model also falls under the umbrella of negotiated procurement in the government.

Sherman refers to his fourth strategy as technological/conceptual. This model is a part of negotiated procurement in the government system, but it differs from classical competitive strategy because the "system" to be bought is not fully defined at time of issuance of the original solicitation. The strategy is rooted in the concept that a series of contracts will be awarded to each of several sources (at least more than one), with the objective that each source will define a specific system that will meet the mission need of the government. Under this approach, negotiation of price is generally based upon cost analysis. It's applicability is limited to major undertakings for which substantial technological/conceptual work is required to create a systems "solution" for the mission need.

Clearly the Corey and Sherman strategy

treatments differ in form and in substance. Both aim at classifying the specific approaches to decision making in procurement. Corey addresses the large corporste environment, Sherman the government environment. The procurement objective in each case is identical: to obtain materials or work that meet standards acceptable to the buyer while encouraging efficiency and economy and/or innovation through the competitive process. Corey also reports expanded corporate attention to procurement over the decade of the 70s--particularly in the area of long-range planning. Planning is an area in which government procurement may be lacking at present.

Gansler's criticism of the Department of Defense procurement process is a part of his overall criticism of the defense industry and its management (or lack of management) by the DOD. He asserts that "the relationship between the government and the defense industry is not that of a normal free market..."[6] He justifies his position with a table that lists over thirty areas where the "assumptions" concerning the characteristics of a free market are not met by the defense industry/DOD relationship.[7] His solutions to this situation require a substantial increase in planning by the government for its use of the defense industries, the adoption of a "second best philosophy" respecting defense procurement, and the creation of competition by the government through its procurement practices. Gansler's approach is to maintain what competition exists, or to create competition where possible (perhaps through government action such as second sourcing).[8] His treatise is strongly stated but does not account adequately for existing systems and is unclear respecting specific steps that might be taken. Nevertheless, he advocates "structural" analysis, sector by sector planning, and coordinated macro level policy development.

The fourth recent publication which addresses competition in procurement is OFPP's proposal for a uniform Federal Procurement System, dated February 26, 1982.[9] It contains a critique and proposed revision of the methods by which the federal government secures competition. The proposal is specific. It addresses the current statutory structure and suggests significant changes. They are summarized below:

1. Eliminates preference for formal advertising.
2. Makes procurement method discretionary at the administrative level.
3. Eliminates statutory justifications for negotiation.
4. Seeks rules simplification and paperwork reduction.
5. Promotes competition by moving away from use of government-mandated designs.
6. Introduces new limitations on use of noncompetitive procurement.
7. Gives recognition to the existence of more than one form of competition including innovative combinations of methods.[10]

The proposals by OFPP move in the direction of permitting the federal government to use industrial practices so that, to a greater measure, the benefits of competition may be secured for the taxpayer. Of particular importance, the proposed new system would mandate advanced planning for procurement by each of the government agencies. It also stresses the involvement of procurement personnel in the overall coordination and planning processes. This would be complementary to the revised corporate practices reported by Corey. It is impossible to state the extent to which these proposals will be adopted and, if adopted, how fully they would enhance the economy and efficiency of government procurement. They would be likely, however, to significantly improve the quality of competition, if they are successful in gaining broader recognition that the reality of competition is not dependent on traditional government policy and practices.

SURVEY

Each of the foregoing publications has contributed to understanding of procurement competition. However, there is another perspective of the subject which needs understanding. The search for sources and the criteria used by buyers for selecting sources, once a group of competitors has been generated, is far more critical to the real level of competition than the solicitation procedure. Solicitation is one step in the process of securing competition. It is initiated after research of supplier industries and conduct of prequalification efforts during planning phases. Based on that effort, several techniques for generating an adequate number of competitors are effective. In order to identify selection criteria and solicitation techniques in use, the author initiated a survey in March, 1982, to learn from purchasing agents and contracting officers what criteria and techniques they employ.

To gather data on these matters, a survey instrument was designed for distribution to purchasing personnel (both government and industry) in the Washington D. C. area. The survey was self-qualifying in that respondents were requested to complete the questionnaire only if they had experience in the source selection process. Fifty-three responses were obtained, sixteen from government, thirty-two from industry, and four from associations. The responses were validated and summarized for the study and form the basis for the discussion which follows.

To facilitate response, the questionnaire presented respondents with eight suggested criteria for selecting sources and eight suggested techniques for generating competition in procurement. In addition, the questionnaire contained space for fill-in responses in each of these categories. The criteria and techniques are listed below as they appeared in the questionnaire.

Criteria for selecting sources:

1. Lowest price
2. Lowest life cycle cost
3. Past experience with supplier
4. Reputation of supplier organization
5. Technical content of proposal
6. Resume of key personnel in proposal
7. Management proposal of supplier
8. Depth of supplier service capability
9. Other (describe).

Techniques of generating competition:

1. Review of supplier literature followed by order
2. Telephone solicitation of more than one source
3. Written solicitation, award without negotiation
4. Written solicitation, negotiation with best offeror
5. Written solicitation, negotiation with more than one source
6. Allocation among existing suppliers based on evaluation of performance and commitment
7. Public announcement of requirements, followed by proposal, negotiation
8. Negotiation based on mission or needs statement in lieu of definitive requirements statement
9. Other (describe).

Respondents were asked to rate each of these items with respect to their level of use of the criteria or technique in sourcing. The choices provided were:

1. not at all
2. occasionally
3. frequently
4. extensively
5. exclusively.

Tables 1 and 2 summarize the frequencies of responses to the questions identified above. The analysis of responses was accomplished using the Statistical Package for the Social Sciences. Tables 1 and 2 are complete including missing values and provide 9 times 53 or 477 data entries. By observation, certain patterns generated by the respondents may be perceived. Ones that contribute to the purposes of this study include:

1. Very few (9) respondents use any source selection criteria exclusively. Of those who did, only two made exclusive use of price as their source selection criterion.
2. Of the individual criteria, past experience with the supplier was used most.
3. The opportunity to identify additional source selection criteria was taken only eight times. Analysis of the eight suggested additional criteria caused the author to conclude that only four were actually different from those listed in the survey instrument.
4. Key personnel resumes are least used of the listed source selection criteria.
5. The opportunity to identify additional techniques for generating competition was taken by only five respondents. Analysis of those five indicated to the author that only three were actually different from those listed in the survey instrument.
6. Public announcement is the least used solicitation technique.
7. Very few (5) respondents use any technique for generating competition exclusively.

The data in Tables 1 and 2 lead the author to several conclusions. One is that most buyers use several solicitation techniques, but almost none use all of the techniques listed in the survey. A second and important conclusion is that the techniques and criteria set forth in the survey cover most sourcing situations. A third is that most source selections are based on multiple factors and no single criterion suffices. Of particular note—price, while always important, is seldom a singular decision criterion. A fourth conclusion: of the listed factors, past experience with the vendor is dominant.

In addition to Tables 1 and 2, the survey generated several statistically significant relationships between certain subclassifications of respondents and planning activities reported. Three planning-oriented questions appeared on the questionnaire. One was, "How often have you prepared a projection of critical materials availability?" Allowed answers were: Never, Sometimes and Regularly. The second was, "Are you directly involved in long-range planning?" Allowed answers were: Yes, No. The third was, "Is your organization regularly involved in long-range planning concerning sources of supply?" Allowed answers were: Yes, No.

Crosstabulation was used between these variables and certain identifying information used to group the respondents. Crosstabulation generates a Chi Square statistic with degrees of freedom and level of significance. The identifying variables with which significant relationships were found are: (1) Employed by: a. Government, b. Industry, c. Association. (2) Experience level: a. Trainee, b. Journeyman, c. Supervisor, d. Manager, e. Executive. (3) Years experience: a. <2, b. 2-5, c. 5-10, d. 10-20, e. >20. (4) Authority Level: a. <10K, b. 10-100K, c. 100K-1.0M, d. >1.0M.

Conclusions drawn from these crosstabulations are stated below with, in each case, the level of significance computed for the particular relationship.

Table 1

Criteria for Selecting Sources
(Frequency of Use)

Criteria	Missing	Never	Occasionally	Frequently	Extensively	Exclusively
LP	3	1	8	19	20	2
LCC	2	15	14	13	9	0
Past Exp.	2	3	4	22	22	0
Reputation	2	6	9	20	15	1
Tech. Content (Proposal)	2	7	11	11	19	3
Key Personnel	2	24	14	7	5	1
Mgt. Proposal	2	15	19	12	5	0
Service	2	6	4	17	22	2
Other	3	42	0	4	4	0
	20	119	83	125	121	9

Table 2

Techniques for Generating Competition
(Frequency of Use)

Technique	Missing	Never	Occasionally	Frequently	Extensively	Exclusively
Supplier Lit.	3	25	10	12	3	0
Tel. Sol.	3	12	10	19	7	2
Written, No Neg.	3	23	5	20	1	1
Written, Neg. with Best	3	16	6	24	4	0
Written, Neg. >1	2	17	5	23	4	2
Allocate (Existing Sup.)	2	26	7	13	5	0
Pub. Announce	2	39	4	6	2	0
Mission Basis	2	35	3	10	3	0
Other	2	46	0	3	2	0
	22	239	50	130	31	5

1. Respondent involvement in long-range planning for materials is directly related to the long-range planning activity of his organization. Sig. .0045.
2. The experience level of a respondent is directly related to the liklihood of involvment in long-range planning for materials. Sig. .0258.
3. The length of a respondent's experience (in years) is directly related to the liklihood of involvement in long range planning for materials. Sig. .0011.
4. A respondent's level of authority (in dollars) is directly related to the liklihood of involvement in long-range planning. Sig. .0798.
5. Government employees generally do not prepare projections of critical materials availability, whereas industry respondents do prepare them. Sig. .0442.
6. Experience level is directly related to the liklihood the respondent will prepare a critical materials availability plan. Sig. .0152.
7. The length of a respondent's experience (in years) is directly related to involvement in projection of a plan for availability of critical materials. Sig. .0066.

In addition to the above, several conclusions are indicated by crosstabulation of selection criteria, solicitation technique, and respondent identification information.

1. Use of the selection criteria, past experience with the supplier, is directly related to the level of authority of the respondent. Sig. .0370.
2. Use of the selection criteria, reputation of the supplier organization, is directly related to the level of authority of the respondent. Sig. .0325.
3. Use of the selection criteria, low price, is directly related to the respondent's use of the solicitation technique, written

solicitition followed by negotiation with the best offeror. Sig. .0062.

4. Use of the selection criteria, technical content of proposals, is directly related to the respondent's use of the solicitation technique, written solicitation followed by negotiation with > one source. Sig. .0001.

The foregoing indicators of relationships are viewed by the author as preliminary findings based on initial analysis of the recent survey. Much more data is needed in this area to draw firm conclusions regarding planning and sourcing issues and the techniques by which effective competition might be achieved.

In a sense, the indication from the present survey that government organizations are not as deeply involved in procurement planning as their private sector contemporaries may be the most important area for further study. One recent study has pinpointed failures in the long range perspectives of private sector procurement personnel as their weakest characteristic.[11] If government procurement personnel are even worse, it is time for renewed emphasis in the planning area.

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[1] E. Raymond Corey, Procurement Management: Strategy, Organization, and Decision Making. (Boston, MA., CBI Publishing Co., 1978).

[2] Stanley N. Sherman, Government Procurement Management (Gaithersburg, MD., Wordcrafters Publications, 1981).

[3] Jacques S. Gansler, The Defense Industry. (Cambridge, MA., The MIT Press, 1980).

[4] "Proposal For A Uniform Federal Procurement System." (Washington D. C., Office of Federal Procurement Policy, OMB, February 26, 1982).

[5] Corey, p. ix.

[6] Gansler, p. 29.

[7] Ibid, p. 30.

[8] Ibid, p. 250.

[9] UFPS, pp. 41-56.

[10] Ibid, p. 51.

[11] Robert Spekman and Ronald Hill, "Strategy for Effective Procurement in the 1980s," Journal of Purchasing and Materials Management, Winter, 1980, p. 2.

ON COMPETING THE PRODUCTION OF WEAPON SYSTEMS

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INTRODUCTION

Determining whether to compete the production phase of a system acquisition can be a difficult, but significant and revealing, analysis. In recent years a number of studies have summarized the cost experiences of past competitive productions. Other studies have proposed methods for forecasting costs or savings attributable to this decision for a particular system. The purpose of this paper is to expand the point of view usually considered in addressing this issue. The production competition decision needs to be seen as a full multi-objective decision analysis tailored to the specific circumstances of each system acquisition.

Several issues bearing on the problem that have tended to be overlooked in previous research are discussed. These include, the appropriateness of several existing models; multiple approaches useful in estimating the key elements of recurring cost savings under competition; and recently acquired data pertaining to non-cost effects of the decision. After reading this paper, the reader should have a greater appreciation of the major factors involved in analyzing the competition decision.

Each full decision analysis includes four steps: (1) problem modeling, (2) input selection, (3) output generation, and (4) preference assessment. Existing analytical models used to assist in the decision making process have not provided adequate scope. They generally accomplish only part of the necessary analysis (e.g., production cost) or in some cases fail to correctly interpret the data. They have not considered all three parts of the decision environment: (1) the various objectives to be achieved, (2) the potential strategies, and (3) the special conditions describing a specific system. A sound approach to this decision problem must realistically deal with both the complexities and the uncertainties present at the time a decision is to be made.

PROBLEM ELEMENTS

To better understand the complexities involved in the decision environment, the three principal parts are discussed below.

a. Acquisition Objectives.

The objectives of the acquisition comprise the first major part of the environment. An example hierarchy of general objectives applicable to the production strategy decision is shown schematically in Figure 1. Each strategy will have different effects according to the objective it is measured against as the following examples show. Existing data has shown that recurring production costs tend to be reduced by competitive strategies [4, 6, 7]. The time at which the system is fielded can also be affected. In some cases this timing impact may best be measured as the date by which a "critical mass" of the system is fielded. Likewise, the strategy decision can affect the ultimate operational reliability of the system. For example, a second source may produce a less reliable product due to a deficiency in its manufacturing process below the level of detail specified by the technical data package. Equally, in any given setting specific objectives may be paramount. For example, it may be critical that a multi-source mobilization capability exist. The objectives vary in importance from case to case. Cost, however, is almost always considered important, and it is the objective that most fully needs and is suited to a comprehensive modeling effort.

b. Acquisition Strategies.

In Cox and Hullander [3], an acquisition strategy was a vector quantity (T_0, T_1, T_2, T_3) representing the selection of a particular strategy for each of the four major phases of a system acquisition: concept development, demonstration and validation, full-scale development, and production and deployment. Interdependencies between the T_i's may exist in the sense that a decision for an early phase may preclude the use of a particular strategy in a later phase. The set of production strategies in [3] has been slightly expanded and is shown in Figure 2. The concept of a production strategy must be even further expanded. Production may be accomplished through a series of buys. Potential acquisition strategies must be specified in sufficient detail to permit cost forecasting over a lengthy period of time. It is insufficient to merely identify the strategy generically (leader-follower, for example) when several production contracts are to be awarded over several years and alternative allocation rules are possible. Thus, a production strategy

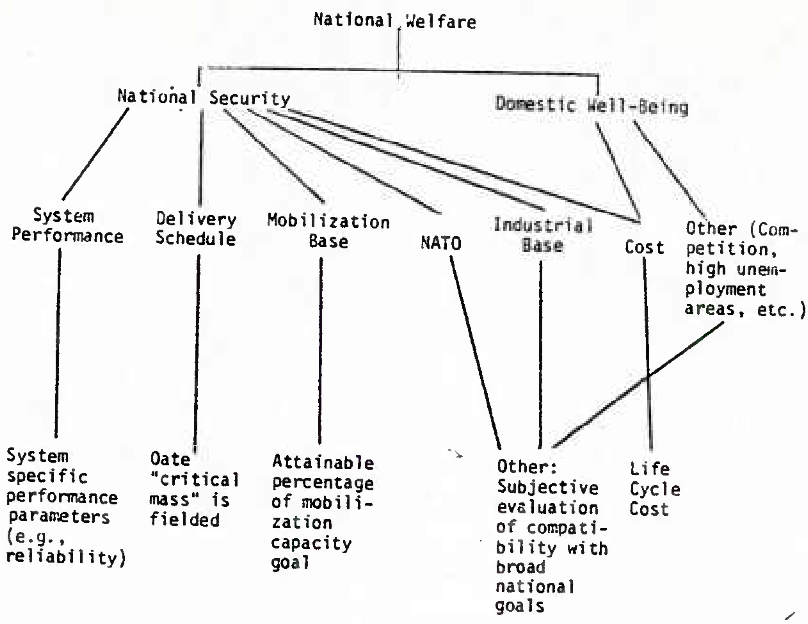


Figure 1. Hierarchy of Acquisition Objectives

Sole Source	Multiple Sources
Single Source, no options	Leader-Follower
Single Source, with options	Licensing
Single Source, multi-year contract	TDP
	Form, Fit, Function
	Teaming

Figure 2. General Production Strategies.

itself can be regarded as a vector quantity. Additionally, at the level of the contracting officer, tactics must be chosen to support the strategic choice [14].

c. System Conditions.

In addition to objectives and strategies, the third major defining topic is the conditions present for the system. A suggested list of conditions that affect the various outcome objectives is provided in Figure 3. Other authors [3, 10, 11, 14] have also suggested critical conditions in a system acquisition.

COST MODELING

The cost models that have been proposed for this problem differ significantly. A model appropriate for one system with a particular set of conditions may be inappropriate in another setting. A principal point of this paper is the need for a suitable model to be chosen from the available spectrum. The model may be deterministic or probabilistic. The model may treat the competitive environment as fixed or may permit a reassessment with each contract award. The guiding principle is to choose the simplest model that adequately deals with the dynamics of a given situation.

Although different models have been proposed for explaining competitive cost behavior, some common precepts are present. All of the approaches focus on the trade-off between additional start-up costs and the recurring cost savings that are exoected through the production life of the system. The application of some form of the cost improvement or learning curve theory is also a universal feature of these models. Usually analysts have assumed a

1. Affecting Life Cycle Cost:

Complexity	Funding
Quantity	Commodity Class
Duration	Technical maturity at beg. of production
Non-recurring costs to establish a source	Capacity
Extent of subcontracting	Learning curve slopes
Nature of Production Process	Quality of TDP
Extent of FMS	No. of qualified Krs
Technical data rights	Attitude of Prime

2. Affecting Performance:

Complexity	No. of qualified Krs.
Extent of subcontracting	Attitude of prime
Nature of production process	Cost to develop 2nd source
Commodity Class	Time to develop 2nd source
Technical maturity at beg. of production	Kr's past performance
Quality of TDP	Commonality

3. Affecting Delivery Schedule:

Complexity	Quality of TDP
Commodity class	No. of qualified Krs.
Technical maturity at beg. of production	Attitude of prime

4. Affecting mobilization goal:

Capacity

5. Broad goals:

NATO agreements
State of industrial base
State of general economy

Figure 3. Significant System Conditions

power function cost improvement curve ($y = ax^b$). Such a curve results from the assumption that every doubling of cumulative production quantity results in a fixed percentage reduction in unit cost.

A model for the strategy selection decision should recognize several other key factors associated with the problem. One of these factors is the effect of production rate on system cost. It has not achieved the same recognition as the cost improvement curve, but it can be important to include this factor in comparing alternatives involving significantly different production rates. Several different approaches have been suggested for linking the rate effect with the learning effect [1, 2, 12]. While the proposed treatments have differed, actual cases have demonstrated that in the current defense environment production stretchouts with their lower annual quantities lead to higher costs.

Another key factor in the problem is the form taken by the competitive buy. It is clear that greater competitive pressures exist in some contracting situations than in others. Further, the extent to which competitive prices are reduced below sole source levels ought to reflect the necessarily subjective degree of competitive pressure.

Earlier cost models of the competitive versus sole source strategy problem have been too simplistic. In [4] and [7] regression models were proposed for use in predicting the cost of acquiring systems under competition. These models are unsatisfactory because they do not permit a reasonably accurate estimate of recurring cost savings and do not recognize the wide variation in possible outcomes. The dependent variable in these regressions is inappropriate; typically it is the projected competitive price. The studies then show a regression curve using this dependent variable which has a deceptively good fit (R^2). Seemingly accurate prediction of the competitive price is not nearly the same as predicting the savings, however. The underlying data are simply too erratic to permit accurate projections of savings.

In [6] another approach is presented, but the model in [6] applies only to the case of sustained split awards among the two sources. Like the models above, it does not recognize the wide variations in competitive environments. It indiscriminately uses the historical data base to predict savings in the split award environment. Thus this approach extends without modification the data base findings too far outside their legitimate domain. In fact, most of the historical cases reflected buy-out situations or a mixture of split award and buy-out results. The cost model described below improves on the approach in [6] by reflecting the dynamic nature of the competitive environment.

Several modifications to the basic unit learning curve are required in order to analyze the strategy problem. Consider a single delivery year which is embedded in an overall production effort. Since the particular delivery year deals with only a portion of the total buy, an appropriate discount rate α_i should be applied to the recurring cost expression. This leads to year i cost C_i given by

$$C_i = \alpha_i \sum_{q=q_{i-1}+1}^{q_i} aq^b \qquad (2)$$

where q_i represents the production experience of a producer at the end of year i.

In addition to several years of production, several different production contracts may also be involved. Alterations to the competitive environment may lead to expected cost effects reflected by the random variables $\tilde{I}_i$ and $\tilde{b}_i$ where typically the expected value $E(\tilde{I}_i) < 1$ for more competitive environments. Then the contract cost is given by

$$K_i = \tilde{I}_i \sum_{q=q_{i-1}+1}^{q_i} aq^{(b-\tilde{b}_i)} \qquad (3)$$

where $\tilde{I}_i$ measures a competitive shift in the learning curve and $\tilde{b}_i$ measures a change in the rate of learning. In this particular expression, the previously mentioned discounting has been suppressed for purposes of simplicity. The values of $\tilde{I}_i$ and $\tilde{b}_i$ and the degree of production experience q_{i-1} are affected by the previous production awards for the system.

These complexities suggest that a strategy's cost can be modeled as a stochastic network like the example in Figure 4. The various branches represent potential outcomes of contract awards. The branches are labeled with estimates of the conditional probability of that particular outcome being generated. The competitive environment is path dependent and described by subjectively estimated orobability density functions. Some examoles are provided in Figure 5. The total set of probabilistic inputs to the cost model includes the non-recurring costs, the recurrinq shifts and/or rotations, and the contractor win probabilities. The other major input is the detailed strategic schedule of quantities by year and type of award. For the more complex strategies the Venture Evaluation and Review Technique (VERT) can be used. To acquire in-depth familiarity with VERT the reader should see [9] and then acquire a VERT guide from the US Army Loqistics Management Center, Fort Lee, VA.

Comments need to be made about certain specific characteristics of the cost model. For example, the allocation of production quantity in split-buy situations affects future cost projections because it affects the production experience of the firms. Particular assessments of outcomes and their probabilities can be made judgmentally for each case. The allocation history should not be ignored, however, for a contractor who gets little production experience will not likely remain a viable competitor.

In some situations it will be necessary to model various dependencies. For example, one of the potential second sources may already be a system subcontractor and have available some of the necessary production equipment. This particular case may not be common, but it has occurred and every real case is likely to have some peculiarity. Yet the modeling approach recommended here is general and ought to be able to accommodate most of these unusual features.

INPUT SELECTION

Each individual case will require the direct estimation of uncertain outcomes in a settinq that differs from all prior data base cases. There are no mathematical results such as Bayes Theorem that can reveal what the oro-bability distributions ought to be. It is necessarily a subjective process. Yet the magnitude of the cost makes a formal, explicit judgment preferable. For example, the estimated recurring cost oarameters are affected by variations in the competitive environment, by special contracting factors, and by system-specific oroduction characteristics. The latter factor is very important; it includes features such as degree of production automation, percentage of total cost represented by materials, and many others.

In the area of input selection, the parameters measuring shifts and rotations in learning curves under competitive conditions are both the most influential input values and the most uncertain. The most siqnificant characteristic of the historical data base is the great dispersion of competitive savings about the median. The historical data base also suffers because it is a conglomerate of cases with different system and contractual characteristics.

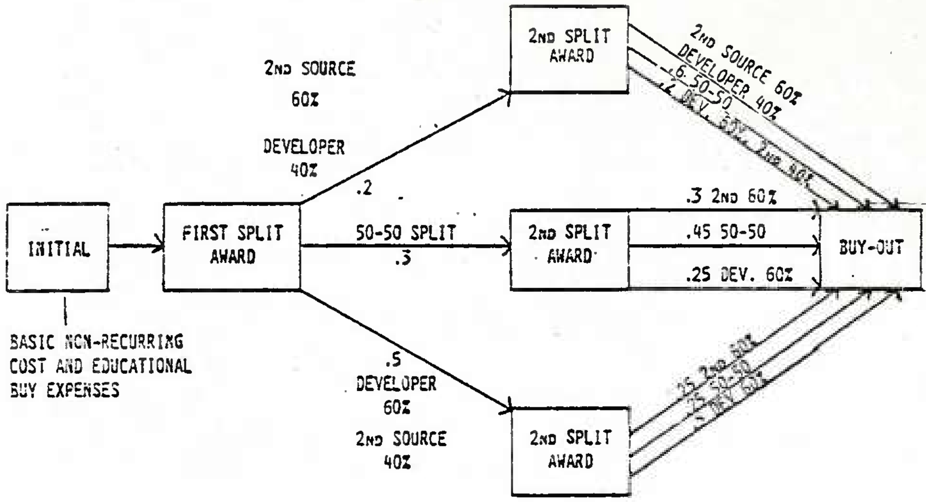


Figure 4. Network for Example Competitive Strategy.

Competitive Environment	Type of Distribution	Minimum	Maximum	Mode
First Split Award	Triangular	4%	10%	7%
Second Split Award where second source won 60% of first split award	Triangular	9	16	12
Second Split Award where developer won 60% of first split award	Triangular	7	14	10
Buy-out where both split awards divided evenly between the two sources	Triangular	12	30	20
Buy-out where developer won 60% of both split awards	Triangular	9	16	12

Figure 5. Some Example Probability Density Functions for Percentage Recurring Cost Savings Relative to Sole Source.

For example, cases have not been distinguished according to the nature of the competitive environment. Some cases include both limited split-award competitions and more intensive buy-out competitions, but other cases contain only buy-out situations. Finally, it can be deduced from [6] that behavior may be different for different classes of systems. For example, the missile system findings in [6] are quite different than the data base average. What then does one do about systems for which no past data has existed (e.g., armor)?

Although great uncertainty is found in the historical data, the value of the recurring savings parameters is very significant in the cost analysis. It seems that the best solution is to use a multiple forecasting approach where possible. The general historical data may suggest one parameter value (or probability distribution). A very small set of savings data for related products may be an important additional piece of savings information. Further consideration of system peculiar characteristics and consultation with experts may further aid in refining the savings forecast. The difference in parameter estimates between two different competitive strategies can be as important as the sole source comparison.

NON-COST ISSUES

Earlier empirical research related to acquisition strategy decision-making has focused on the cost dimension. Although non-cost issues can be decision drivers, little attention has been given to systematically gathering the pertinent data. Cases providing schedule and reliability information about second source production proved to be extremely limited. The cases for which data proved obtainable were projects with the Naval Material Command and the US Army Materiel Development and Readiness Command. While the findings are insufficient for rigorous statistical analysis, the charts and graphs recording the actual observations are presented in full in [13]. All the cases were second sourcing of the TDP (technical data package) type in which an exact copy was made by the second source. Portions of the available new data concerning second source reliability and schedule behavior are presented here.

The second source sometimes encountered reliability problems early in production. These were generally corrected with little or no degradation of operational reliability. It must be noted that these cases reflect situations where competition was actually undertaken. Therefore, some basic conditions must have been previously met. For example, a determination would have been made that the source was technically qualified. Note too that the aspect of reliability bearing on the strategy decision is the operational reliability of the second source's product relative to the first source. Under some options it may be that the second source is producing a different product than the original developer. However, as mentioned above, all of the data presented here deals with identical TDP copies.

An important point is that deficiencies in the technical data packages were commonly acknowledged by Government personnel. Contracting-oriented persons seemed frequently, however, to have a narrow and mistaken view that a quality technical data package and a well-prepared contract would resolve all the problems. It is apparent, though, that even a quality technical data package is not sufficient to insure the absence of production problems. At least two reasons have been offered to explain this. In the first place, continual corrections are made to the TDP in the early stages of production. Some of these corrections may fail to be fed to the second source. Secondly, the level of detail of a TDP is not sufficient to explain all production processes.

Figure 6 documents the Army situations the data-gathering effort uncovered. The completeness of the available reliability information varied from informal generalities in personal interviews to extensive test results for thousands of missile firings. The tentative conclusion is that the weight of reliability considerations in the strategy decision should be typically very small. Most problems are uncovered in system acceptance testing and do not reach the field to affect capability provided government monitoring is adequate.

The date at which a "critical mass" of a system is fielded may be used to measure strategy differences in the schedule area. The definition of a critical mass may vary with the system, but it typically might involve the fielding of many more product units than the initial operating capability (IOC) entails. IOC is a commonly used date for reporting progress on major systems.

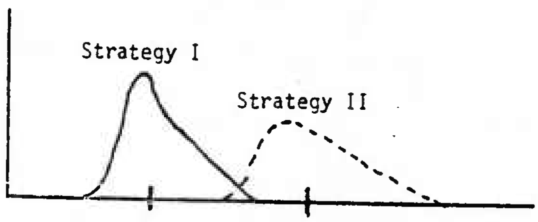
There are two ways in which delivery time of the system can be affected by a second source strategy. First, an alternative production strategy may require a new fielding schedule. For example, additional time may be required for adequately establishing a second source. The other effect is on the risk of meeting planned delivery schedules. These two effects are illustrated in Figure 7.

Commonly, the second sources encountered an initial period of difficulty in meeting their production delivery schedule. The graphs in Figures 8 and 9 are examples of the data reported in [13] and serve to illustrate the typical problem. The graphs compare the sources at equivalent times past their

RELIABILITY FINDINGS

SYSTEM	SYNOPSIS OF FINDINGS
1. Army missile	Second source initially had reliability problems due to production details (a specific soldering requirement and installation of a particular spring). Reliability soon improved, and any manufacturer's difference was overwhelmed by other factors (e.g., weather, target speed, gunner skill). Source: written documentation from Test and Evaluation Directorate, MICOM.
2. Army missile subsystem	Government sources informally reported no differences in reliability.
3. Army missile	Examination of results of several thousand firings showed essentially no difference in reliability from the beginning of production by the two sources.
4. Army missile subsystem	Government sources informally reported no differences in reliability.
5. Army missile	Examination of statistics covering missile firing over several years showed no reliability differences. These firings included a stockpile reliability testing which permitted comparison by age.
6. Army laser range finder	Government sources informally reported no differences in reliability.
7. Army night vision system	Government sources informally reported no differences in reliability.
8. Army night vision subsystem	Government sources informally reported no significant differences in reliability.
9. Army night vision system	Government sources informally reported no differences, but for the second source only first article testing had been accepted to date.

Figure 6. Reliability Findings - Army Systems



Date "Critical Mass" Fielded

A. PRODUCTION SCHEDULE CHANGE (SHIFT OF MEAN)
B. RISK CHANGE (INCREASED VARIANCE)

Figure 7. Example Schedule Effect.

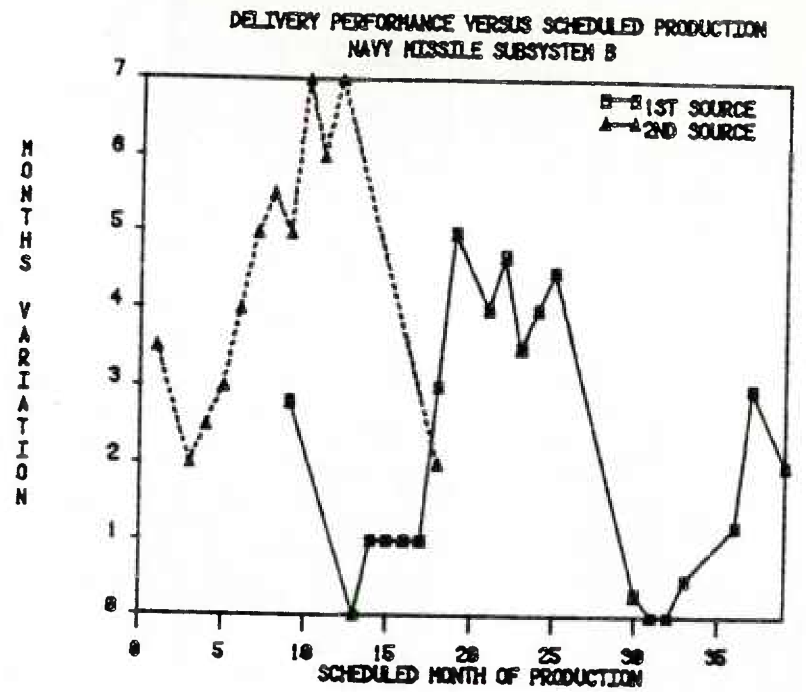


FIGURE 8

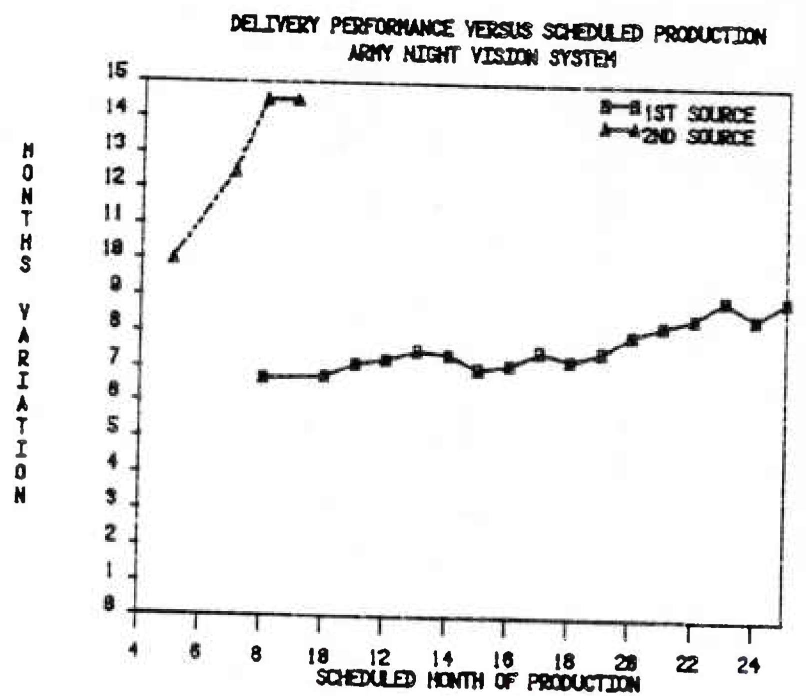


FIGURE 9

original initial delivery date. The vertical axis measures the months from scheduled delivery to actual delivery of the required quantity. A positive value is measuring a late delivery, and a negative value reflects ahead of schedule performance.

For the six systems graphed in [13] the second production sources were consistently more delinquent than the original source at comparable points in their production experience. The results varied widely, but the difference between the sources in deliveries versus schedule was typically three to five months.

The suggested conclusion from the data is that the technical data package does not solve all production-related issues. It is common for the second source to encounter production delays. Since the second source is usually initially assigned only small quantities, the total effect on system effectiveness may be slight. Review of Lovett and Norton [7] leads to the thought that another, albeit small, risk also exists that this study's limited data base also found. This risk is the risk of never getting deliveries from the second production source.

It seems conceivable that the developer's reliability and schedule performance are enhanced by the mere presence of an alternate source. The second source's reliability, if deficient early in production, does seem to improve over time. In any case, the relatively small observed differences in reliability are most likely overwhelmed by the conditions of actual use, e.g., gunner accuracy.

The available data are too sparse and the effect typically too small to make a complex approach to dealing with schedule and reliability worthwhile. It is recommended that the analyst combine judicious use of the data reported with system-specific considerations to directly create an outcome probability density function. The ultimate goal is the same as for the cost objective--to project a measure of the difference in outcome to be expected if one follows a competitive or sole source strategy. The decision-maker will typically be able to evaluate directly the relative importance of schedule and reliability differences among strategies. If this is too difficult, then the more elaborate techniques of multi-attribute utility theory can be used.

The final part of a decision analysis is the assessment of outputs. The organizational structure of the government interferes with the ability of the analyst to formally assess the trade-off preferences across the affected objectives. For example, no one feels in a position to say how many dollars equate to a given enhancement of the mobilization response. Thus,studies have typically gone no further than predicting outcomes on the different objectives without formally assessing acceptable trade-offs. An exception for a related problem is [5] in which group multi-attribute utility theory was applied.

DISCUSSION AND SUMMARY

The studies analyzing the cost behavior of systems acquired competitively have reoorted varying levels of competitive savings due to lower unit recurring costs. Despite the wide variation in the reported savings, the studies consistently agree that the potential savings are substantial. In this paper (and more fully in [13]) the state of the art in modeling problems of acquisition strategy choice was reported. Key conditions which affect the outcomes likely for a given system were described. Progress in dealing with such related problems as the effect of production rate on system cost was also described.

This study marked the first empirical attention to non-cost issues in strategy selection. In particular, findings concerning the reliability and schedule effects of second sources were reported. A tentative conclusion was that the reliability objective should be given little weight in the strategy selection decision. Initial schedule delays involving second sources are common. The importance of this consideration depends on the volume of production affected and on the significance of a schedule delay for the given system.

The approach advocated here tries to deal realistically with the important parameters of the problem. It is important to have a certain structural integrity to the model even though it means admitting that some of the input data in an application is heavily judgmental. If factors do importantly affect the outcome, it is preferable to make conscious efforts to evaluate their effects than to use a more simplistic model in which the influence of these important factors is suppressed. The structure of the problem and the limited number and type of cases comprising the data base lead to the importance of a systematic application of judgment.

SELECTED REFERENCES

1. Balut, S.J., "Redistributing Fixed Overhead Costs," Concepts: The Journal of Defense Systems Acquisition Management, 4(2), 63-76 (1981).

2. Bemis, J.C., "A Model for Examining the Cost Implications of Production Rate," Concepts: The Journal of Defense Systems Acquisition Management, 4(2), 84-94 (1981).

3. Cox, L.W., and R.A. Hullander, Feasibility and Development Study for a System Acquisition Strategy Model, The Analytic Sciences Corporation, TR-1375, Arlington, VA, 1981.

4. Daly, G.G., H.P. Gates, and J.A. Schuttinga, The Effect of Price Competition on Weapon System Acquisition Costs, Institute for Defense Analyses, P-1435, Arlington, VA 1979.

5. DeWispelare, A.R., and A.P. Sage, "On the Application of Multiple Criteria Decision Making to a Problem in Defense Systems Acquisition," Int. Jour. Systems Science, 11, 1213-1240 (1980).

6. Drinnon, J.W., and J.R. Hiller, Predicting the Costs and Benefits of Competitive Production Sources, The Analytic Sciences Corporation, TR-1511, Arlington, VA, 1979.

7. Lovett, E.T., and M.G. Norton, Determining and Forecasting Savings from Competing Previously Sole Source/Noncompetitive Contracts, Army Procurement Research Office, APRO 709-2, Fort Lee, VA, 1978.

8. MLRS Second Source Rocket Acquisition Study, Plans, Analysis, and Evaluation Directorate, US Army Missile Command, Redstone Arsenal, AL, 1980 (Approval required for release outside DOD).

9. Moeller, G.L., and L.A. Digman, "Operations Planning with VERT," Operations Research, 29, 676-697 (1981).

10. Parry, D.S., Second Sourcing in the Acquisition of Major Weapon Systems, Master's Thesis, Naval Postgraduate School, Monterey, CA, 1979.

11. Sellers, B.R., "A Model for Enhancing Second Sourcing and Production Competition in Major Weapon Systems Acquisition," National Contract Management Journal, 15, 27-40 (1981).

12. Smith, C.H., "Effect of Production Rate on Weapon System Cost," Concepts: The Journal of Defense Systems Acquisition Management, 4(2), 77-83 (1981).

13. Smith, C.H. and C.M. Lowe, Jr., Strategy Selection for the Production Phase of Weapon System Acquisition, Army Procurement Research Office, APRO 81-05, Fort Lee, VA, 1982.

14. Williams, R.F., and D.D. Knittle, "A Contingency Approach to Acquisition Planning," Concepts: The Journal of Defense Systems Acquisition Management, 4(3) 7-20 (1981).

PANEL M

PROCUREMENT UNDER GRANTS

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PROCUREMENT UNDER GRANTS

This panel's proceedings were primarily addressed to civil agency attendees, as the Department of Defense rarely utilizes grants in its procurement mission. Panelists were drawn from both the legal community and various civil agencies directly involved with procurement under grants. Panel discussions encompassed a number of areas which are of current interest in the grants arena. The philosophy behind, major changes in and recent revisions to regulations governing procurement under grants were explored. Particular emphasis was given to the impact of such recent initiatives as prevention of fraud, waste and abuse; conversion to block grants; and adoption of the Model Procurement Code for state and local governments on Federal grants programs. The session concluded with a question and answer period in which attendees were afforded an opportunity to query panelists as to the impact which these recent developments might have on their individual missions.

O. S. HIESTAND
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WASHINGTON, D.C.

Prepared Remarks For FAI Program

May 6, 1982

A. Background

In 1974 the ABA initiated a project to develop a Model Procurement Code for State and Local Governments. The idea and need for improving state and local procurement statutes and ordinances had been advanced and recognized for a number of years. Those who were involved with both federal and state/local procurement knew the federal system, notwithstanding many shortcomings, had adapted to accommodate new market conditions and government needs. Most analyses indicated, however, that little, if any, changes were taking place in state/local laws and ordinances.

For example, most state statutes required all contracts to be awarded by competitive sealed bids. Also, only a few states had any formal bid protest procedures, or permitted judicial review of state decisions on contract disputes. Until we studied how the states did their buying, and got to know many state puchasing agents, at least some of us with mostly federal backgrounds considered they were rather primeval and uneducated. Now, I think, we learned a lot and gained a healthy respect for the expertise of many state/ local purchasing agents.

When we started discussing competitive negotiations as an alternate to formal advertising, they asked what is that? After some explanations, the usual question was what is wrong with having negotiations after formal advertising? Really, that was a hard question to answer. The states had long ago combined the two -- get sealed bids, then negotiate if you didn't like the bid. In addition, the states utilized judgmental factors in bid evaluations for commercial-type products, even though they were not spelled out in the solicitation. For example, it was an accepted practice to obtain user ratings; e.g., compare hammers; sample the food.

It was a cross-educational process to develop a consensus that sealed bidding should be restricted to price comparisons, and competitive proposals were appropriate when other evaluation factors were important.

We exposed another very significant difference between federal and state procurement in things like equitable adjustments for changes or differing site conditions. Many state/local contracts -- particularly construction -- are financed through bond issues, and this means there are no additional resources to turn to for paying costs.

B. Summary Of Code

Notwithstanding these and other problems, we produced a Model Procurement Code that was adopted by both the Local Government Law Section and the Public Contract Law Section of the ABA and the ABA House of Delegates. I believe it represents a better system for public procurement than currently exists in the federal government; and most state/local governments.

The Model Procurement Code has 12 articles.

Article 1 - General Provisions, states the purposes, application, and contains definitions.

Article 2 Procurement Organization, establishes a Procurement Policy Office, a Chief Procurement Officer, and provides for the issuance of regulations to supplement the statutory provisions.

Article 3 - Source Selection and Contract Formation, establishes the methods of source selection to be used -- competitive sealed bidding, competitive sealed proposals, small purchases, sole source and emergency procurements. It also sets requirements for cancellation of IFBs and RFPs, responsibility of bidders, use of cost or pricing data, types of contracts, and use of multi-term contracts.

Article 4 - Specifications, establishes responsibilities of the Policy Office and the Chief Procurement

Officer for specifications, and mandates they shall permit maximum practicable competition.

Article 5 - Procurement of Construction, A/E and Land Survey Services, establishes broad requirements for construction contracts, and the use of changes, variation in quantity, suspension, and differing site condition clauses. The Model Code adopts the federal (Brooks Bill) method of selecting and contracting for A/E services.

Article 6 - Modification and Termination of Contracts for Supplies and Services, authorizes the use of changes, suspension of work, and variation of quantities clauses.

Article 7 - Cost Principles, mandates the issuance of cost principles for use in determining allowable costs.

Article 8 - Supply Management, requires the issuance of regulations for the management of supplies, and disposal of surplus supplies.

Article 9 - Legal Contractual Remedies, establishes a bid protest system, requirements for debarment and suspension, and a right of judicial review of contract disputes.

Article 10 - Intergovernmental Relations, authorizes cooperative buying.

Article 11 - Assistance to Small and Disadvantaged Businesses; Federal Assistance or Contract Procurement Requirements, states a policy of assisting small and disadvantaged businesses, and mandates compliance with federal requirements when a procurement involves federal assistance or procurement funds.

Article 12 - Ethics in Public Contracting, establishes standards of conduct for state employees; requirements for financial disclosure; prohibits kickbacks and contingent fees; and establishes remedies for breach of ethical standards by employees and non-employees.

C. Implementation Status

Last year a set of Model Regulation was issued to implement the Model Code.

To date some 9 states have adopted new procurement laws based on the Model Code. The most recent is the Commonwealth of Virginia. Projects are underway in another 7 states. In addition, a number of cities either have adopted or are considering ordinances based on the Model Code.

In this regard, at the request of EPA, the ABA has undertaken to develop a Model Ordinance for use by smaller cities and other local governmental entities. While the principles are consistent with the Model Code the Model

Ordinance eliminates some of the organizational structure recommended for states, and accommodates the differences in the legal authorities of cities; i.e., disputes resolution.

The March 1982 issue of School Business Affairs contains an article by Joe Macaluso, Director of Purchasing, Jefferson County (Kentucky) Board of Education, entitled "Model Procurement Code Allows Flexibility in Kentucky School Purchasing Operations." Kentucky was the first state to upgrade its procurement statues based on the ABA Model Code. Mr. Macaluso describes what has occurred in his area, and states:

> With a combination of Model Procurement, well defined regulations and extensive inservice training, we have developed an efficient and effective purchasing procedure.
>
> We have not reached an Utopia in purchasing but we have developed a well defined systematical approach which allows the Purchasing Unit the flexibility to venture into new areas. We have also accomplished one other major achievement and that is the creation of vendor and public confidence in a system they can understand.

D. Significance to Federal Programs

What does all of this have to do with federal programs?

You may recall there is a document, Attachment O to OMB Circular A-102, that establishes standards and guidelines for procurement by grantees under federal assistance programs. In addition, it provides for federal review of grantee procurement systems, and for certification that they meet the standards set forth or the provisions of the ABA Model Code. If certified the grantee can be exempted from review of proposed contracts. I anticipate that similar treatment will be accorded municipalities that adopt the Model Ordinance.

Thus, certification will reduce paper work, and hopefully eliminate many of the irritations between grantor agencies and grantees.

As the federal government turns to more block grant programs, there is a greater need to assure that those funds, when used for procurement, are expended in accordance with good public procurement rules. One way to help effect this is to improve the statutory framework for state/local procurement, whether or not federal funds are involved. Another, of course, is to improve the professional capability of state/local purchasing agents and buyers.

And, since we all are taxpayers, it behooves us to help assure that our tax dollars are used economically and fairly.

Conclusion

The ABA Model Code and Model Ordinance are Models. It is not expected that each enacting jurisdiction adopt them verbatim. They do represent a conscientious effort to put on the table fundamental criteria for modern public procurement systems, including standards for accountability and resolution of disputes.

GRANTEE PROCUREMENTS UNDER BLOCK GRANTS

THAT PORTION OF OUR DEPARTMENT'S REGULATIONS ON THE ADMINISTRATION OF GRANTS THAT DEALS WITH PROCUREMENT UNDER GRANTS MIRRORS TREATMENT OF THE SUBJECT IN OMB CIRCULAR A-102. ALTHOUGH THERE ARE SEVERAL STANDARDS THAT WE EXPECT OF STATE AND LOCAL GOVERNMENTS WHEN THEY PROCURE GOODS AND SERVICES USING FEDERAL GRANT FUNDS, THE MOST SIGNIFICANT ONE IS THAT THEY USE FREE AND OPEN COMPETITION. FREE AND OPEN COMPETITION ON GRANTS DOES NOT MEAN THAT THE RULES AND PROCEDURES IN THE FPR ARE IMPOSED ON GRANTEES. INSTEAD WE WANT STATE AND LOCAL GOVERNMENTS TO CARRY OUT THEIR PROCUREMENT ACTIVITIES IN ACCORDANCE WITH SOME FUNDAMENTAL STANDARDS SO, THAT, FOR EXAMPLE, PROPOSALS ARE SOLICITED FROM QUALIFIED SOURCES AND ALL IFB'S AND RFP's ARE PUBLICIZED THROUGH NORMAL STATE MECHANISMS, THAT AWARDS SHOULD BE MADE TO RESPONSIBLE BIDDERS OR OFFERORS WHEN THE OFFER IS RESPONSIVE AND ADVANTAGEOUS TO THE STATE OR LOCAL GOVERNMENT. IT ALSO MEANS THAT STATES ARE EXPECTED TO USE CLEAR AND UNRESTRICTIVE SPECIFICATIONS THAT DO NOT CONTAIN FEATURES WHICH WOULD UNDULY RESTRICT COMPETITION.

For Delivery at Federal
R&D Procurement Symposium
Washington, D. C., May 6, 1982
Matthias Lasker, Director
Office of Procurement & Assistance
PPolicy - Dept. of Health &
Human Services

ASIDE FROM THE EMPHASIS IN OUR REGULATIONS ON THE USE OF COMPETITION, THERE ARE OTHER STANDARDS WE WANT STATE AND LOCAL GOVERNMENTS TO ABIDE BY IN CONDUCTING THEIR PROCUREMENT OPERATIONS. FOR EXAMPLE, WE REQUIRE THEM TO HAVE ADEQUATE PROTECTIONS AGAINST CONFLICTS OF INTEREST ON THE PART OF THEIR EMPLOYEES AND TO AVOID PURCHASING UNNECESSARY OR DUPLICATIVE SERVICES OR GOODS. THEY ARE EXPECTED TO PERFORM COST OR PRICE ANALYSES AND TO MAKE POSITIVE EFFORTS TO USE SMALL AND MINORITY OWNED BUSINESS FIRMS AS SOURCES OF SUPPLY. AND WE ALSO REQUIRE THAT THEY DOCUMENT THEIR PROCUREMENT ACTIONS TO REFLECT THE RATIONALE FOR DETERMINING THE METHODS OF PROCUREMENT, THE SELECTION OF CONTRACT TYPE, THE BASIS FOR THE COST OR PRICE ARRIVED AT, AND THE RATIONALE FOR SELECTION OR REJECTION OF BIDS OR OFFERS. ALL OF THIS DOCUMENTATION IS, OF COURSE, SUBJECT TO FEDERAL REVIEW.

MOST OF THE GRANT PROGRAMS OF THE DEPARTMENT OF HEALTH AND HUMAN SERVICES ARE HEAVILY LABOR INTENSIVE. WE ARE PAYING FOR THE SERVICES OF SOCIAl WORKERS, PHYSICIANS, BIOMEDICAL RESEARCHERS AND LOCAL GOVERNMENT ADMINISTRATIVE AND MANAGERIAL EMPLOYEES. AS A RESULT THE AMOUNT OF PROCUREMENT OF GOODS OR SERVICES IS NOT A MAJOR FACTOR, USUALLY, ON MOST OF OUR GRANT PROGRAMS. WE DO NOT NORMALLY EMPHASIZE FEDERAL OVERSIGHT OF STATE AND LOCAL PROCUREMENT ACTIVITIES EXCEPT THAT WE RESERVE THE RIGHT TO PRIOR APPROVAL OF STATE AND LOCAL SOLE SOURCE AWARDS.

ON A FEW OF OUR MULTI-BILLION DOLLAR GRANT PROGRAMS HOWEVER SUCH AS MEDICAID, PROCUREMENT IS A VERY SIGNIFICANT FEATURE OF STATE AND LOCAL GRANT ACTIVITY. IN THE MEDICAID PROGRAM FOR EXAMPLE, MOST STATE WELFARE DEPARTMENTS CONTRACT WITH DATA PROESSING FIRMS TO PROCESS THE BILLINGS FROM HEALTH CARE PROVIDERS SUCH AS PHYSICIANS, HOSPITALS AND MEDICAL LAORATORIES. IN A STATE WITH A LARGE MEDICAID POPULATION ONE OF THESE CONTRACTS BY THE STATE WELFARE DEPARTMENT MAY AMOUNT TO HUNDREDS OF MILLIONS OF DOLLARS. WE DO CAREFULLY MONITOR THE STATE PROCUREMENT PRACTICES ON CONTRACTS OF THIS MAGNITUDE AND EXPECT TO CONTINUE TO DO SO. WE ALSO PAY CLOSE ATTENTION, ON A MULTI-BILLION DOLLAR GRANT PROGRAM LIKE MEDICAID, TO STATE PROCUREMENTS OF ADP EQUIPMENT AND SOFT WARE. HERE AGAIN WE ARE CONCERNED BECAUSE OF THE LARGE SUMS OF GRANT MONEY STATES EXPEND FOR ADA. BUT THE TIMES ARE A-CHANGING, AS THE SONG GOES.

AS YOU KNOW CANDIDATE REAGAN EXPRESSED THE STRONG VIEW THAT THE FEDERAL GOVERNMENT WAS OVERLY INTRUSIVE AND DEMANDING IN ITS RELATIONS WITH THE STATES AND, WHEN HE WAS ELECTED, PRESIDENT REAGAN REQUIRED THAT THE EXTENT OF THIS INTRUSION WOULD BE LIMITED. THE BLOCK GRANTS THAT WERE

ENACTED INTO LAW LAST YEAR ARE EVIDENCE OF THIS NEW APPROACH TO FEDERALISM. I'D LIKE TO DISCUSS OUR APPROACH TO THE BLOCK GRANTS WITH YOU NOW - AND THE IMPACT OF THAT APPROACH ON OUR OVERSIGHT OF STATE AND LOCAL PROCUREMENT ACTIVITY.

WHILE THERE HAS BEEN A STEADY INCREASE EVER SINCE THE DEPRESSION IN THE FEDERAL GOVERNMENT'S INFLUENCE AND AUTHORITY OVER THE ACTIONS OF STATE AND LOCAL GOVERNMENTS AND THEIR CITIZENS, THE CURRENT FEELING IS THAT THIS TREND SHOULD BE REVERSED. MORE SPECIFICALLY, MANY TAXPAYERS BELIEVE THAT THE FEDERAL GOVERNMENT'S PRIMARY RESPONSIILITIES SHOULD BE LIMITED TO THE AREAS WHICH UNAMBIGUOUSLY ARE IN THE INTEREST OF THE ENTIRE NATION SUCH AS DEFENSE AND FOREIGN AFFAIRS, AND THAT THE PRIMARY RESPONSIBILITY FOR THE DELIVERY OF DOMESTIC SERVICES SHOULD BE WITH STATE AND LOCAL GOVERNMENTS. ACCORDINGLY THIS ADMINISTRATION FEELS STRONGLY THAT STATE AND LOCAL GOVERNMENTS SHOULD BE RESPONSIBLE FOR DETERMINING AND SHAPING THE SERVICES THAT ARE INTENDED TO MEET THE NEEDS OF THEIR CITIZENS RATHER THAN DEPENDING ON THE FEDERAL GOVERNMENT. FURTHERMORE, THAT SHAPING AND DESIGNING SHOULD BE CARRIED OUT IN THE CONTEXT OF A FRAMEWORK THAT RECOGNIZES THAT LOCAL GOVERNMENTS ARE ENTITIES OF THE STATES, AND THAT THE INTERPLAY OF STATE AND LOCAL GOVERNMENTS, COMBINED WITH MINIMAL FEDERAL PRESENCE, WILL LEAD TO BETTER DECISIONS AFFECTING THE CITIZENRY AS A WHOLE.

THE REVENUE SHARING PROGRAM AND THE NEW BLOCK GRANTS ARE AMONG THE INITIAL STEPS TOWARD THIS ULTIMATE TRANSFER TO THE STATES OF THE AUTHORITY TO DETERMINE THEIR SOCIAL PROGRAMS AND GOALS AND THE REVENUE SOURCES TO FINANCE THEM. THE BLOCK GRANTS WERE PROPOSED THIS PAST YEAR IN A FISCAL ENVIRONMENT IN WHICH, FOR MANY SOCIAL SERVICES PROGRAMS, THE BUDGETS WERE GOING TO BE CUT. MAXIMUM FLEXIBILITY WAS THEREFORE NEEDED TO IMPROVE THE EFFICIENCY WITH WHICH THE PROGRAMS COULD BE OPERATED AND MINIMAL FEDERAL INTRUSION AND OVERSIGHT WERE TO BE ALLOWED. IMMEDIATE RELIEF FROM FEDERALLY IMPOSED PAPERWORK AND REGULATORY REQUIREMENTS WAS SOUGHT TO CUT STATE COSTS AND HELP ASSURE THAT THE STATES WERE IN CONTROL.

THE WHITE HOUSE AND OMB DETERMINED THAT EACH FEDERAL DEPARTMENT SHOULD IMPLEMENT THE BLOCK GRANT PROGRAMS IN A MANNER THAT WAS FULLY CONSISTENT WITH THE CONGRESSIONAL INTENT TO ENLARGE THE STATES' ABILITIES TO CONTROL THEIR USE OF THE GRANT FUNDS INVOLVED. ACCORDINGLY, TO THE EXTENT POSSIBLE IN DEVELOPING THE HHS BLOCK GRANT REGULATIONS, WE DECIDED NOT TO BURDEN THE STATES' ADMINISTRATION OF THE PROGRAMS WITH DEFINITIONS OF PERMISSIBLE AND PROHIBITED

ACTIVITIES, PROCEDURAL RULES, PAPERWORK AND RECORDKEEPING REQUIREMENTS, OR OTHER SIMILAR REGULATORY PROVISIONS. THE STATES ARE, FOR THE MOST PART, SUBJECT ONLY TO THE STATUTORY REQUIREMENTS INCLUDED IN THE OMNIBUS BUDGET RECONCILIATION ACT. THE DEPARTMENT CARRIES OUT ITS FUNCTIONS WITH DUE REGARD FOR THE LIMITED NATURE OF THE ROLE THAT CONGRESS HAS ASSIGNED TO US. BOTH THE DEPARTMENTS OF EDUCATION AND HOUSING AND URBAN DEVELOPMENT ADOPTED SIMILAR APPROACHES ON THEIR BLOCK GRANT PROGRAMS. AS A CONSEQUENCE OF THIS DECISION TO PLACE ALMOST TOTAL RELIANCE ON STATE GOVERNMENT WE DECLINED TO ISSUE COMPREHENSIVE REGULATIONS OR VOLUNTARY "GUIDELINES," FOR THE BLOCK GRANTS SINCE THESE COULD EASILY BE MISINTERPRETED AS ESTABLISHING STANDARDS AGAINST WHICH STATE CONDUCT WOULD LATER BE JUDGED. THE BLOCK GRANTS THEREFORE ARE EXEMPT FROM THE USUAL DEPARTMENTAL GRANT ADMINISTRATION REQUIREMENTS FOUND IN 45 CFR PART 74, THAT DEAL WITH SUCH ISSUES AS RECORDS RETENTION AND ACCESS THERETO, COST SHARING, PAYMENT METHODS, FINANCIAL MANAGEMENT STANDARDS, PROPERTY MANAGEMENT, ALLOWABILITY OF COSTS, AND PROCUREMENT STANDARDS. BECAUSE A FEDERAL REQUIREMENT FOR USE OF THE PART 74 RULES WOULD BE

INAPPROPRIATE FOR BLOCK GRANTS, WE ESTABLISHED A FISCAL AND ADMINISTRATIVE STANDARD IN THE BLOCK GRANT REGULATIONS PROVIDING MAXIMUM DISCRETION TO THE STATES AND PLACING FULL RELIANCE ON STATE LAW AND PROCEDURES. UNDER THIS STANDARD, INSTEAD OF LOOKING TO FEDERAL REGULATIONS FOR SUCH MATTERS AS PROPERTY MANAGEMENT OR PROCUREMENT STANDARDS, OR WHAT IS AN ALLOWABLE OR UNALLOWABLE COST, THE STATE'S LAWS AND PROCEDURES COVERING THE ADMINISTRATION AND EXPENDITURE OF ITS OWN REVENUES GOVERN. ANY EXPENDITURES IN VIOLATION OF THE STATE'S OWN LAWS AND PROCEDURES WOULD BE UNAUTHORIZED AND SUBJECT TO DISALLOWANCE.

SEVERAL SERVICE DELIVERY ORGANIZATIONS AND ASSOCIATIONS QUESTIONED THE LEGALITY OF "WAIVING" THE REQUIREMENTS OF 45 CFR PART 74. THEY NOTED THAT THE OMNIBUS BUDGET RECONCILIATION ACT DID NOT SPECIFICALLY WAIVE THESE PROVISIONS, AND STATED THAT AMENDMENT OF OMB CIRCULARS A-102 AND A-87 OR DIRECT APPLICATION TO OMB FOR AN EXEMPTION FROM THEM WAS REQUIRED. OUR DECISION NOT TO APPLY 45 CFR PART 74 TO THE BLOCK GRANTS WAS, HOWEVER, EXPLICITLY APPROVED BY OMB IN A LETTER FROM MR. STOCKMAN TO THE SECRETARY AND THEREFORE WAS FULLY AUTHORIZED.

THE OMNIBUS BUDGET RECONCILIATION ACT REQUIRES STATES TO COMPLY WITH THE ASSURANCES SUBMITTED WITH THEIR BLOCK GRANT APPLICATIONS AND THE STATUTORY PROVISIONS OF THE ACT. THE BLOCK GRANT PROGRAMS ARE INTENDED TO CONFER GREAT DISCRETION ON THE STATES, WHICH BY STATUTE ARE THE PRIMARY AUDITORS OF THEIR OWN EXPENDITURES. THE FUNDAMENTAL CHECK IN USE OF BLOCK GRANT FUNDS IS THE STATE'S ACCOUNTABILITY TO ITS CITIZENS, WHICH IS IMPLEMENTED BY PUBLIC DISCLOSURE WITHIN THE STATE OF INFORMATION GOVERNING USE OF THE GRANT FUNDS. ACCORDINGLY, WHEN AN ISSUE RISES AS TO WHETHER A STATE HAS COMPLIED WITH ITS ASSURANCES AND THE STATUTORY, PROVISIONS, THE REGULATIONS PROVIDE THAT THE DEPARTMENT WILL ORDINARILY DEFER TO THE STATE'S INTERPRETATION OF ITS ASSURANCES AND THE STATUTORY PROVISIONS OF THE OMNIBUS BUDGET RECONCILIATION ACT.

WHAT THE RESULTS OF THESE EXPERIMENTS WILL BE ON THE NATURE OF OUR FEDERAL SYSTEM, IT'S TOO SOON TO SAY. THE ADMINISTRATION, THE CONGRESS, THE NATIONAL GOVERNORS' ASSOCIATION, THE GAO, AND THE PRIVATE SECTOR ARE ALL INTERESTED. WHAT WILL BE THE EFFECT ON FEDERAL/STATE/AND

LOCAL GOVERNMENT RELATIONSHIPS? WILL DELIVERY OF SOCIAL, HEALTH, AND EDUCATIONAL SERVICES TO THE NEEDY AND DEPRIVED SUFFER IRREPARABLE HARM? WILL THE STRUCTURE OF THE CONGRESSIONAL COMMITTEE SYSTEM BE AFFECTED? WHAT MIGHT THE IMPACTS BE ON FEDERAL TAXING POLICY? ON STATE AND LOCAL TAXES?

WE'RE EXPERIENCING A REVOLUTION IN THE CONCEPTS THAT HAVE UNDERPINNED OUR SYSTEM OF FEDERALISM SINCE THE EARLY DAYS OF THE FIRST ROOSEVELT ADMINISTRATION. POWER HAS FLOWED INEXORABLY TO WASHINGTON FOR ALMOST 50 YEARS. NOW THE TIDE IS BEGINNING TO TURN IN THE DIRECTION OF THE STATES. ALL OF US WILL BE AFFECTED.

PANEL N

GOVERNMENT ACQUISITION RESEARCH PROGRAMS

PANEL CHAIRMAN

COL G. Dana Brabson, USAF
Dean, Department of Research and Information
Defense Systems Management College

PANEL MEMBERS

Dr. Paul F. Arvis
Manager
Army Procurement Research Office

COL Ronald Deep, USAF
Executive Director
Air Force Business Research Management Center

Dr. Joseph H. Augusta
Executive Director
Navy Center for Acquisition Research

GOVERNMENT ACQUISITION RESEARCH PROGRAMS

This panel's presentations were addressed primarily to defense agency attendees, as civil agencies do not currently employ dedicated acquisition research organizations. The Defense Systems Management College's (DSMC) presentation included an overview of the DOD structure for acquisition research: functions of the Defense Acquisition Research Council and Elements, coordination procedures, cooperative efforts, and plans. Directors of acquisition research for DSMC, Army, Navy and Air Force presented their organizations' missions, staffs, research methods, current and planned research projects, and peculiar problems. Each gave a detailed account of major projects in progress and planned, with emphasis on desired objectives, data acquisition, analytical techniques, and resources employed. Topics of the research described include practically everything addressed at this symposium. The research directors' encouraged suggestions for research topics and gave instructions on how to obtain the results of their research.

PANEL O

MULTI-YEAR CONTRACTING:
TERMS, CONDITIONS AND FUNDING ALTERNATIVES

PANEL CHAIRMAN

Mr. John H. Flaherty
Assistant Deputy Chief for Contracts and
Business Management
Naval Material Command

PANEL MEMBERS

Mr. John Jury
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Mr. Charles P. Nemfakos
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Office of the Navy Comptroller

Mr. Edward J. Trusela
Deputy for Acquisition
Office of the Deputy Assistant Secretary of the Air Force
for Acquisition Management

MULTIYEAR CONTRACTING AS A SHIP REPAIR CAPITAL INVESTMENT INCENTIVE

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CAVEAT

The opinions expressed herein are solely those of the authors and do not represent official positions of the Naval Sea Systems Command or the Department of the Navy.

ABSTRACT

As a result of the passage of the Fiscal Year 1982 Defense Authorization Act, Public Law 97-86, many of the statutory barriers that previously limited the use of multi-year contracting as an acquisition strategy have been lifted. It is apparent that a new sense of Congress has been expressed, encouraging the exploration of innovative multiyear contracting techniques. In this vein, this paper explores the use of a multiyear contracting technique to stimulate and foster heavy capital investment for the repair and overhaul of Navy ships. With the relaxation of the cancellation ceiling approval threshold and the authorization of the use of single-year monies to finance multiyear contracts for supplies and services in the 48 contiguous United States contained within the new law, it is highly possible that multiyear contracting, if properly managed, could be utilized to alleviate an element of risk that has previously prohibited substantial private capital investment in this industry.

Navy ship repair and overhaul is a unique commodity. The increasing complexity of installed electronics and weapon systems makes regular overhaul less susceptible to fixed price contract types. Additionally, the commodity also requires contractors to possess adequate and ample physical resources, e.g., piers, cranes, synchrolifts and drydocks, to perform a major overhaul. Many of the Navy's Master Ship Repair Contractors possess neither control over, nor access to, these facilities and current inflationary pressures, high interest rates and, above all, the uncertainty of guaranteed future work seem to mitigate against independent investments that may cost $10 to $80 million.

This paper poses a strategy that exploits the expanded multiyear contracting approach recently endorsed and recognizes the unique characteristics of ship repair. A five-year, multi-ship, multiyear cost-type contract is posited, including recommended procedures for source selection, incentive arrangements and special clauses, all of which attempt to integrate sound procurement practices with a procurement action designed to motivate capital investment for a less-than-stable commodity. Necessary Defense Acquisition Regulation deviations and a plan of action and milestones are also outlined.

It is the opinion of the authors that, despite its dichotomy with the classical multiyear approach, the strategy will successfully incentivize substantial facility capital investment, minimize the risk shouldered by the Government and achieve the objectives and benefits expressed in Public Law 97-86.

BACKGROUND-MULTIYEAR CONTRACTING

Multiyear contracting is defined as a method of contracting for goods and services in excess of current year (but no more than five years') Department of Defense requirements. In a multiyear scenario, monies are budgeted, appropriated by Congress and funded in annual increments. The contracting agency retains the unilateral right to cancel its requirements for all unfunded program years after the first year. In the event of cancellation, the contractor is protected from loss of unamortized costs up to an amount stipulated in the contract, a cancellation ceiling.

Multiyear contracting is a strategy intended to provide the Department of Defense the benefits of lower costs through increased contractor learning, the avoidance of repeated start up costs and the diminishment of administrative expenses in placement of contracts. Additionally, the long-term commitment for performance affords new sources an opportunity to compete and lessens the risk borne by new entrants to the marketplace. Finally, multiyear contracting provides contractors a capital investment incentive that may be unequaled by any other contracting arrangement.

A. Past Concepts

Multiyear contracting has long been recognized as a viable and valuable acquisition strategy. Prior to the passage of the Fiscal Year 1982 Department of Defense Authorization Act, Public Law 97-86 of 1 December 1981, however, legislative and regulatory restrictions on the application of multiyear contracting for supplies or services significantly limited the use of this technique.

1. Legislative Prohibitions

Public Law 94-106, the Fiscal Year 1976 Appropriation Authorization Act, placed a $5 million ceiling on cancellation charges that could be approved by the Services. This prohibition required the services to seek Congressional approval for cancellation arrangements in excess of this threshold. As a result, multiyear contracting, which had been authorized in Armed Services Procurement Requlations in 1963, became an acquisition strategy infrequently applied.

Public Law 90-378, codified as 10 U.S.C. 2306(g), authorized the Department of Defense to enter into multiyear contracts with single-year monies for supplies and services outside the 48 contiguous United States. As a result of this statute, the Comptroller General held consistently that, absent Congressional authorization to the contrary, multiyear contracting with one-year appropriations within the continental United States would violate the Anti-Deficiency Act, the Surplus-Fund-Certified Claims Act of 1949, and the Adequacy of Appropriations Act.

2. Regulatory Standards

Defense Acquisition Regulations (DAR), paragraph 1-322, provides regulatory implementation of the legislative restrictions cited above and sets forth the policy in which multiyear contracting may be considered a viable alternative.

Multiyear contracting may only be used when:

i) The need for the requirements is firm and continuing;
ii) The contract will realize significant benefits or cost savings by encouraging effective competition or promoting economies in performance or operations;
iii) The requirements are technically stable (no major design or specification changes are expected);
iv) If noncompetitive, the item will be obtainable only from the sole source during the entire multiyear period;
v) Risk of cancellation is low; and
vi) A high degree of confidence exists in the contractor's cost estimates and capabilities.

Current regulations allow multiyear contracting in both competitive and noncompetitive acquisitions, however the resultant contract must be either firm-fixed price or fixed price with economic price adjustment. Except for the escalation provisions in the latter, unit prices for each item in the multiyear requirement must be the same in all program years. Though cancellation charges of the contract need not be obligated in advance, they must be funded. Cancellation charges are limited to non-recurring costs.

Public Law 94-106 is implemented within Defense Acquisition Regulations in paragraph 1-322.1(a). The provisions of Public Law 90-378 are contained in paragraph 1-322.1 (d)(1).

B. Expanded Multiyear Contracting

In late 1980, multiyear contracting became the focus of increasing attention and scrutiny as an underutilized acquisition strategy that offered significant cost-saving benefits. The Defense Industrial Base Panel of the House Armed Services Committee, the Ichord Panel on the Defense Mobilization Base, and House Resolution 745 introduced by Congressman Dan Daniel with the strong endorsement of the Comptroller General all indicated that more flexible legislation and regulation should be applied to multiyear contracting, in order to expand its use and application. This groundswell of opinion continued through Fiscal Year 1982 Budget Hearings and culminated in very specific and more permissive language in Public Law 97-86 of 1 December 1981.

1. The New Legislation

In the Fiscal Year 1982 Authorization Act, Congress has specifically endorsed multiyear contracts and sanctioned their use "for the purchase of property, including weapon systems and items and services associated with weapon systems (or the logistics support thereof)" as long as the following conditions are met:

i) the national security of the United States will be promoted and total costs under the contract will be reduced;
ii) the need for the property or services is expected to remain relatively unchanged over the term of the contract and rates of production and quantities procured will be stable;
iii) the Department of Defense will annually request funding for the remaining program years;
iv) a stable design exists for the program and technical risk associated with its production is low; and

v) realistic costs savings and performance cost estimates can be computed.

Within the legislation, multiyear contracts utilizing any type of contract, other than cost-plus-percentage-of-cost, are sanctioned and the use of this strategy "to provide incentives to contractors to improve productivity through investment in capital facilities, equipment and advanced technology" is declared Congressional policy. Furthermore, the restriction on cancellation ceilings in excess of $5 million is lifted (replaced by a reporting requirement to the Armed Services and Appropriation Committees for any cancellation ceiling in excess of $100 million) and the language formerly interpreted to prohibit multiyear contracts for services in the continental United States is revoked. Finally, the inclusion of recurring costs within the cancellation charge is permitted.

At the conclusion of this Congressional endorsement of multiyear contracting, the Secretary of Defense is instructed to issue implementing regulations promoting its use within 90 days of enactment.

2. Implementing Regulations.

Expedited departmental implementation of the statute was forwarded to Navy procurement commands, via the Chief of Naval Material, on 1 March 1982. Preliminary changes reflect the revision made to cancellation ceiling thresholds and the lifting of the prohibition for multiyear service contracts in the continental United States. Additionally, the use of multiyear contracting to provide capital facility investment incentives is formally recognized. It is expected that a completely rewritten version of DAR 1-322 will follow.

The Chief of Naval Material's covering letter encourages innovative contracting terms and conditions to fully exploit, where appropriate, the expanded and permissive multiyear concept endorsed by Congress. Such innovations are suggested in cases:

1) where there may be application to other than major programs,
2) where the same unit price for all program years is not appropriate,
3) where requiring both single year and multiyear offers serves no useful purpose,
4) where facts justify the inclusion of recurring costs in the cancellation ceiling,
5) where the prudent use of options would provide a contributory benefit to the applicable cancellation ceiling, and
6) where advance procurement of economic order quantities of out-year parts, components and materials can be effected.

It is therefore expected that, pending the issuance of new regulations, appropriate deviations from existing standards of DAR 1-322 will be favorably considered.

BACKGROUND-OVERHAUL AND SHIP REPAIR

A. Introduction

Overhaul and repair of surface ships encompasses extensive maintenance actions performed by a public or private shipyard. The types of maintenance actions performed include major and minor repairs to all ship's systems, modernization of existing equipments through installation of major alterations and dry docking of the vessel. The Navy's current policy is to overhaul ships in or near the ship's homeport to minimize family disruption and improve crew morale. Other key factors considered in determining the industrial facility at which a ship will be overhauled include ship complexity (nuclear or non-nuclear propulsion and type of weapon systems), fleet operating schedule, material readiness requirements, shipyard workload and qualifications, shipyard capacity, capability and capacity in homeport areas and DAR applications to private sector competition requirements and small businesses.

The ship repair and overhaul industry is different from all other industries with which the Navy associates. It cannot be classified as either a pure supply product or a service. Basically, ship repair and overhaul of a Navy surface ship involves delivering a large Navy vessel to a contractor's facility, and leaving it for major repairs for a period of 8-12 months. During this period of time the contractor will be required to repair, overhaul and modernize portions of nearly every major system installed in the ship. The most common areas where work is performed include electronics, combat weapons systems, propulsion systems, mechanical systems, auxiliary systems, electrical systems, the hull, the sonar dome and propeller repairs. The objective of the overhaul is repair of systems, replacement of sub-systems and parts, and installation of major modernization alterations. The integration of these efforts results in restoring the ship to a material condition that enables it to perform reliably during the subsequent operating cycle.

Due to the inability of a contractor to verify the material condition of all systems prior to delivery of the ship to his yard, ship repair and overhaul entails several sets of work specifications requiring "open and inspect" in order to determine the precise status of various equipments and systems. Thus, in this environment, a strict categorization of either supply or service effort cannot be employed.

B. Ship Repair and Overhaul in the Private Sector

Navy shipyards overhaul the Navy's most complex ships, submarines, cruisers, aircraft carriers, guided missile destroyers and frigates, and a large investment in specialized skills, facilities and equipment is required. Ships of lesser complexity (amphibious, auxiliary and support ships) have been overhauled in commercial shipyards. Only one private shipyard is engaged in the overhaul of nuclear powered surface ships or submarines. However, an increasing number of complex combatants will be overhauled in the private sector over the next several years because of increasing complex ship workload in the public shipyards. In 1981, seven combatants with complex weapons systems were overhauled in the private sector; by 1984, this number will increase to approximately 23. No short-term changes in the number of shipyards, either public or private, are forseen. It is further indicated that nuclear-capable shipyards will be more heavily involved in nuclear ship work. Thus, there will be a shift of more non-nuclear complex ship overhauls to the private sector.

As a consequence, private industry must strengthen its capability to overhaul the complex weapon and electronics systems found on these combatants. Current planning calls for the Navy to continue to accomplish a minimum of 30% of ship maintenance and modernization work in the private sector.

C. The Ship Repair Marketplace

Master Ship Repair (MSR) "contracts" are unique agreements the existence and legitimacy of which as a contracting form is upheld by the DAR. Essentially, an MSR agreement is a multi-source basic ordering agreement containing specifically approved clauses that are unique to the ship repair and overhaul industry. Contracts are awarded under the master MSR agreement via job orders. Private concerns desiring an MSR agreement must apply to the Navy and, if granted one, become eligible to bid on Navy ship repair and overhaul work. Private firms which do not hold an MSR agreement may not be restrained from bidding on Navy work provided they can obtain an MSR agreement prior to commencement of the work. MSR eligibility is established among other things by a pre-award survey to determine if the contractor possesses the necessary resources (e.g., management, technical, facilities and financial) to accomplish the Navy overhaul and repair work.

The importance to the Navy of ensuring that only qualified contractors work on Navy vessels cannot be over-emphasized. The risks to the Navy and the national defense posture are too great not to have some mechanism for ensuring that only qualified sources work on Navy ships. The prominent role the Navy plays in national defense and foreign policy matters necessitates that ship repair and overhaul be performed competently and in a specific period of time. Readiness to meet sea-borne hostile threats and the requirement to be able to respond to national or international emergencies make it imperative that Navy assets be materially ready on short notice. In order to accomplish these missions, the Navy establishes maintenance cycles for each class ship that permit adequate coverage of mission requirements while ensuring some ships receive both new equipments reflecting the latest technological advances and the normal major maintenance due high investment capital assets. To this end, the Navy attempts to protect its investment in surface ships by having only qualified ship repair and overhaul firms perform work on these ships.

D. Techniques for Contracting For Ship Repair

Job orders awarded under the MSR agreement are firm-fixed price in type, however not all ship repair and overhaul efforts are awarded in this manner. In response to strong encouragement from the General Accounting Office (GAO), Invitations for Bid (IFBs) have given way to Requests for Proposals (RFPs) and the Navy has awarded several cost-type contracts for ship overhaul and repair. These contracts contain standard cost-type (supply) provisions, not MSR clauses. All awards have been competitive in nature and only offerors who hold MSR agreements have submitted proposals. Thus, the validity of the Navy's view that only qualified ship repair and overhaul firms should bid on these efforts seems to be both recognized and upheld by industry.

In solicitations for the accomplishment of complex, large dollar value overhauls over the past two years, the RFP has stated that a cost-type contract was contemplated and that formal source selection procedures would be used. A significant feature of the source selection process has been the identification of several ship repair firms which lack substantial physical assets, skills and facilities to be competitive for contract award. In several instances the Navy has had to provide key assets, e.g., drydocking facilities, or else "split bid" the awards to ensure the drydocking portion of the overhaul is accomplished by a qualified source.

The Navy's migration to utilizing RFPs resulting in cost-type contracts has permitted grouping two or more ships into multi-ship lots. These ships have been of the same kind (DD, LST or FF) and of the same class. The work package, including specifications, has been referred to as "notional" due to the inability of the Navy to draft complete specifications for ships in the work package beyond the lead ship. Thus, all of the ships are bid to the lead ship's specifications with the understanding that optional follow-on individual ship's specifications will be furnished approximately 120 days before the commencement of the individual ship's overhaul date. This technique affords substantial flexibility to the Navy in accomplishing emergent work, installation of various ship's systems alterations and configuration control.

Another improvement in contracting for ship repair and overhaul was the establishment, in July 1981, of a solicitation area policy. Such a policy, which limits the solicitation to the smallest of three geographical areas in which adequate competition is expected to be obtained, homeport area, extended solicitation area or coast-wide, is aimed at implementing the Chief of Naval Operations (CNO) objective of performing ship overhauls at or near the ship's homeport.

Thus, three key changes have been made: a shift in emphasis from formal advertising to negotiation of cost-type contracts; solicitation and award of multi-ship option packages; and the establishment of a uniform solicitation area policy. It has been expected that these changes would successfully recognize the entrance of more complex ship repair procurements into the private sector, better implement CNO overhaul in homeport policy and lead to an increase in private sector industrial capacity near major homeport areas.

E. Facility Improvement in the Private Sector

Though the Navy continues to emphasize the goal of high quality private sector overhauls, a strong commitment from industry will be necessary to ensure that Navy ships are completed within budget and schedule constraints. As more and more combatant ships are overhauled in the private sector, emphasis will be placed on applying new technology to improve the private sector's industrial work process, plant equipment and facilities. Such improvements should result in a reduction of overhaul costs and duration. However, the necessary improvements will not be forthcoming from the private sector without sufficient support and recognition for their efforts by the Navy. Industry has already provided these signals in areas of heavy fleet concentration throughout the country. In response, the Navy can indicate its support to industry by providing encouragement in the form of significant contractual incentives that will motivate industry to build and develop a robust industrial base for ship repair and overhaul where shortfalls exist.

ANALYSIS - MULTIYEAR CONTRACTING FOR SHIP REPAIR

To summarize the discussion thus far, maintenance of afloat Navy assets is an increasingly complex task. A typical statement of work for a single ship begins to evolve eighteen to twenty-four months prior to the ship's availability. Though many of the elements of the work package are common among ships of the same class (a drydock period for hull work, "K" alterations as part of the Fleet Modernization Program, etc.), each ship will inevitably be different, owing to its deployment schedule, maintenance history and the talents of its individual crew. Coupled with the growing sophistication of onboard weapons and electronics suites, these facts have given rise to significantly more use of negotiation, formal source selection (with technical and management expertise predominant among evaluation factors) and cost-type contracts.

To respond to the Navy's overhaul in homeport policy, an acquisition strategy must be fashioned that both recognizes the procurement techniques required for many overhauls (negotiation, formal source selection and cost type contracts), while channeling sufficient contractual incentive to a geographic area lacking sufficient ship repair facility capacity.

A. Alternative Incentives

1. Profit

In the authors' assessment, recent Navy experience has indicated that profit, under current Weighted Guidelines, provides an incentive insufficient to alleviate the risk associated with a contractor's long-term construction of a ship repair capital facility. A recent interview by the authors with an executive of a West Coast ship repair company revealed that a drydock large enough to accommodate the majority of surface combatants would take a minimum of 2 1/2 years to construct and represents approximately a $40 million investment. A survey of defense contractors conducted by the National Security Industrial Association indicated that the minimum return on assets (ROA), after taxes, for capital acquisition is 15 percent. In light of the necessary movement toward cost-type contracts, it is therefore considered infeasible that a profit or fee level large enough to provide the overwhelming minimum ROA considered necessary by industry could be authorized for an expenditure of this magnitude.

2. Multi-Ship (Option) Contracts

The Navy is currently packaging many multi-ship solicitations for contract award by utilizing the notional work package technique discussed previously to price follow-on option ships. Though multiship packages have been intended to provide an incentive for facility improvement, they have not been successful. The Navy's unilateral right to require performance of the follow-on overhauls, though generally exercised, still requires a contractor to shoulder an unreasonable (in the eyes of the contractor) amount of risk in assuming that the future work in the option ships will provide an amortization base for a repair facility capital-improvement venture. Too many variables and unknowns, schedule slippages caused by new work discovered in individual ships or operational commitments that delay the availability of the follow ships, can void any guarantee of future work the contractor may entertain.

3. Capital Investment Incentive Clauses

DAR 3-815 posits a strategy whereby a contractor may be motivated to acquire capital facilities through a contractual guarantee that, should a program be terminated, the Government will fund the residual, undepreciated value of the asset.

The technique has drawbacks when contemplated as a solution to ship repair capital investment shortfalls. First, it presupposes that ownership of the asset, should the program be cancelled, would be useful to the Navy. Ship repair facilities, such as drydocks, cranes or machine shops, are not generally severable assets of which the Navy could make sufficient use to justify the cost. Capital facility investment clauses are generally utilized only for major systems acquisitions. Their use is prohibited by DAR for real property. Thus, this technique may be dismissed as a viable alternative.

4. Multiyear Contracting

In recognition of the permissive language of the 1982 Authorization Act, recent expedited implementation regulations, the encouragement of innovative applications and appropriate deviation requests, and the imminence of changed DAR Provisions expected to sanction expanded utilization, it is now possible to seriously explore multiyear contracting as a viable capital investment incentive for the ship repair industry. A recapitulation of the facts presented earlier illustrates that a cancellation ceiling approval threshold large enough to accommodate ship repair facilities is now within the domain of the Services and that single-year monies can be utilized to fund multiyear contractual arrangements. A multiyear, multi-ship package assembled for a specific geographical area with ship repair facility shortfalls poses the best available contracting alternative discovered by the authors to provide industry sufficient incentive to embark on a $40-50 million capital acquisition venture. Such an arrangement, however, requires careful and detailed planning and execution with a continuing perspective on the conditions under which Congress has endorsed multiyear contracting.

B. Impediments and Compatibility in the Multiyear Ship Repair Scheme

A ship repair multiyear contract poses unusual, albeit not overwhelming, challenges. A growing recognition that cost-type contracts are more suitable for major ship repair availabilities forces one to explore a multiyear cost-type arrangement, with adequate protection against "buy-ins" and suitable cost control leverage. Though ship repair is generally considered an effort of only moderate, at its extreme, technical risk, one can hardly characterize the specifications "stable." The unknowns inherent within an "open and inspect" effort, the unique material condition of individual ships and the inability to definitize a work package for follow on ships at the outset of any multiyear arrangement requires the presumption of contract growth through new work. The use of the experimental notional work package technique would seem to mitigate against the classical multiyear technique. Cost accounting standards may prohibit full amortization of ship repair facilities within the maximum five-year boundaries of a multiyear scheme, therefore incentives additional to the risk-diminishing cancellation ceiling may be necessary to encourage capital acquisition progress. Finally, the use of single-year monies to finance out-year long-lead material acquisitions, a major source of multiyear savings, must be explored.

Nonetheless, the authors believe that a multiyear arrangement for ship repair is viable and will both be beneficial for the Navy and meet the conditions set forth by Congress for expanded multiyear application. Reviewing the five conditions cited in Public Law 97-86, the authors believe that:

(i) the national security of the United States and reduced total costs will be promoted by the exploitation of learning, both from a quality and an economic perspective, offered by a multiyear ship repair contract;

(ii) the need for major ship repair availabilities will remain stable and can be accurately forecast;
(iii) the Department of the Navy will continue to annually request funding for maintenance of its major capital assets;
(iv) specifications provided at the outset of contract award, coupled with the presumption of new work growth, pose an acceptable pricing risk as long as the notional work package concept and additional cost control incentives can be employed; and
v) realistic cost estimates can be computed within the notional work packages.

PROCUREMENT METHODOLOGY

This section of the research paper sets forth the basic requirements of a multiyear approach to ship repair, in consonance with sound procurement practices, that will serve to encourage facility investment.

A. Determinations and Approvals Necessary and DAR Deviations Required

Prior to planning the multiyear scenario that will be posited herein, existing DAR regulations require that the following written determinations be made by the procuring agency:

(i) the need for the overhaul and repair services is firm and continuing (DAR 1-322.1(c)(1)(i) and 1-322.1(d)(3)(i));
(ii) a multiyear contract will serve the best interests of the Government through effective competition and cost savings will result (DAR 1-322.1(c)(1)(ii) and 1-322.1(d)(3)(iii));
(iii) a substantial initial capital investment will be required of the awardee (DAR 1-322.1(d)(3)(ii)); and
(iv) in order to minimize a first program year "buy-in", solicited prices should be submitted for the multiyear requirements only, since it would be impractical to recompete the out-year requirements (DAR 1-322.2(a)(3)).

Additionally, since the proposed multiyear contract period will exceed 3 years, regulations require a determination signed by the Assistant Secretary of the Navy (Shipbuilding and Logistics) concurring in the determinations shown in (i), (ii) and (iii) above.

Finally, as encouraged by the Chief of Naval Material, the following assumptions of the strategy require deviations from DAR in order to proceed:

(i) a cost-type multiyear contract with non-level pricing among ships packaged together is necessary in recognition of individual ship material conditions;
(ii) a maximum award fee of 15% is believed necessary to properly encourage quality, schedule and cost control, and facilitization efforts;
(iii) multiyear contracts have generally not been considered for a commodity such as ship repair, an other-than-major systems acquisition program;
(iv) advanced procurement with single-year monies will effect cost savings for long-lead material; and
(v) performance periods for individual ships, which will be contracted for on a completion basis, will span fiscal years.

Once these issues have been resolved, the multiyear acquisition can be initiated.

B. RFP Preparation

Formulation of the RFP will require a clear statement of work that accomplishes both satisfactory repair and overhaul of the assigned vessels and investment in extensive facilities and equipment. The authors envision a draft RFP being forwarded to industry for comments and recommendations. It is anticipated that industry would require 60 days to thoroughly review the RFP. After assessing industry's comments and recommendations, a firm solicitation would be forwarded to industry to commence the competition. It is anticipated that industry would have approximately 90 days to submit proposals. Approximately 30 days into the solicitation period, a bidder's conference would be held to facilitate a more comprehensive understanding of the requirements of the RFP. Included in the RFP would be special clauses that would direct industry's responses to the following specific requirements:

(i) establishment of a local, permanent facility in which the full range of ship repair and overhaul activities can be performed as one goal of this acquisition;
(ii) the amount of the cancellation ceiling and the conditions under which specific recurring and non-recurring costs, and the method by which these costs would be allocated as overhead, would be included;
(iii) establishment of a precise cost accounting system that would permit segregation of costs for the work required for each vessel in addition to the capital improvement investments;
(iv) establishment of more precise definitions of "growth" and "new-work" so

that cost overruns and fee-bearing changes may be more properly assessed;

(v) ability of the Navy to substitute like-ships in the event that unforseen operational commitments cause a ship listed in the RFP to be removed from the schedule.

The authors envision that three separate proposals will be submitted by each contractor. One proposal would be required for technical aspects of the repair and overhaul of the multi-ship package; one for facilities development and costs thereof; and one for the costs of the multi-ship package. A key aspect of the evaluation of the above proposals would be the manner in which contractors successfully integrate their respective capital investment approach with the requirements of the multi-ship package.

Since the objective of this procurement is to encourage significant private capital investment in facilities concurrent with satisfactorily overhauling several Navy ships, a careful structuring of the award fee provisions is necessary. Simultaneous emphasis would be placed on schedule, cost and performance of the current work in addition to the contractor's efforts in facilitization. Presumably, this emphasis would be reflected in the award fee category weights and level of award fee funding provided.

C. Source Selection Criteria

Due to the high degree of commitment by industry required for the proposed procurement, a formal source selection process that includes the Navy's most talented experts is warranted. These experts would be assembled from several commands around the country. Their selection would be based on strong, demonstrated professional performance in their fields of expertise. Selection criteria as listed in the Source Selection Plan would be as follows (in descending order of importance): Management Approach; Resources (Facilities); Cost; Technical Approach; and Experience/Past Performance.

Management Approach would consider the contractors' organizational structure and their organizational approach for accomplishing both the multiship and facilitization efforts. The Resources category would examine current physical resources and manpower available to accomplish the stated overhauls. Further, contractors would have to integrate their investment in facilities approach with existing resources to demonstrate its feasibility. The Cost category would consider both cost realism in estimating the scope of the overhauls involved and lowest overall projected cost to the Government. Technical Approach would consider the various specific approaches utilized by contractors in performing work on combat systems, propulsion systems, quality control and extent and use of subcontractors in the overall effort. Experience and Past Performance would reflect each contractor's experience and cost and schedule performance with Navy repair and overhaul over the last five years.

D. Additional Contract Provision

In addition to the special clauses discussed in paragraph B above, the RFP would include a provision for the Navy to provide interim facilities for the first 2-3 ships in the multi-ship package while the contractor is acquiring or developing the facilities necessary to meet the capital improvement requirements of the solicitation. Alternatives available to the Navy are as follows:

(i) in-place local facilities, i.e., a dry dock/graving dock;

(ii) a re-located facility (floating dry dock); or

(iii) lease of a local commercial facility.

E. Plan of Action and Milestones for Accomplishment of Multiyear Contracting Technique

The following schedule proposes a planning horizon timeline for development of the multiyear technique postulated and is predicated upon the number of calendar days required for each event prior to commencement of the lead ship availability. It is recognized by the authors that several of the events may be pursued in parallel and, thus, compress the timeline further. Based on the postulated timeline, approximately one year prior to the commencement of the lead ship's availability would be the required timeframe to accomplish the proposed procurement.

EVENT	TIME LINE *
1. Identify specific ships for the work package	Note 1
2. Prepare the work package, including notional specifications.	Note 2
3. Prepare the Source Selection Plan (including source selection criteria) and appoint the source selection officials	A-360
4. Prepare a draft RFP	A-360
5. Request necessary DAR deviations	Note 3
6. Release draft RFP to industry for information and comment	A-330
7. Distribute firm RFP to industry	A-270
8. Bidders' conference	A-240
9. Evaluate proposals, hold discussions, request best and final offers	A-180
10. Award contract	A-90

11. Commence lead ship overhaul A-0

*The traditional method of reflecting milestones in ship repair and overhaul is to use the abbreviation "A-" preceding the number of days estimated for that event. For example, an A-90 notation would indicate completion of an event 90 days prior to the commencement of the ship's overhaul start date.

Note 1. Subsequent to the Head of the Procurement Agency's (HPA's) approval of the postulated multiyear technique, the appropriate Fleet and Type Commander would be tasked to provide several candidates for the proposed work package. As a practical matter, the Fleet and Type Commanders would not be totally unfamiliar with the proposed procurement technique since the authors presume their general concurrence in the concept proposed prior to HPA approval.

Note 2. Preparation of the work package is not considered a major obstacle in that the planning effort for the lead ship's overhaul is presumed to be in progress regardless of the specific ship designated to be first in the multi-ship package. The current work package preparation efforts utilized by the Navy would not have to be altered dramatically to accommodate the procurement unless the proposed concept was to be implemented prior to the normal availability of the work package specifications.

Note 3. The necessary DAR deviations would, in any event, be required prior to forwarding the firm RFP to industry (A-270). It is conceivable that certain final deviation authority may not be granted until a thorough review of the comments and recommendations from industry is completed. DAR deviations would not be pursued until the HPA indicated approval for the postulated multiyear approach.

RISK ASSESSMENT

No analysis of an acquisition strategy would be complete without a review of the risks inherent in application of the strategy. Multiyear contracting for ship repair is not without risk; no new procurement technique is adopted with all unknowns identified. However, within the framework of the methodology described in this paper, an adequate risk assessment can be performed by weighing known benefits of the stategy against known detriments.

A. Benefits

One of the primary benefits of a multiyear ship repair arrangement is the early identification of the planned overhaul site for all ships within the multiyear package. Such identification is in accordance with the goals of CNO policy to minimize the Fleet disruption caused by less than timely decisions on an overhaul site. Additionally, multiyear contracting makes possible a sufficient contractual incentive, via a shift in risk away from the contractor, for substantial ship repair capital investment. By targeting the solicitation and award to a specific geographical area, full compliance with CNO Policy, overhaul in homeport, may be realized.

It is striking to recognize that there are alternative solutions to geographical ship repair facility shortfalls other than contract incentives. But, Military Construction projects, reassignment of homeports or an abrogation of CNO Policy, are simply not considered viable due to high costs or political sensitivity. Therefore, the multiyear contract strategy seems both the best contracting solution and the best overall solution to ship repair facility shortfalls.

Cost savings are expected to be realized in increased learning for identical follow on ship work items and by early economic lot purchases of long lead material. Additionally, some savings may be effected by the contractor's involvement in the planning process for follow ships.

Finally, the exploitation of the expanded multiyear concepts to ship repair is considered beneficial in its application of innovative techniques to a commodity that heretofore was not considered susceptible to multiyear contracting.

B. Detriments

One drawback to the strategy posed is the need for the Navy to provide interim facilities while those the contractor is acquiring are being constructed or developed. Another option would be to structure the multiship package with front end ships that would not require the use of the facilities (minor restricted availabilities requiring no drydock period). Though varying solutions can be postulated, an important portion of planning the acquisition will be resolving the issue of interim facilities.

A major disadvantage to this strategy is the complexity of contract administration necessary for success. The contractor's progress on facility development will have to be continually gauged, cost incurrence and control will need to be surveilled, new work, work deleted or cost overrun must constantly be negotiated and priced and schedule and quality emphasis will be constantly shifting. These facts necessitate a constant reappraisal of the award fee structure and relative position of the various evaluation factors.

Fortunately, the flexibility of this incentive approach accommodates changing priorities. Unfortunately, adequate administration to secure success is both time-consuming and challenging.

The final detriment to a multiyear cost-type contract is the inherent lessening of termination flexibility as a solution to poor performance by a contractor. Except in the final year of a multiyear arrangement, termination of the multiyear contract will invoke the provisions of the Cancellation Clause for the outyears. The expense associated with a termination action is infinitely greater than that associated with failing to exercise an option under the current multi-ship contracting technique.

C. Measuring Cost Savings

Though it may be possible to demonstrate some measure of cost savings associated with advance procurement and learning on the multiyear contract described in this paper, the validation of actual overall cost savings accruing to the Navy from a multiyear arrangement in comparison with a series of single year (or single ship) contracts may not be possible. Given the inevitable differences between ship platform maintenance requirements, the analysis required to determine the benefits of multiyear buys of weapon systems cannot be performed in a single year to multiyear ship repair comparison. One must also consider the "cost savings" associated with the improvements to the ship repair mobilization base that is the main objective of this recommended contract. How does the opportunity cost (more correctly, credit) of acquiring the long-term benefit of correcting a geographical ship repair facility shortfall enter the savings computation? It may be that the inability to precisely forecast cost savings, despite concurrence that it will result, is both an advantage and a disadvantage to the ship repair multiyear scheme.

D. Summary

A benefit to detriment "ratio" can only be computed in light of specific facts and circumstances. Against the general strategy presented in this paper, it is not possible to accurately determine that a multiyear contract for ship repair would pose an acceptable assumption of risk for the Navy in all cases. Clearly, unknown benefits and detriments would be identified as the acquisition planning progresses. The authors do believe, however, that many of the disadvantages identified in this paper can be minimized in impact with proper planning and execution and that, thus diminished, are significantly outweighed by the opportunity to bolster the ship repair industrial capacity inherent within the expanded multiyear concept.

CONCLUSION

Multiyear contracting is by no means a panacea for nationwide economic ills and their impact upon mobilization base capabilities. Nor is this paper meant to serve a purpose other than to suggest a general framework in which this procurement technique can be applied to a commodity that heretofore would not have been considered a multiyear candidate. It is, however, the opinion of the authors that a multiyear contracting strategy to incentivize capital facility investment can successfully be adapted to the acquisition of ship repair and overhaul. The planning, execution and administration of such an acquisition will be a challenging task and it should only be undertaken with a full realization that certain risks will have to be assumed by the Navy in its adoption. Additionally, the classical multiyear mindset must be overcome in order to obtain the regulatory relief necessary. Despite these obstacles, it is an experiment that will fully exploit the expanded multiyear approach sanctioned by Congress and it is further believed that such a strategy poses the only workable solution to correcting geographical shortfalls of ship repair facilities.

REFERENCES

Public Laws 90-378, 94-106 and 97-86.

Defense Acquisition Regulations.

Chief of Naval Material letter 02A/DR NDAR Imp 82-5 of 1 March 1982.

"DOD Urged to Revise Methods to Improve Capital Acquisition," Federal Contracts Report, Number 917, 1 February 1982, Bureau of National Affairs.

ADVANCE PURCHASE FUNDING

FOR

MULTI-YEAR CONTRACTS

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BACKGROUND

Multi-year procurement was first adopted by the Department of Defense in 1962. In its original form, multi-year procurement simply amounted to a promise by the contracting service to award something akin to a series of single year contracts to a particular producer. While a single contractual instrument was employed, funds to support each program year of the multi-year period had to be authorized and appropriated separately. The primary linkage among program years arose from the fact that nonrecurring costs were amortized over all units to be delivered during the multi-year period. If future program years were not funded, the contract was considered to be cancelled. The contracting service then assumed a liability to reimburse the contractor for that portion of nonrecurring costs allocated to the cancelled program years. Originally, there was no limitation on the amount of unamortized nonrecurring cost for which the service would be liable in the event of cancellation. However, as a part of the 1976 Defense Authorization Act, Congress limited the Government's cancellation liability to $5 million. The establishment of this limitation completed the evolution of the form of multi-year procurement which was employed until passage of the Department of Defense Authorization Act of 1982. It is particularly important to note that only unamortized nonrecurring costs were recognized as a legitimate cancellation liability. Any materials purchased, or other recurring cost incurred, to support a future program year which was never funded became a nonreimbursable expense for the contractor.

As can be deduced from the preceding paragraph, multi-year procurement was characterized by rather rigid and restrictive requirements. The $5 million cancellation liability ceiling effectively limited multi-year contracts to nonmajor systems and replenishment items; and exclusion of recurring costs from cancellation settlements discouraged contractors from making advance purchases of materials to exploit economies of scale. Any attempt to provide Government funding for such advance purchases was frustrated by the full funding requirements of DOD Directive 7200.4. Thus, on the one hand the Government refused to finance advance purchases, and on the other hand refused to recognize contractor financed advance buys in the event of cancellation. The net effect was to preclude the advance purchases of economic order quantities.

With the advent of the 1982 Defense Authorization Act (P.L. 97-86), much greater latitude is provided for multi-year procurement. Three provisions of the Act are particularly germane to this writing. First, the cancellation liability ceiling is raised from $5 million to $100 million[1], thus greatly expanding the scope of multi-year contracting. Second, the inclusion of both nonrecurring and recurring costs in cancellation ceilings and settlements is authorized. Finally, the Act clearly authorizes the advance purchase of components, parts and materials to achieve economic lot purchases and more efficient production rates.

By providing for inclusion of recurring costs in cancellation ceilings, Congress has assumed that in certain circumstances a contractor will finance advance purchases from its own working or debt capital. If this were the case, large unfunded liabilities would be created, and moneys to liquidate these liabilities would have to be made available at the time of any subsequent cancellation. In this regard, P.L. 97-86 provides that costs of cancellation may be paid from:

(a) Appropriations originally available for the performance of the contract concerned;

(b) Appropriations currently available for procurement of the type of property concerned,

[1] Even this limitation can be exceeded if Congress is notified thirty days in advance of entering into the contract and interposes no objection.

and not otherwise obligated; or

(c) Funds appropriated for those payments.

On the other hand, by explicitly authorizing advance purchases for the sake of economy, Congress has implicitly recognized an obligation to fund such purchases when the situation demands. In this case, a funding "bow wave" could be created, as funds are obligated in advance of the benefiting program year. However, the magnitude of unfunded liabilities to be included in cancellation ceilings would be greatly decreased.

Thus, the Government is faced with a difficult choice. It must either appropriate sufficient moneys to fund the advance purchase, or incur large unfunded liabilities if contractor financing is required. Beyond this, there are a number of available methods which could be employed to provide advance purchase funding. The remainder of this paper will be devoted to exploring the various advance purchase financing techniques which might be adopted, together with analyzing the advantages and disadvantages of each approach.

FUNDING OPTIONS

There are four basic alternatives for funding advance material purchases. The following paragraphs discuss these options in the context of a hypothetical multi-year procurement.

Figures 1 through 4 will serve as the framework for this analysis. Each assumes a three-year contract, requiring delivery of 33 end items for each program year. Nonrecurring costs (NRC) in the amount of $35 million are amortized evenly across all three years. The advance purchase of materials is included at $100 million. A distinction is then made between the prime contractor's obligation and expenditure profiles. That is, it is assumed that subcontracts for advance materials will be awarded as follows: $60 million to be obligated in fiscal year one (FY 1); $40 million in FY 2. However, actual vendor payments will not be made until delivery takes place. The expenditure profile developed in this example assumes payment of $50 million in FY 1; $30 million in FY 2; and $20 million in FY 3. The effect of progress payments on this expenditure profile is also considered. Finally, other recurring costs (ORC) are established at $165 million, or $55 million in each program year. While highly simplified, the following examples of advance purchase alternatives illustrate many of the advantages and disadvantages of each option.

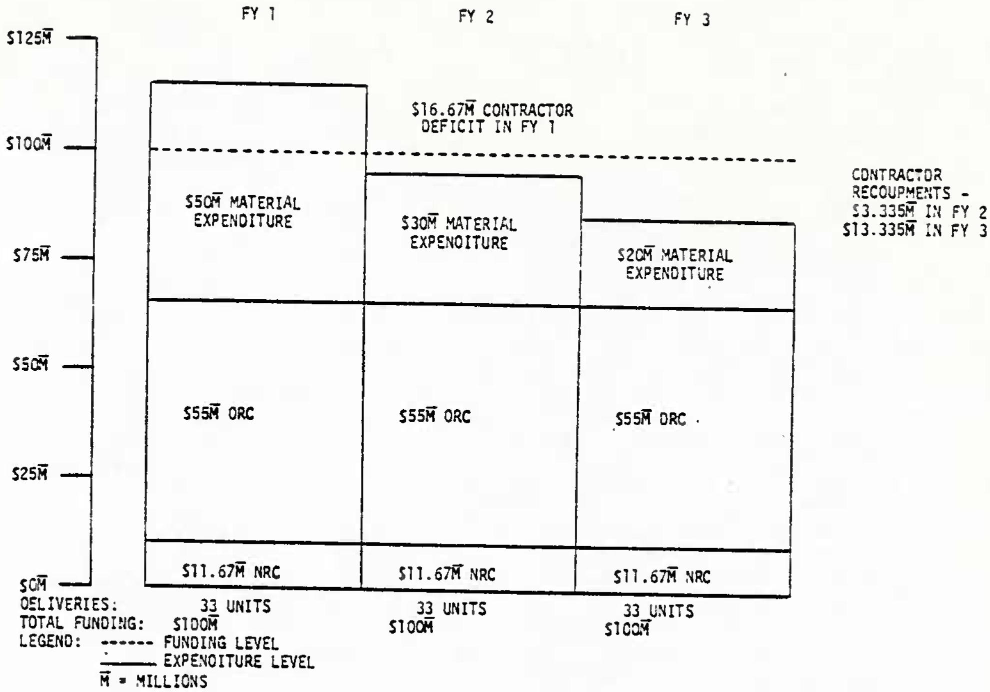
Contractor Financing

If the alternative portrayed in Figure 1 is applied, level funding of $100 million per year would be provided, and the financing of the advance purchase would come from the contractor's own working or debt capital. Under this concept, the contractor would incur a deficit in FY 1 of $16.67 million which would not be fully recouped until contract completion. While some relief would be provided by progress payments, this would not be sufficient to cover purchases for all unfunded program years. Borrowing costs associated with a contractor financed advance purchase would either be absorbed in the form of reduced profit or reflected in inflated cost figures.[2] In addition, the prospect of having to finance advance purchases might inhibit competition. Contractor financing has the advantage of eliminating the funding "bow wave" alluded to earlier. However, the Government may ultimately be faced with having to cover a sizeable unfunded liability in the event of cancellation. In sum, while this alternative may be appealing on the surface, it carries distinct disadvantages which could make it difficult to implement in many cases.

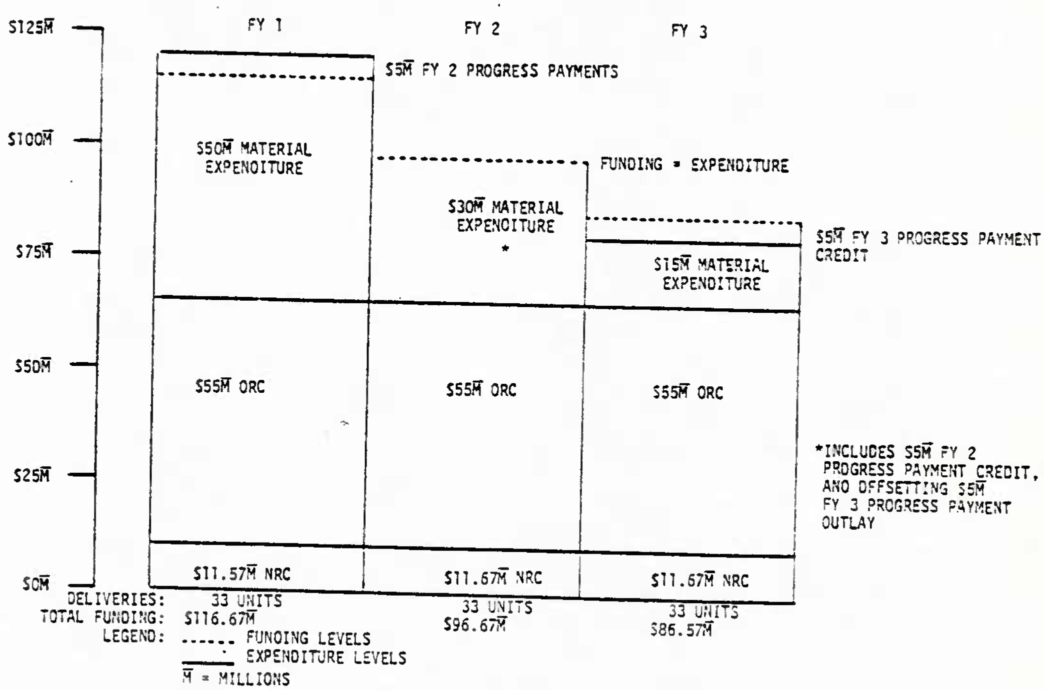
Expenditure Funding

Figure 2 illustrates the concept of expenditure funding for advance purchase costs. Under this concept, Government funds would be obligated at a level sufficient to cover the contractor's payments for delivered items in each program year. Thus, $50 million would be obligated to cover advance purchase deliveries in FY 1; $30 million in FY 2; and $20 million in FY 3. Comparison of the funding profile reflected in Figure 2 with that reflected in Figure 1 illustrates the skewing effect towards early program years--hence, the funding "bow wave." As will be seen in subsequent paragraphs, expenditure funding creates the least acute "bow wave" of any Government financing option. However, it would probably not eliminate contractor investment, as progress payments to vendors would generally be required for outyear fabrication. Funding shortfalls would most certainly occur if flexible progress payments were included in the contract. Nonetheless, contractor investments would be greatly reduced. This, in turn, should reduce or eliminate the inhibition to competition discussed above. The provision of expenditure funding would also reduce the Government's unfunded cancellation liability. However, a certain level of unfunded liability would accrue, as the prime contractor would be liable for costs associated with terminating its advance purchase subcontracts in the event of cancellation. In sum, the amount of recurring costs included in the unfunded cancellation ceiling would be

[2] The latter course of action would place the contractor in a compromised position as Defense Acquisition Regulation (DAR) 15-713.7 specifically designates interest and other financial costs as patently unallowable.



CONTRACTOR FINANCED ADVANCE PURCHASE
FIGURE 1



EXPENDITURE FUNDED
ADVANCE PURCHASE
FIGURE 2

greatly reduced--but not entirely eliminated--by moving from contractor financing to expenditure funding.

Termination Liability Funding

Under the concept of funding to termination liability (Figure 3), the Government would again provide advance purchase funds sufficient to cover payments for deliveries actually made by vendors during a given fiscal year. In addition, funds would be included to cover any termination costs for which the prime contractor would be liable if future program years were cancelled. Referring to Figure 4, funds would be obligated on the prime contract in FY 1 for (1) actual payments of $50 million for items to be delivered to the prime contractor in FY 1, and (2) termination liability of $5 million associated with work in process for FY 2 deliverables. Such termination liability funding could be considered a progress payment reserve to cover costs incurred by vendors in FY 1 in support of deliveries to be made in FY 2.[3] This would be a logical approach in that any resultant termination settlement would similarly include payments for completed items and work in process. The approach has certain merits. Constructive use would be made of funds reserved to cover termination liability by providing the prime and subcontractors with sufficient working capital. This would not represent an unearned benefit, as any progress payments would be based on costs actually incurred. In the event of cancellation, any outstanding progress payments could simply be credited against the negotiated termination settlement(s). A major disadvantage of termination liability funding appears to be administrative complexity. First, progress payments made during FY 1, for example, would have to be liquidated against delivery payments in FY 2. Second, as progress payments cover only a portion of costs actually incurred, exclusive of profit, a mechanism would have to be developed to credit any unused FY 1 termination liability funds to the FY 2 account. By applying this technique to the example given, only $25 million would have to be obligated for FY 2 advance purchases, the remaining $5 million being provided by FY 1 progress payment liquidations and other credits. A similar situation would occur in FY 3, in which only $15 million would have to be obligated. As is often the case with multi-year contracting, these factors would lend an additional element of complexity, but should not present an insurmountable barrier to the application of an otherwise sound technique. A second major disadvantage lies in the fact that termination liability results in an even greater "bow wave" in the early program years. On the positive side, it should be noted that no unfunded liability associated with advance purchases is created. Thus, there should be no need to include recurring costs in unfunded cancellation ceilings.

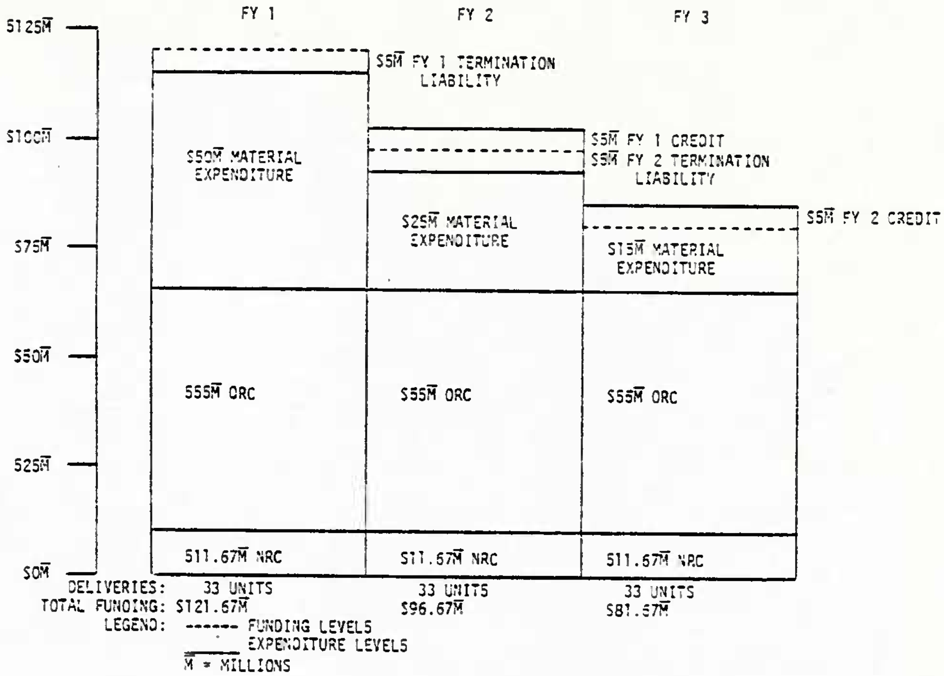
[3] A reserve of this sort would seem to be essential if the contractor investment goals for flexible progress payments are to be maintained in multi-year procurement.

Full Funding

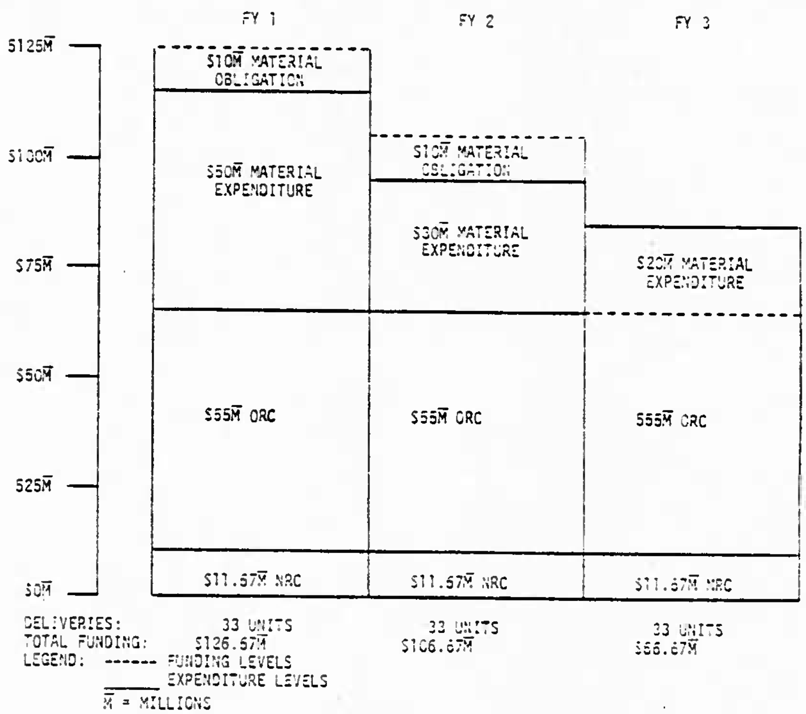
Figure 4 illustrates the full funding concept as it would apply to advance purchases in multi-year procurement. Under this approach, the Government would develop a funding profile which paralleled the contractor's obligation profile. That is, if the contractor intended to place subcontracts and purchase orders totalling $60 million in FY 1, that amount would be funded on the prime contract. Similarly, $40 million would be funded for advance purchases in FY 2. It should be emphasized that this approach is not tied to the contractor's expenditure profile, and therein lies its major drawback. Aside from progress payments, the prime contractor will incur no payment liability to its vendors until delivery is actually made. Reference to the figure will show that actual expenditures (i.e., delivery payments) continue through FY 3. By comparing the funding levels with the expenditure profile reflected in the example, it can be seen that $10 million in FY 1 and a like sum in FY 2 would lie dormant for payment purposes over extended periods, pending delivery of vendor items. While these balances would ultimately be utilized in succeeding years, the cash flow disadvantage to the Government should be clear. In sum, strict application of this concept would result in premature obligation of funds to the benefit of neither party. Full funding of advance purchases would also generate the most extreme "bow wave" effect of any option discussed herein. It is difficult to perceive any advantage in full funding of advance purchases which is not also offered by funding to termination liability. However, it would represent the least radical departure from th. current requirements of DOD Directive 7200.4, which might make it politically "saleable." It would also provide the security of knowing that all funds required to liquidate advance purchase obligations for a given year have been appropriated. Beyond this, fully funding advance purchases appears to be the least attractive alternative available.

INCREMENTAL FUNDING

Incremental funding envisions the appropriation and obligation of funds in an amount which is not sufficient to complete a total fiscal year's quantity of end items or services in a finished, military useable form. This type of funding is provided with the understanding that future year appropriations will be required to complete the items or tasks. Incremental funding is currently a common practice on research and development programs,



TERMINATION LIABILITY FUNDED
ADVANCE PURCHASE
FIGURE 3



FULL FUNDED ADVANCE PURCHASE
FIGURE 4

and could be adapted to certain multi-year procurements.

Figure 5 illustrates the incremental funding concept as it would apply to the same contractual situation portrayed in the preceding examples. In this case, level funding of $100 million would be maintained throughout the multi-year period. The contractor would then be allowed total latitude in expending these funds without regard to the program year such expenditures support. Viewed in this light, an incrementally funded multi-year procurement approaches being a single, extended term contract which is funded in three separate allotments or increments. In the example presented, NRC is again amortized over the entire three year period. The contractor has next expended $50 million of advance purchase costs in order to exploit available economies of scale. This would leave only $38.33 million in other recurring costs (ORC) with which to begin fabricating end items. As approximately $1.67 million ORC per unit is required for manufacture ($165 million ORC ÷ 99 units), only 23 end items could be produced with FY 81 funding. This quantity would be further reduced if progress payments for future year advance purchases were considered. However, by FY 2, $48.33 million ORC would be available after NRC and advance purchase costs are expended. This would allow for the fabrication of 35 units in FY 2, thus beginning to offset the shortfall experienced in FY 1. By FY 3, $68.33 million ORC would be available to manufacture the remaining 41 units.

The reader is again cautioned that this is a highly simplified example in that no material costs other than advance purchases are included; no consideration is given to learning curve effects; and no indirect expenses are recognized. Nonetheless, it illustrates several points about incremental funding. First, incremental funding minimizes the Government's initial financial commitment (i.e., eliminates the "bow wave") while still providing the contractor with adequate working capital. Second, the latitude provided the contractor in expending available funds should maximize multi-year procurement's cost saving potential. Third, this funding strategy should not require a high cancellation ceiling due to the fact that advance purchase costs and ORC expended would be subject to a termination for convenience type settlement, which could be largely paid from available funds. Only nonrecurring costs and possibly some incidental termination liability costs would be included in the cancellation ceiling. Finally, it should present no barrier to competition as contractor working capital requirements should be minimal.

On the other hand, a perceived disadvantage of incremental funding is the fact that early cancellation would result in delivery of less than a total program year's requirement. In this example, if the contract were cancelled after FY 1, the Government would receive only 23 finished end items, plus a large inventory of materials and components. A similar, though less acute, situation would arise upon cancellation after FY 2. If this were to occur, the Government would either be forced to accept lesser deliveries or to appropriate additional funds for completion of the uncancelled program year requirements. This additional ORC funding requirement should approximate the moneys that would have had to have been initially appropriated under the termination liability funding approach outlined above. However, a supplemental appropriation would be needed, and the required funds might not be provided. The specter of an unfavorable cancellation settlement makes the selection of stable programs of the essence for incrementally funded multi-year procurement.

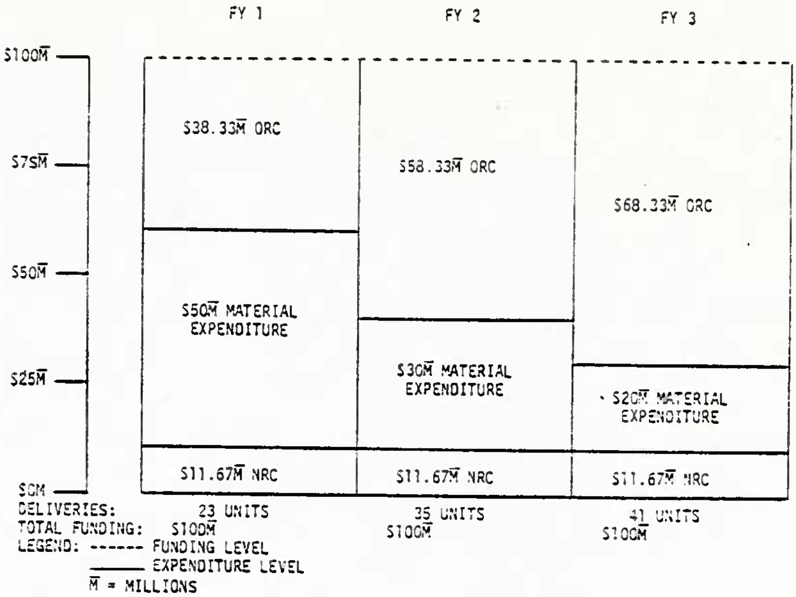
As a final note, it should also be recognized that incremental funding represents a radical departure from the current policy in DODD 7200.4. While this does not make the approach any more or less appropriate for a given acquisition, it may present a practical constraint on wide usage.

CONCLUSIONS

With the passage of P.L. 97-86, Congress has provided the services with a great deal more flexibility for multi-year procurement than previously existed. In the area of advance material purchasing, Congress has provided the latitude to either provide early funding or to incur an unfunded cancellation liability. It is felt that implementing regulations and policies should take advantage of this flexibility by minimizing restrictions on the funding option to be applied to a given multi-year procurement.

In a Memorandum for Secretaries of the Military Departments, dated 5 October 1981, the Under Secretary of Defense endorses the concept of termination liability funding for the economic buying of outyear material. Of the advance purchase funding options discussed above, this alternative is likewise endorsed by the authors of this paper as being the appropriate technique for most multi-year procurements. This is particularly true in the case of major weapon systems. Nonetheless, it is felt that other options should not be foreclosed.

Full funding of advance purchases should be discouraged as a matter of policy, as its disadvantages far outweigh any perceived advantages. However, contractor financing, expenditure funding and termination liability funding should be recognized as viable options for advance purchases. Selection among these options should then be based on a thorough analysis of such factors as (1) the dollar



INCREMENTAL FUNDING
FIGURE 5

magnitude of the advance purchase; (2) the projected expenditure profile attendant to the purchase; (3) current borrowing cost advantages being enjoyed by either party; and (4) the anticipated level of competition for the award. While it is anticipated that termination liability funding will continue to be the preferred approach, it should not be the sole avenue available.

With regard to incremental funding, it is felt that this technique offers the greatest cost savings potential for extremely stable programs. However, it is recognized that this technique is largely untested in multi-year production contracting, and the ramifications of a possible cancellation are not yet completely clear. Consequently, it is felt that incremental funding should be tested on a limited number of multi-year candidates before a firm decision is reached on its general application. If such test candidates are successful, incremental funding may well prove to be the most sound business approach to multi-year procurement.

In summary, the financing of advance purchase costs is an area of considerable debate. This paper has attempted to catalogue the various options available and to analyze some of the advantages and disadvantages attendant to each alternative. However, it must be recognized that any analysis of this issue must remain largely speculative until more empirical data can be gathered on the equity of each approach. The task ahead is to gather such data, and to refine multi-year policies in accordance with the dictates of experience.

REFERENCES

1. Defense Acquisition Regulation 1-322 (as modified through Defense Acquisition Circular 76-22), US Government Printing Office, Washington, DC, 22 February 1980, pp. 1:39-1:53.

2. Department of Defense Directive 7200.4, "Full Funding of DOD Procurement Programs," Washington, DC, 1969.

3. Department of Defense Authorization Act of 1982 (Public Law 97-86), Section 909.

4. Interim DAR 1-322 Changes on "Expanded Multiyear Procurement," 26 February 1982.

5. Deputy Secretary of Defense Policy Memorandum on Multiyear Procurement, 1 May 1981.

6. Under Secretary of Defense Memorandum for Secretaries of Military Departments, Subject: Funding of Multiyear Procurements, 5 October 1981.

THE POTENTIAL EFFECTS OF MULTIYEAR PROCUREMENT
ON INVESTMENT IN THE DEFENSE INDUSTRIAL SECTOR

A Research Study Sponsored by
The Defense Systems Management College
Captain Terry Raney U.S. Air Force Academy

One of the most serious problems facing the defense industrial sector today is the lack of investment in modern, more productive capital assets. This problem has been the subject of numerous articles and many hours of Congressional testimony.[1] As a result, the Department of Defense (DOD) has instituted several programs to improve the productivity and capital structure of the defense industrial sector. One of the policy positions taken by the DOD, and a key element in the Acquisition Improvement Program established by the Deputy Secretary of Defense on 30 April 1981, is the use of multiyear procurement to encourage capital investment and enhance defense industry productivity.[2]

The Defense Industrial Panel of the House Armed Services Committee concluded in its report on the 1980 defense industrial base hearings that the primary potential benefits of multiyear procurement were the reduction of short term costs and the improvement of the industrial base to avoid higher costs in the future.[3] In his testimony before this panel General Alton D. Slay, then the Commander of the Air Force Systems Command, maintained that the use of multiyear procurement would increase capital investment, especially long term investment, and so improve productivity.[4] Before the same hearings the Electronic Industries Association's written statement on multiyear procurement listed the encouragement of capital investment as a primary advantage of multiyear contracting.[5]

Certainly there is no shortage of multiyear procurement advocates, including the United States Congress. Public Law 97-86, dated 1 December 1981 (the Fiscal Year 1982 Defense Authorization Bill) specifically states that:

> The Congress finds that in order to ensure national defense preparedness, to conserve fiscal resources, and to enhance defense production capability, it is in the interest of the United States to acquire property and services for the Department of Defense in the most timely, economic, and efficient manner. It is therefore the policy of the Congress that services and property (including weapon systems and associated items) for the Department of Defense be acquired by any kind of contract, other than cost-plus-percentage-of-cost contracts, but including multiyear contracts, that will promote the interests of the United States. Further, it is the policy of the Congress that such contracts, when practicable, provide for the purchase of property at times and in quantities that will result in reduced costs to the Government and provide incentives to contractors to improve productivity through investment in capital facilities, equipment, and advanced technology.
>
> It is also the policy of the Congress that contracts for advanced procurement of components, parts, and materials necessary for manufacture or for logistics support of a weapon system should, if feasible and practicable, be entered into in a manner to achieve economic-lot purchases and more efficient production rates.

Public Law 97-86 also removed the cancellation ceiling of five million dollars which had been the greatest impediment to the use of multiyear procurement by the military services. The current law only requires the DOD to notify the Congress of a multiyear contract with a cancellation ceiling exceeding $100,000,000. Congress then has 30 days to either stop the contract or do nothing. Of course the funding for cancellation ceilings less than $100,000,000 would have been reviewed in the Congressional review of the

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[1] "Capability of U.S. Defense Industrial Base," Hearings Before the Committee on Armed Services and the Panel on Defense Industrial Base of the Committee on Armed Services, House of Representatives, Ninety-Sixth Congress, Second Session, H.A.S.C. No 96-69.

[2] Deputy Secretary of Defense Memorandum, Subject: Improving the Acquisition Process, 30 April 1981.

[3] Report of the Defense Industrial Base Panel of the Committee on Armed Services, House of Representatives, Ninety-Sixth Congress, 31 December 1980, Committee Print No. 29, Titled, "The Ailing Defense Industrial Base: Unready for Crisis."

[4] "Capability of U.S. Defense," The Committee on Armed Services, p. 620.

[5] Ibid, p. 986.

applicable DOD budget. In addition, Public Law 97-86 now allows both recurring and non-recurring costs in the cancellation ceiling amount. Public Law 97-86 also requires the DOD to furnish evidence of the cost avoidance associated with a particular multiyear buy. Each of the services has either implemented or is in the process of implementing Public Law 97-86 through regulation and policy.

As can be seen from the quotation, policies, and testimonies noted above, multiyear procurement is viewed as a way to lower production costs, shorten delivery schedules, increase industrial productivity, and revitalize the aging defense industrial capital structure. The authorization to use multiyear procurement is a long-needed change to Federal acquisition policy, but its potential effects on capital investment need to be placed in proper perspective to the economic theories of investment. This paper does not attempt to repudiate any of the claimed or potential benefits of multiyear procurement. On the contrary, its purpose is to show that there is a theoretical economic basis for the contention that multiyear procurement will increase investment. It also demonstrates that through an understanding of investment theory and the many factors that influence investment decisions, a multiyear program can be structured that will have positive effects on the level of capital investment in the defense industrial sector.

The relationship between the certainty of increased and constant sales as a result of a multiyear award and capital investment is the key element behind the contentions of the multiyear procurement advocates. There is no question that some degree of confidence concerning the future production of a system is essential before a firm will choose to invest in the productive capacity required for that system. Still, is that connection enough to assure the levels of investment required to enhance productivity and replace the aging capital of much of the defense industrial sector? When one considers the number and importance of other investment factors, the answer to that question has to be no. The decision by a defense contractor to invest in new productive capital assests will be based on an analysis of many factors, including the proposed or agreed-to structure of the financial and contractual agreements between the Government and the contractor.

The remainder of this paper will demonstrate the potential effects of multiyear procurement on capital investment, discuss the impact of the many factors that influence investment, and show the need to recognize these factors when structuring a multiyear program. First, the three best known economic investment theories are explained as are the more important determinants of investment. Next, the effects of a multiyear procurement on these determinants and the resultant most likely effect on investment decisions are examined. Finally, the concept that multiyear procurement can be used to encourage capital investment is demonstrated in a discussion on how a multiyear program contract structure should reflect an assessment of certain company characteristics that are determinants of investment decisions.

To commence, an economic definition of investment is in order. Investment is the purchase of new productive physical assets which will in turn be used to produce other products. Investment is required at the commodity level, the intermediate industry level, and the final product level (i.e., the level of final consumption by either households, businesses, or government). At each industrial level, investment in physical assets is required in order to produce that industry's final product. Investment in an aggregate economic sense is not the purchase of existing facilities or financial assets since neither of these purchases adds to the total economy's capital stock. But, once you move from the aggregate to a particular industrial sector, the purchase of a physical asset from another industrial sector would add to the physical stock of the purchasing sector and would in that sense be appropriately called investment for that industrial sector. Replacement investment is the purchase of physical assets to replace those assets used up in the production process. Net investment is gross investment minus replacement investment. Whenever net investment is positive the capital stock of an industry is growing, and whenever it is negative the capital stock is decreasing. Obviously, the goal of the various government investment encouragement programs is to ensure that net investment is positive and increasing.

There are several economic theories of investment, each the result of an analysis of a set of explanatory variables such as the interest rate, gross sales or capital stock. The three that are discussed below are the best-known and certainly suffice for this particular discussion. Perhaps the best-known economic theory of investment is the accelerator principle which relates increases in capital investment to changes in final sales. The accelerator principle states that as final sales increase there will be an even faster increase in investment, and when final sales fall there will be an even greater decrease in investment. The key relationship here is between a change in sales of a particular industry's final product and the purchase of capital assets required to produce that final product.

A second well-known theory relates

investment decisions to the level of capital stock. According to this theory, firms have levels of capital stock that they want to maintain and when the actual level drops below the desired one, the firms will start buying the physical assets to maintain their desired capital stock level. Of course the desired level of capital stock can change over time if there are changes in any of the determinants of investment discussed below.

A third theory of investment relates investment expenditures to the cost of investment funds, generally meaning the interest rate. The basic idea here is that firms will invest to the point where the rate of return on an investment is equal to the cost of financing that investment. The cost of financing will vary among firms based on the finance community's assessment of their credit worthiness.

Another way that a firm may look at financing costs is in terms of using retained earnings or other financial assets to finance capital investment. This is known as equity financing and the cost in economic terms is an opportunity cost. If the internal funds could be earning income elsewhere, the cost of equity financing is the income given up when the funds are used for capital investment purposes.

These three theories, in fact all investment theories, operate based on the values of the determinants of investment. Investment determinants are the various business and economic factors that influence investment decisions and determine the location of any firm's demand curve for investment funds. It is necessary to discuss each of these determinants briefly to emphasize the myriad of factors that influence investment decisions as well as their importance.

Expected future returns is a key determinant when using the cost of investment theory. As long as expected future returns on a product exceed the cost of borrowing to produce it, a firm will theoretically invest in whatever is necessary to produce that product. Another determinant of investment is the level of unfilled orders or sales backlog. In accordance with the accelerator principal, as the sales backlog increases firms will respond by increasing their investment in new plant and equipment. They will respond by decreasing investment when sales backlogs decline.

The amount of retained earnings can influence the level of investment in two ways. First, just the absolute amount, availability or nonavailability, may influence an investment decision. Second, the cost of equity financing, as measured by the interest income foregone if physical assets are purchased with retained earnings, will also be a factor. An individual company's stock price may also influence investment decisions. If a firm has a substantial amount of treasury stock and the current market price is significantly above the price at which the stock was purchased, a firm would be more inclined to invest using funds obtained from the sale of treasury stock. By the same token, if the current stock price, in the opinion of the company, is underpriced, a firm may feel its best "investment" is the purchase of its own stock and hence forego the purchase of new physical assets. Corporate dividend policy and historical dividend standards also have a significant effect on investment decisions. If a firm has historically paid a certain minimum dividend, then the firm may forego investment expenditures to fund dividend payments.

The speed of technological change or innovation also influences investment decisions. In some cases firms are forced to invest in new technology or become noncompetitive. In other cases, firms may delay investment decisions in anticipation of technological breakthroughs. In either case, the firm is betting on what the future of its industry will be like, and that assessment may transcend all other investment factors. The first situation is demonstrated by the decision of the J.C. Penny Company to spend $325 million in 1982 to modernize obsolete facilities. According to a company spokesman, these investments were required to remain competitive. Ironically, the spokesman also pointed out that in a strong economy they might not have made the investment since competition would not have been so intense.[6]

Another determinant of investment is the cost of the factors of production such as labor or energy, especially in comparison with other factors of production. For example, if labor costs decline in comparison to capital equipment costs, firms will tend not to invest in capital intensive manufacturing methods. Changes or anticipated changes (e.g., future union negotiations) in factor costs will also influence investment decisions, as will tax policies and expected changes in them. After-tax profitability is the bottom line for all companies, and tax incentive programs have been the cornerstone of many government economic recovery programs, including the Reagan Administration's. Tax laws can also be very specific as to the type of industries affected and often have different influences on different industrial sectors.

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[6] New York Times, Sunday, January 31, 1982, "Why Business Won't Invest," Section 3, p. 1.

Capacity utilization is one of the most important investment determinants. Significant excess capacity will negate the accelerator principle since increases in sales can be accommodated through increased use of existing facilities and equipment in lieu of purchasing new productive assets. This of course assumes that the idle capacity is technologically current and applicable. Other determinants include the cost of lost management attention to existing projects, the effect of borrowing for current investment on future borrowing capability, and previous demand stability experience. The determinants described above are by no means a complete set, and each industry and company may have many other unique factors.

In their 1967 article on investment determinants published for the National Bureau of Economic Research, Dhrymes and Kurz proposed that a firm's investment decisions should be considered one of several simultaneous decisions made by top corporate executives.[7] Their point was that an investment decision is not an independent one based on an analysis of a certain factor such as projected sales or existing capital, but is an interdependent decision influenced by such diverse concerns as dividend payments, types of borrowing arrangements and tax payments. Too often investment is considered to be a relatively simple function of interest rates or projected sales. In fact, investment decisions are influenced by many determinants that will vary from industry to industry and from firm to firm. There are several different industrial segments within the defense industrial sector, each with its own set of problems and characteristics, and the effect of a multiyear procurement award will vary among them.

The first investment theory discussed above was the accelerator principle. How does a multiyear procurement fit in the operation of that theory? Theoretically the increase in sales should cause an increase in investment, but what happens if the company in question is not operating at some level approaching full capacity? As was pointed out above, excess capacity will negate the accelerator principle. The most recent capacity utilization figures from the Federal Reserve show an overall aerospace industry utilization rate for the first quarter of 1982 of 71.8%. The rate for the fourth quarter of 1981 was 75.1%. The capacity utilization figures for the electronics industry for the same time periods were 77.7% and 80.4% respectively. For all U.S. manufacturing the figures were 71.5% and 74.8%.[8] In light of these statistics, increased capital investment in the defense sector based solely on the accelerator principle is unlikely.

In an Air Force Command and Staff College student research report, Major Orville Collins found a statistically significant relationship between order backlogs and investment in the aerospace industry.[9] No doubt the award of a multiyear contract will create an order backlog. The question is whether this backlog, especially the yearly production rate of that backlog, will require more than the contractor's current capacity. If current capacity is not sufficient, the accelerator principle will probably hold.

The second theory of investment discussed concerned the desired versus actual levels of capital stock. The award of a multiyear procurement would work through this particular theory if the award altered the desired amount of capital stock or if, in the performance of the contract, the actual level decreased. The first case is the applicable one for this discussion. The desired capital stock level is a function of many of the determinants of investment. The effect of a multiyear award on each of these determinants is discussed below, but the effect of technological change is particularly appropriate at this point. To some degree the stock of capital also refers to the technological level of the capital. If the award of a multiyear contract changes the required technological level of the capital stock, then this particular theory of investment would apply.

The third theory of investment related the cost of investment to the expected rate of return. A multiyear award can affect investment through this theory if the projected rate of return on the multiyear program exceeds to some degree the cost of funds required to invest in new physical assets. This assumes that the contractor could perform the contract with current facilities, but new, more productive assets would increase program profitability and hence make it worthwhile for the contractor to attempt to equate the cost of additional investment

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[7]P.J. Dhrymes and M. Kurz, "Investment, Dividend, and External Finance Behavior of Firms," in Determinants of Investment Behavior, (New York: Columbus University Press for National Bureau of Economic Research, 1967), pp. 427-467.

[8]Federal Reserve Board Monthly Utilization Statistics, Federal Reserve Board Research Division, Washington, D.C.

[9]Major Orville M. Collins, USAF, Research Report, "Can the Pentagon Use Its Purchasing Power to Improve Industrial Responsiveness in the U.S. Aircraft Industry?", Report No. 0545-81.

to the projected rate of return.

Before showing how an understanding of investment theory and the determinants of investment can be used to structure a multiyear program that will encourage investment, it is necessary to demonstrate the theoretical basis for the effect of a multiyear award on investment spending. This theoretical basis can be shown by briefly describing the effects of a multiyear award on some of the investment determinants. For example, expected future returns would be favorably affected, assuming the award was seen as profitable by the firm. Although in all likelihood the firm would not have contracted for an unprofitable arrangement, it is conceivable in a competitive environment for a firm to be overly optimistic and suddenly find future earnings adversely affected.

The effect of a multiyear contract on unfilled orders is obvious and has already been discussed. The amount of retained earnings would not be affected in the near term, but it is possible that a company's stock price could rise upon receipt of a major multiyear award. To the degree that this increase in stock prices could generate more internal funds through the sale of treasury stock, the level of investment could be positively influenced.

The award of a multiyear contract and technological change could combine to affect investment in two ways. First, the award would have a positive effect if the purchase of new technology can lower unit production costs and so increase the projected rate of return. The second connection applies in a competitive situation where the winner receives a multiyear contract. If new technology is the only way a firm can make a profit as a result of a competitive bid, then capital investment is likely regardless of current capacity utilization. A rather obvious point should be made. At any point one investment determinant can become more important than all the other determinants combined, especially when that determinant is the overriding profit-determining factor.

The effect of a multiyear award on the costs of the factors of production is probably limited to labor and borrowing costs. The acceptance of a multiyear contract could increase union wage and benefit demands and hence alter the relative prices of labor and capital. The result would be a positive effect on capital investment since labor would then be relatively more expensive. To the degree that the receipt of a multiyear award would make a contractor a better financial risk and so lower borrowing costs, capital investment would also be enhanced.

There appears to be little connection between tax policies as an investment determinant and a multiyear award, but a multiyear award could have a significant effect on the future borrowing capability of a firm. As pointed out by Jacques Gansler in The Defense Industry, most defense contractors are perceived as poor credit risks by the financial community.[10] One of the primary reasons behind this belief is the volatile demand associated with defense business. Since a multiyear award would be viewed as a firm commitment, both the absolute borrowing capability and probably the cost of borrowing would be affected in favor of the firm.

The fact that there is a theoretical economic basis for the effects of multiyear procurement on capital investment has been demonstrated through the associations discussed above. The next step is to show how capital investment can be encouraged if the contractual structure of the multiyear procurement reflects the relationships between investment theory and multiyear procurement previously discussed.

If encouraging capital investment is a program goal, the first step that a program manager or contracting officer should take is to identify the contractor characteristics that will be major investment determinants. Next they must include in the contract, elements that help to accommodate problems and to reenforce factors that favor investment. For example, data should be gathered on the current capacity utilization of a firm, the age and technological obsolescence of the firm's equipment, the firm's current order backlog, the borrowing capability of the firm, the amount of treasury stock, the amount of retained earnings, and the current market price of the firm's stock. Next the potential effect of a multiyear award on each of these company investment determinants should be assessed based on the investment theory previously discussed, and a determination should be made as to the likely effects on the firm's capital investment decisions. If this assessment indicates that capital investment could realistically be enhanced, then the next step is to structure the multiyear contractual arrangements to take advantage of those company characteristics that will have the greatest effect on company investment decisions. Included in this assessment should be an appraisal of the potential effects of the multiyear award on investment at the subcontractor level of the program.

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[10]Jacques S. Gansler, The Defense Industry, Cambridge, MA, The MIT Press, 1980, p. 62.

The first company characteristic that should be addressed is the borrowing capability of the firm. The potential rate of return, both as a percentage of sales and as a return on investment, must be in a range close to the borrowing costs of the firm. If the firm's borrowing cost is significantly higher than the projected rate of return, then the firm will attempt to produce the product using existing facilities and equipment, no matter what their efficiency. This will result in both higher costs and increased overrun risks. The solution is not just a matter of raising the negotiated profit but of structuring the program and contract to lower the borrowing costs of the firm. This will require a coordinated effort between the Government and the contractor to identify and allay the concerns of the financial community. If this can be done and borrowing costs reduced, then investment in new plant and equipment is certainly more likely.

Capacity utilization and the technological level of a firm's capital assets must also be addressed when the multiyear contract is structured. If the firm has a significant amount of excess capacity, even if much of the capacity is obsolete, there will have to be specific incentives to encourage the contractor to invest in new, more productive assests. These measures could take the form of incentive fees based on productivity improvements, funded manufacturing technology programs, or cost incentives that could only be attained through significant productivity improvements. The planned production rate of a program could also be used to encourage investment. A slow, inefficient production rate could actually discourage investment because it could be accomplished with current assets, while a faster, more efficient production rate should encourage investment in new facilities.

The award of a multiyear buy on a competitive basis could also be used to encourage investment, especially if both competitors have relatively old capital assets and the purchase of new technology is the only way for either or both to maintain a competitive posture. Of course the proposed multiyear program would have to contain other features that also encouraged investment to ensure that the winner followed through on his investment plans.

The financing and payment provisions are other elements of a multiyear contract structure that can be used to enhance investment. Unusual progress payments, advance payments, or even loan guarantees can be used to lower the cost of investment by either reducing the negative cash flow early in a program or actually reducing borrowing costs. Other elements of a multiyear contract structure that could influence investment are specification tailoring to accommodate proposed new manufacturing technology studies, value engineering funding and incentive provisions, and even patent protection provisions. The point is that there are numerous elements of every contract that can be manipulated to encourage investment, but there must be a conscious effort to reflect this goal throughout the contract or the contractor will not receive the incentives needed to take the investment risks. In addition, the contract structure must be based on an analysis of the individual contractor's investment determinants and an understanding of how investment theory applies in each situation.

The award of a multiyear buy to a prime contractor will also affect capital investment in the subcontractor tier (those small and medium size firms that make up the second and third tier of the defense industrial sector). The relationship between the determinants of investment and the investment decisions of a subcontractor are the same as those of a prime contractor to a large degree, but there are two complicating factors associated with the subcontractor tier. The first is that the savings from large-lot orders are one of the primary benefits of a multiyear procurement. If a prime contractor attempts to achieve those savings through a huge one-time order that may only run through one third of the period of a multiyear contract, the subcontractor could attempt to perform its contract with existing facilities and not invest in new capital equipment due to the short term nature of the program. The second factor is that a multiyear buy could encourage the prime contractor to make, rather than buy, more components. In effect, the prime contractor could use the extended commitment of a multiyear buy to develop his own capability. On an annual appropriation basis, the prime might not take the risk associated with developing a new manufacturing capability. This growth in vertical integration would be at the expense of an already declining subcontractor tier.

Obviously, one of the goals of multiyear procurement is not to discourage growth in the subcontractor tier. A crucial part of every multiyear procurement plan must be a thorough review of the prime contractor's make-or-buy plan and of the planned production rate of each of the critical subcontractors. Otherwise the prime contractor may grow at the expense of certain subcontractors, and other subcontractors will experience very violent demand fluctuations that will discourage capital investment. A multiyear award provides an excellent opportunity for the DOD to expand the defense subcontractor tier through directed second-source and dual-source programs and through the inclusion of incentives in the prime contract that reward the prime for developing new sources and protecting existing ones. The effect of a multiyear buy on defense subcontractors is just as important as the impact on the prime tier, and the planning of every multiyear program should include elements to both expand and protect defense subcontractors.

This paper has shown that there is a strong theoretical economic basis behind the belief that multiyear procurement can be used to influence investment, in the defense industrial sector, but that the relationship is much more complex than is realized or at least shown by current evidence. Multiyear procurement can be used to influence investment, but only if the structure of the multiyear contract takes into account the many influencing factors other than the certainty of a long term commitment. If the contractor has a significant amount of excess capacity, there must be incentives in the contract to encourage him to purchase new, more productive assets. If the contractor faces expensive borrowing costs, then program commitments and financing characteristics should be used to help lower those costs. Assessments must also be made of equity financing costs and the effect the multiyear award will have on them. The Government must face the fact that investment decisions are based on numerous factors, many of which can offset the positive influences of the long-term commitments of a multiyear award. To at least increase the likelihood that capital investment will occur, these other factors must be addressed in structuring the multiyear contract. In fact, these factors should be addressed in the planning and conception of a multiyear program.

One problem that may be very difficult to overcome concerns the program stage at which the Government may be willing to make a multiyear commitment. The stated policies of both the DOD and Congress are that multiyear procurement will only be pursued when the production rate, procurement rate, required quantities, and configuration are all stable and the technical risks are not excessive. This may be some distance into the production of a program, and the benefits of investment could be minimized since the contractor would already have a production capability established. In fact, the contractor would probably already be at rate production. If this is the case, the incentives to encourage contractor investment will have to be especially significant, and the payoffs for the specific program will be minimized. However, the long term benefits (i.e., beyond the current program), would still be valid.

The program office must also be prepared to accept the fact that in some cases multiyear procurement will not encourage investment. That of course in no way implies that a multiyear buy should not be used when investment growth is unlikely. The savings associated with economic order quantities, or even the more efficient use of existing facilities, may well make the multiyear commitment worthwhile, and it certainly should be pursued on that basis.

In conclusion, the substantial and complex theoretical basis for the effects of a multiyear procurement award on the investment decisions of a firm have been demonstrated. The implications and opportunities of this complex relationship have been dealt with by showing how the contract structure of a multiyear procurement can be used to encourage investment by taking advantage of those company characteristics that are primary investment determinants. Finally, the need to address the many investment determinants in program and contract planning is obvious. Unfortunately there is no "cookbook" solution. Each program is different and the unique characteristics of each contractor must be reflected in the negotiated multiyear contract structure.

BIBLIOGRAPHY

Ackley, Gardner, Macroeconomics: Theory and Policy, New York: Macmillian Publishing Co., Inc., 1978.

Air Force Systems Guide for Multiyear Procurement, Draft, November 1981.

Brabson, Colonel G. Dana, "Department of Defense Acquisition Improvement Program", Concepts-The Journal Of Defense Systems Acquisition Management, Autumn 1981, Volume 4, No. 4., pages 54-75.

Capability of U.S. Defense Industrial Base, Hearings Before the Committee On Armed Services And The Panel On Defense Industrial Base Of The Committee On Armed Services, House Of Representatives, Ninety-Sixth Congress, H.A.S.C. No. 96-69.

Department of Defense, Defense Acquisition Regulation Manual, DAR No. 3, Improving Productivity, 6 November 1981.

Evans, Michael K., Macroeconomics Activity-Theory, Forecasting and Control, New York: Harper and Row, 1969.

Gansler, Jacques S., The Defense Industry, Cambridge, Mass., The MIT Press, 1980.

Poindexter, J.C. Macroeconomics, New York: The Dryden Press, 1981.

The Ailing Defense Industrial Base: Unready For Crisis Report Of The Defense Industrial Base Panel Of The Committee On Armed Services, House of Representatives, Ninety-Sixth Congress, 31 December 1980, Committee Print No. 29.

Weidenbaum, Murray L., The Economics of New York, Praeger Publishers, 1974.

PLENARY PANEL

PREVENTION OF FRAUD, WASTE AND ABUSE IN PROCUREMENT

PANEL CHAIRMAN

Mr. Jack Nadol
Assistant Administrator for Procurement Practices
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Department of Education

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Director, Office of Government Ethics

Herbert L. Fenster, Esquire
McKenna, Conner and Cuneo

PREVENTION OF FRAUD, WASTE AND ABUSE IN PROCUREMENT

This panel was characterized by diverse views on the equity of the Administration's current initiatives to prevent fraud, waste and abuse throughout Government. Discussions were directed to the effect of such policies on the procurement missions of the services and agencies represented at the Symposium. A wide range of views was obtained from representatives of the legal community, the behavioral science discipline, the Office of Government Ethics, and the Office of Federal Procurement Policy. All participants supported the prevention of fraud, waste and abuse in principle. However, opinions varied greatly as to the magnitude of the current problem and the need for broader investigative and enforcement powers to address existent fraud, waste and abuse. Strong positions were taken both for and against devoting greater Governmental resources to preventing fraud, waste and abuse in procurement. The ambivalence reflected in the widely differing views of the panelists highlighted the need for additional research in this regard.

The papers in this section were not presented during panel sessions at the symposium. However, panel chairmen in the various subject areas selected these papers for publication in symposium proceedings.

THE ACQUISITION PROCESS AND NEW TECHNOLOGICAL DEVELOPMENTS: LESSONS FROM A CASE STUDY

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ABSTRACT

This study sets out the parallels between the DOD acquisition process and the R&D process as the latter is envisioned in the models of R&D recently proposed by Kelly et al (1975). Special attention is focused on the role of in-house laboratories as a source of small or incremental technical advances and the extent to which the organizational conflict hypothesized by Kelly et al is present within the DOD acquisition process.

The main findings of the study are that the key factors known to be associated with successful technical advances are present within the Army R&D labs which successfully developed the Dover Devil and STAFF, two important small weapons developments. These in-house labs have been a fruitful source of incremental technical advances and to that extent have proven to be an effective mechanism for supporting phase-dominant R&D activities within the project-dominant acquisition process. The findings are more equivocal with respect to the effective transfer of lab developments into the DOD acquisition process. The role of the user appears to be quite formal and significant here. This should facilitate the process. However, for the Dover Devil and STAFF, it appears that shifting user preferences has been a factor preventing the movement of these weapons into the DOD acquisition process. Until more is known about the determinants of user preferences, it is impossible to say whether a more rapid development of these weapons would be a net gain to the Army.

PURPOSE

The purpose of this paper is threefold: 1) to briefly review the major research findings pertaining to successful technological development as these have been reported in numerous public documents; 2) to report the results of a case study of new product development within U.S. Army in-house laboratories; and 3) to offer a tentative assessment of the relative success of the Army's in-house R&D program.

SOME GENERAL RESEARCH RESULTS ON R&D

A wide variety of models have been developed which provide a framework for the study of the R&D process. Information flow models such as Myers and Marquis (1969) focus on the idea generation-development stage of the R&D process. Studies based on these models report that recognized user need is the primary stimulus to successful R&D (Goldhar, 1976); that a successful innovation frequently originates outside the developing firm (Utterback, 1971); that the successful development of innovations is identified with key individuals who provide a conduit through which new ideas enter the firm and who enthusiastically promote the development of the idea within the organization (Utterback, 1974); and that successful innovation requires a (primarily) middle-level management comfortable with risk-taking (Goldhar, 1976).

Economists have divided the R&D process into discrete phases (the so-called process-phase model) and stuided project characteristics such as cost, elapsed time, and risk within and across these phases (Mansfield, 1971). A major finding of this literature is the preoccupation of organizations with incremental product improvements rather than major new product developments. The result is a relatively high (60 percent) probability of technical success. However, the probability of commercial success for these projects is a relatively low 30 percent. Not surprisingly, a frequently cited explanation for the low rate of commercial success is inadequate attention to user requirements.

Organizational theorists (e.g., Hage and Aiken, 1967 and Zaltman et al, 1973) have examined the way in which organizational characteristics impinge on the process of successful innovation. Characteristics identified as important to the innovation process are:

1. Complexity - variety of occupational specialties within the organization.

2. Formalization - organizational emphasis on following rules and procedures.

3. Centralization - authority and decision-making in the organization.

4. Ability to deal with conflict - the manner in which an organization effectively integrates various diverse units and activities.

5. Organizational slack - extent of uncommitted resources available to the organization.

High complexity, low centralization, and low formalization appear to encourage creativity while low complexity, high centralization, and high formalization are conducive to the effective implementation of promising innovations.

Organizational slack and ability to deal with conflict are important to both the creation of new products and their effective implementation.

Recently, Kelley et al (1975) hypothesized that organized R&D activity is either phase- or project-dominated. They further hypothesized that an organizational structure conducive to project dominance is inhospitable to phase-dominant technological advance.

A so-called phase-dominant model of R&D is illustrated in Figure 1.

As shown in Figure 1, innovations arise and are nurtured within well defined phases of project development. In each phase, the organizational needs are identified, ideas are generated, projects selected, and personnel assigned. Project results of one phase are reviewed by the organization and discontinued or passed forward (backward) to the next phase for continued development. Many projects will tend to be single-phase efforts with relatively short time horizons and will require a small number of scientific disciplines. And the technical advances will tend to be of the small or incremental product improvement type. The typical project is funded on an annual basis through R&D funding and generally receives only minor attention from the corporate level. A hierarchical organization characterized by low complexity, high formalization, and high centralization is thought to be best suited for this type of R&D activity.

The project-dominant model of R&D is illustrated in Figure 2.

Kelly et al describe this model as follows:

"Ideas are generated, projects are selected, and resources are allocated... A project team is responsible for accomplishing the activities necessary to complete the project and the activities most likely cut across all the R&D process phases. As a whole, the project either progresses through the remaining R&D phases or it is terminated. Thus, resource allocation and scheduling decisions occur within the confines of the project, but across process phases."

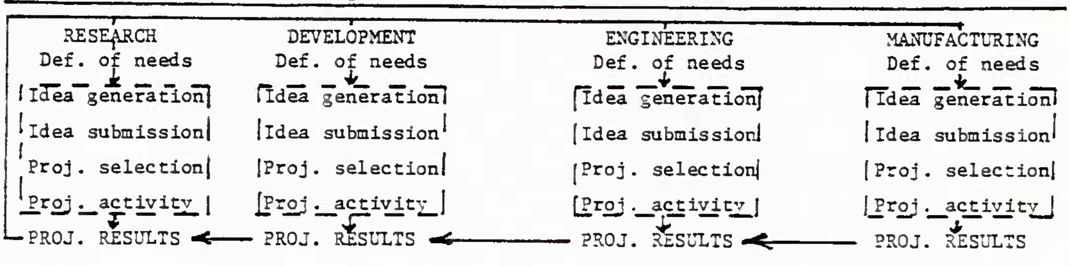
Major R&D projects will be multi-phase, multi-year efforts which require the work of many scientists and engineers in many scientific disciplines. Additionally, these projects will require the commitment of large amounts of resources and will involve the active participation of corporate management throughout their development. This type of project necessitates the frequent crossing of organizational boundaries and some type of project team is needed to integrate the diverse activities. Kelly et al hypothesize that this type of R&D effort is best suited to an organization characterized by high complexity, low formalization, and low centralization. Thus, a matrix organization is best suited to the project-dominant mode of R&D.

Frequently, organizations with a research orientation will wish to pursue R&D activities which promise a major technological advance while at the same time embracing R&D which offers the promise of small or incremental improvements to their product line. However, if as hypothesized by Kelley et al, these different kinds of technical advance call for quite different organizational structures, a single organization may find it difficult to effectively pursue R&D programs directed at both the incremental and major technological advance. The case study which follows offers a test of the extent of this hypothesized conflict within the context of the R&D programs of the Department of Defense.

A CASE STUDY OF ARMY IN-HOUSE R&D

Product innovations within the Department of Defense take place within the confines of the acquisition process. This process is characterized by a series of complex, formal procedures involving several levels of review

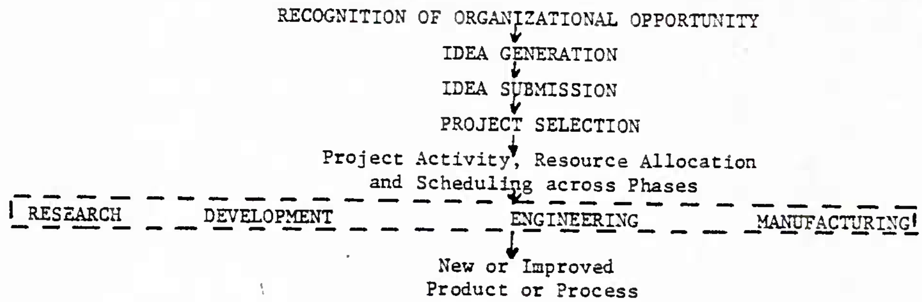
Figure 1. Phase-Dominant R&D Model



The boxes defined by broken lines contain activity which is conducted within each process phase.

authority and various types of formal requirements documentation. The basic acquisition model is illustrated in Figure 3.

Figure 2. Project-Dominant R&D Model



The box defined by broken lines contains project activity which flows across the R&D process phases.

Figure 3. Acquisition Model

Phases	Conceptual	Validation	Full-Scale Development / Low Initial Production	Full-Scale Production
Program Funding	Basic and Applied Research 6.1 6.2 6.3A	Development 6.3B	Development 6.4 / Procurement	Production & Deployment

Major new product (project) developments are under the direction of a designated management authority whose job is to tie together, manage, and direct development and production of the new product (project) in accordance with the formal documentation and review of his/her Service and the Secretary of Defense.

The program manager frequently crosses over various organizational boundaries both in and out of his/her Service. This is necessitated by the large number of organizations normally involved in the development effort and by the fact that various portions of the program are frequently not in the same development phases (e.g. the engine for a new tank may be in advanced development, while the fire control system may be in engineering development). Such major systems involve a broad technical scope and an associated broad number of technical approaches. Many personnel, encompassing multiple scientific discipines, are involved in the process.

The development of major projects (programs) within DOD thus follows the general pattern of the Project-Dominant model of organized research and development.

Within this organizational setting there is a provision for numerous in-house R&D laboratories. The Army, for example, has 35 in-house research laboratories. Their responsibilities include, among other things, the development of military technology not available in industry and/or the development of industrial interest in promising technological innovations of interest to the military (Gruen, 1977). These labs are hierarchical in nature, are funded on an annual basis by department and funding category, and collectively account for less than 20 percent of the research, development, test and evaluation monies expended by the Army in recent years (Eckert, 1981). What new technical advances originate in such a setting are of necessity of the small or incremental product-improvement type. These technical advances and their organizational setting correspond to the Phase-Dominant model of R&D. Two recent technical advances, the STAFF and Dover Devil, may be used to illustrate the R&D effectiveness of the in-house labs and their ability to move products into the product-dominant DOD acquisition program.

THE STAFF AND DOVER DEVIL

The STAFF round, developed primarily by the Army's Large Caliber Weapon System Laboratory (LCWSL) and the Dover Devil, developed by the Army's Fire Control and Small Caliber Weapon Systems Laboratory (FC&SCWSL) have important similarities. First, each project was developed almost exclusively in-house. Second, each project was initiated and developed in the late 1970's time frame. Third, each project is now at the end of the conceptualization phase of the acquisition process. Fourth, each project received the 1979 Army R&D Achievement Award. Thus, the STAFF round and the Dover Devil represent significant technological achievements.

Briefly stated, the Dover Devil is:

> "...a gas-operated Cal .50 MG developed to replace the current M2HB and M85 machine guns on surface vehicles, aircraft ships, and ground mounts. The gun will weigh less than 50 lbs.
>
> This new weapon is built around a three-tube receiver for maximum strength and minimum weight, improved RAM, and reduced manufacturing cost. It is powered by a dual gas system to allow greater ammunition flexibility within calibers, allowing the use of high- or normal-impulse ammunition. A quick-response, dual rotary feed capability allows instant change from anti-armor to anti-personnel ammunition. The basic Dover Devil is scalable from Cal .50 to 20mm x 102 by simply changing barrels, feed box, and bolt carrier..." (LCWSL, 1980).

The early development of the Dover Devil and STAFF followed a pattern similar to that widely reported to accompany successful technological innovation. As noted previously, recognized user need is the primary stimulus to successful innovation, the probability of technical success for incremental product improvements is a relatively high 60 percent, organizational slack and low formalization are conducive to creativity, successful innovations are identified with key individuals who provide a conduit through which new ideas enter the organization and who enthusiastically promote the idea within the organization, and successful innovation requires a (primarily) middle-level management comfortable with risk taking.

Each of these conditions appears to have been present in the case of the STAFF and Dover Devil. The developers had a clear potential application in mind. In the case of the Dover Devil, there was a "perceived" need by FC&SCWSL and later, by the Armament Research and Development Command (ARRADCOM) that an improved heavy machine gun was needed by the Army. In the case of STAFF, the concept had been discussed by the Infantry School Combat Development Directorate as early as 1975.

Key individuals were evident in the conception of both projects. In the case of STAFF, the individual was Mr. Lew Cole (the STAFF project officer at LCWSL). In the case of the Dover Devil, the individual was Mr. Curtis Johnson (the crew served weapon chief in FC&SCWSL small arms branch of the Armament Division). Through contact with colleagues and the monitoring of new technological developments, these two individuals brought the initial concepts into their respective organizations.

Both projects were enthusiastically promoted within their organizations, the user community, and various other Army and DOD agencies. This served not only to generate user interest, but also to develop a strategic constituency in LCWSL and ARRADCOM.

Management (primarily middle-level) played a key role in the development of both projects. The innovators were given a significant amount of freedom in how they directed and controlled their development efforts. Additionally, the initial development effort for both projects was predicated on the willingness of laboratory management to commit resources towards a potentially significant technical activity. This was made possible by the existence of organizational slack in the form of uncommitted funds at the laboratory level.

Finally, good formal and informal communication flow patterns were developed and maintained throughout both development efforts.

The Dover Devil and the STAFF are unquestioned technical successes. The organizational conflict posed by Kelley et al has not been a factor in their history to date. That is, the creation and technical development of these projects within the labs has not been impeded by the fact that the labs exist within a project-dominant organizational framework. Thus the organization of R&D activities within the Army (or DOD) may well be conducive to both the incremental and major technical advance.

Continued development of the Dover Devil and STAFF cannot occur until an approved user requirement document exists. When and if such a document is generated and approved, these projects will achieve project management status. That is, the projects will move from the phase-dominant mode into the project-dominant acquisition system of DOD.

In the case of the Dover Devil, the transfer has not occurred due to an apparent difference of opinion between the developer and various members of the user community concerning the ultimate cost effectiveness of the new weapon system.

For STAFF, the issue is somewhat different. In the case of STAFF's potential 120mm tank ammunition application, there appears to be an impasse between the Armor Center and ARRADCOM centering around how best to fund the future development effort. In the case of the Dragon follow-on program, a delay has resulted while the Infantry School reexamines what is really needed in the new system.

For both new weapon systems, the attitude of the user community toward them appears to be the single most important factor bearing on their effective transfer into the product-dominant acquisition system. This is not surprising. Less than one-half of all technically successful product developments are reported to become a commercial success (Mansfield, 1971). This low rate of commercial success is more often than not attributed to inadequate attention to user requirement. In the case of the Dover Devil and STAFF, the problem is less a matter of attention to user requirements than a matter of shifting user preferences.

While full development has not occurred for STAFF or the Dover Devil, there are some benefits which have accrued. First, the user community was given additional alternatives which might not have been known until a later date if reliance had been placed solely on the private sector of the user community to identify a need. Second, the laboratories enhanced their abilities as "smart buyers" by pursuing projects which supported the Army's technology base program.

Additionally, there are some inherent advantages in not immediately proceeding from demonstration of technical feasibility to validation. For example, it may not be desirable to automatically proceed with the development of a technically successful in-house system. It is conceivable that the results of one successful system may provide an impetus to industry to quickly develop a more cost-effective follow-on system. Also, it may be desirable (or as appears to be the case with STAFF), necessary to allow the user community additional time to reexamine what is really needed in the form of a requirement document.

There are, of course, some disadvantages in not immediately proceeding from demonstration of technical feasibility to the validation phase. First, the eventual fielding of the item will be delayed. Thus, a system which may have enjoyed perhaps 5 to 10 years of relative technical advantage may enjoy only perhaps 3 to 7 years. Second, although most of the data involved in developing a system has been formally recorded, there is still some knowledge which exists only in the minds of the developers as institutional memory. As the system development time lengthens, this information may be forgotten or lost as individuals retire or relocate organizationally.

CONCLUSIONS

The case studies involving STAFF and the Dover Devil have served to highlight the fact that many factors which are recognized as critical to the success of technological innovations are present in the development of weapon systems in the Army's in-house laboratories.

Additionally, this study shows that, while DOD has developed an organizational framework which successfully supports two quite diverse types of R&D activity, technically successful in-house projects face a difficult transfer problem when moving into the acquisition process. This occurs at the completion of the conceptualization stage. At this point, a large degree of responsibility is transferred to the user community as it is asked to commit significant resources to support the move toward the fielding of a new item of equipment.

This study suggests that, given adequate user interest and reasonably stable user preferences, the organizational conflict hypothesized by Kelly et al is probably a minor factor in the DOD acquisition process.

BIBLIOGRAPHY

1. Eckert, Gregory M. "The Dover Devil and STAFF Round: An Investigation of Innovation in Army In-House Laboratories," M.S. thesis, Air Force Institute of Technology, December 1981.

2. Fire Control and Small Caliber Weapon System Laboratory, Nomination for the U.S. Army Research and Development Achievement Award. HQ FC&SCWSL, Dover, N.J., January 1980.

3. Goldhar, Joel D. et al. "Information Flows, Management Styles and Technological Innovation," IEEE Transactions on Engineering Management, 23: 51-61 (February 1976).

4. Gruen, Robert W., LTC, U.S. Army. Army Materiel Command Laboratories: A Description and Overview of Current Management Issues. Defense System Management School: Ft. Belvoir VA, May 1977.

5. Hage, J. and M. Aiken. "Program Change and Organizational Properties, a Comparative Analysis," American Journal of Sociology, 72: 503-519 (March 1967).

6. Kelly, Patrick et al. Technological Innovation: A Critical Review of Current Knowledge, Vol I, The Ecology of Innovation. Advanced Technology and Science Studies Group: Georgia Tech., 1975.

7. Large Caliber Weapon Systems Laboratory. Nomination for the U.S. Army Research and Development Achievement Award. HQ LCWSL: Dover N.J., January 1980.

8. Mansfield, Edwin, et al. Research and Innovation in the Modern Corporation. New York: W. W. Norton, 1971.

9. Myers, S. and D. Marquis. Successful Industrial Innovations National Science Foundation Report NSF 69-71: Washington D.C., 1969.

10. Utterback, James M. "The Process of Innovation: A Study of the Orgination and Development of Ideas for New Scientific Instruments," IEEE Transactions on Engineering Management, 18: 124-131 (November 1971).

11. Zaltman, Gerald et al. Innovation and Organizations. New York: John Wiley and Sons, 1973.

Arms Length or Arm-in-Arm?
An Introduction to the Management and Operating Contractor Concept

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"Government has become the indispensible partner of American business; the two entities do not exist at "arms length," they are in a state of symbiosis."

-J. K. Galbraith, "American Capitalism"

The wide spectrum of Government contracting necessitates a variety of Government-contractor relationships ranging from the traditional "buyer-seller" relationship of formally advertised procurement to the fair and reasonable ventures of research and development to the partnerships of cooperative agreements. But nowhere in the Federal procurement system does the relationship properly and necessarily move the parties closer together than in the Department of Energy's Management and Operating contracts.

The key characteristics of a management and operating contract that distinguish it from other categories of contracts are the purpose of the contract and the special contractual relationship between the Government and the contractor. The purpose of these contracts is to operate and manage Government-owned or controlled facilities incidental to the performance of work on behalf of the Government. The contractor, in operating the facilities, is serving an important Government purpose. The words "on behalf of" recognize a relationship that is apart from the usual contracting relationship but does not interfere with the contractor's fundamental status as an independent contractor. In the operating contract, the contractor must react more closely to and be more integrated with the Government's policies and requirements. The advantage of an operating contract is that it best enables the contractor, as an independent entity, to apply industrial practices and management techniques to serve the needs of major Governmental missions. The Government, of course, must maintain overall program responsibility, oversight and control, in addition to retaining a variety of specific approval rights. The conduct of the work under a management and operating contract is wholly or substantially separate from the contractor's other business.

The Department of Energy particularly makes use of this type of contract to perform a significant part of its Congressionally assigned mission, as have all of its Federal predecessors (i.e., Manhattan Engineer District (MED); Atomic Energy Commission (AEC); Energy Research and Development Administration (ERDA).

The DOE National Laboratories and other management and operating contractors employ large multidisciplinary facilities with broad capabilities in energy research, development and conservation, physical, chemical and nuclear engineering, nuclear materials production and waste management, biomedical and environmental research as well as an array of atomic energy defense programs. The operations are complex, difficult and uncommonly hazardous involving elaborate industrial facilities in which are emphasized technical excellence, safety, and security.

The Atomic Energy Act of 1946 authorized the management contract for the operation of Government-owned atomic energy production facilities which were, up to that time, controlled and operated under contractual arrangements with the War Department's Manhattan Engineer District (MED). The MED had employed a cost plus fixed fee construction contract which had been modified to recognize the unique nature of the undertaking - the race for the atomic bomb. The constantly advancing state-of-the-art, the novel alliance of industry, academia and government, the building of complex production facilities which preceded the successful completion of research and development activities and the overwhelming security aspects of the entire venture all necessitated a number of unique variations of the standard contract as well as recognition of the unique legal relationship among the parties. The Senate Report on the 1946 Atomic Energy Act said, in relation to Section 31 which authorized and directed the operation by contract of research and development activities and production facilities:

"Wherever possible, the committee endeavors to reconcile Government monopoly of the production of fissionable material with our traditional free enterprise system. Thus, the bill permits management contracts for the operation of Government-owned plants so as to gain the full advantage of the skill and experience of American industry."[1] The Atomic Energy Commission endeavored to better define the MED's somewhat loose contractual relationship without losing the benefits of the relationship which had grown among the industry-Government-academic group and which had been so successful for MED and for the country. "The Commission chose to continue the contract method of operation, and added unique features encouraging flexible decentralized operation."[2] The Commission in a report to Congress stated that:

"The firms operating large Government-owned production plants, carrying on extensive development projects, and undertaking urgent construction jobs, work in close day-by-day cooperation with the Commission and its staff. They have been selected for their competence and the Government is contracting with them not only for technical ability but for managerial ability as well. The working relationship between the Commission and its operating contractors resemble in some respects those between industrial companies and their branch offices. The contractor undertakes to carry on an extensive ooeration; the Commission establishes the objectives and makes the decisions required to fit the operation into the national program, and exercises the controls necessary to assure security, safety, desirable personnel administration and prudent use of the public funds."[3]

Prior to the Second World War, technological advancements predominently depended on non-governmental enterprises which were motivated by the commercial incentives of the marketplace. Since that time the urgency and the magnitude of the national interests which are at stake no longer permit technology and science to be advanced by economic considerations alone. Indeed, the primary initiative and responsibility for the promotion and funding of research and development has shifted to the Federal government. However, while this overall reorientation of the purpose of R&D has been, in many areas from private to public, the overwhelming preponderance of the nation's scientific and engineering talent remains firmly in the private sector.

In this combination of private enterprise and public interest there has been created an entity which conforms to a general theory of industrial organization. The senior executive decisions, those of deciding the ultimate ends to be pursued, are made by the Government. The mid-level executive decisions, those of reducing general aims into specific programmatic and technical directions, are also made by the Government. It is at the lower executive and operation levels, at which the decisions refer to technologically correct conduct, that the contractor is relied upon, subject to certain reviews and approvals, to act as the vehicle for accomplishment of Government's desired results. Consistent with (though preceding by almost a quarter of a century) Drucker's theory of "reprivatization," the management and operating contractors perform the required work functions while the "Government would be seen as society's resource for the determination of major objectives..."[4]

"The exact legal relationship under the management contract concept is difficult to define in traditional legal terminology. The AEC management contractor relationship is unique. It contains elements of the master servant, principal-agent and principal-independent contractor relationships. These ordinary legal classification, however, are inadequate to identify accurately the relationship existing under the long term arrangements utilized for conducting AEC's operations...."[5]

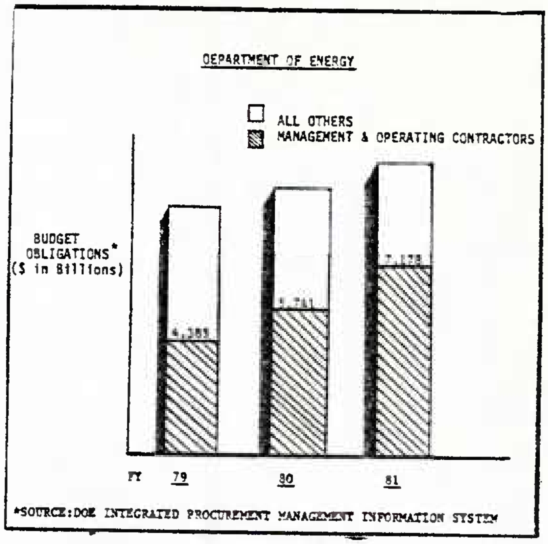
It is this very "unique relationship" that has caused some legal difficulties since the Second World War. Liability vs. immunity from State taxes and from State health and safety requirements; the applicability of Federal labor laws (i.e., Walsh-Healy, Davis-Bacon, etc.); the applicability of the Federal Procurement Regulations; as well as the rights to access the Boards of Contract appeals have been subjects of legal disputes over the decades, some of which continue to the present day.

In U. S. vs Boyd, 378 U. S. 39 (1964), which still stands, the Tennessee State Supreme court held that two management contractors were agents of the Government in procurement and hence immune from sales and use taxes, but were liable for privilege taxes imposed on use of "exempt" property. The U. S. Supreme Court agreed and held that the two management contractors were "independent" contractors in operating the Government facilities. With regard to treatment of a contractor as a Government agent, the U. S. Supreme Court affirmed, on March 24, 1982, the 10th Circuit Court of Appeals ruling in U. S. vs. New Mexico, 624 2nd 111 (1980), that a DOE contractor operating a Government-owned facility does not share the Government's tax immunity and is subject to a state's gross receipts and compensating use taxes. While something of a monetary setback for the Federal Government (New Mexico will collect about $100 million in back taxes and can look forward to approximately $20 million annually) this decision underscores the unique and complex nature of the Government/Contractor relationship inherent in these contracts. As has been the case since M'Cullock V. Maryland, 4 Wheat 316,419 (1819), we can probably look forward to continuing controversy in what the High Court itself describes as," ....a 'much litigated and often confused field,' United States V. City of Detroit, 355 U. S. 466, 473 (1958), one that has been marked from the beginning by inconsistent decisions and excessively delicate distinctions."[6]

The issue of applicability of state and local regulations to management and operating contractors represents less of an area of contention. The Government ownership of the property, the statutory nature of the work involved, the fact that the contractor is not pursuing his own business but federal activities has generally resulted in avoidance or resolution of any problems without major legal confrontations.

The expenditure of such a large proportion of DOE's appropriations by management and operating contractors (see Figure 1) has raised many questions as to who actually constitutes parties to these transactions, the applicability of Federal Procurement Regulations and the liability for federal labor statute violation. The U. S. Supreme Court, in Kern-Limerick Inc. vs. Scurlock, 347 U. S. 110 (1954), has held that absent express statutory requirement, an agency's use of an agent for procurement matters is not subject to the federal procurement provisions which apply to agency's direct procurements. The Comptroller General agreed in Tennecomp Systems Inc.,[7] stating that, "while a contract awarded by a cost-type prime contractor of the AEC (DOE) is considered an award made for a federal agency, propriety of award must be considered in light of relevant prime contract provisions, not statutory and regulatory requirements governing direct federal procurements."

Figure 1



Although the "privity" doctrine generally denies direct access to an agency for subcontractors, the AEC had allowed such access where the "Disputes" clause had "flowed down" to the subcontractors. In Optimum System Inc., and more recently in C-E Air Preheater Co. Inc.,[8] the Comptroller General held that GAO will consider protests of awards made by prime contractors acting under cost-type management contracts who operate and manage DOE facilities.

The labor field also provides excellent examples of the uniqueness of the management and operating contract concept. The Walsh-Healey Act refers to contracts between the Government and a supplier and the Department of Labor regulations imply that the Act's coverage does not extend to subcontractors of a prime. However, the court of appeals upheld a lower court finding in U. S. vs. Davidson Fuel and Dock Company[9], that the Act was applicable to subcontracts of the management and operating contractors. Therefore, to avoid problems with DOL, the Department of Energy requires inclusion of the Walsh-Healy Act contract provisions in our management and operating contractor's procurement actions as we do in our direct contracts.

The Davis-Bacon Act raised different problems for our management contractors. These contracts usually provide for both operation and maintenance of the DOE-owned facility, hence, the issue has been frequently raised as to whether some portion of the maintenance type work is, in fact "construction, alteration and repair of public buildings and public works" which is "covered" by Davis-Bacon. With the highly complex operations which are conducted in these facilities the answer is not always clear. However, the management and operating contracts are being held subject to Davis-Bacon when determined by the contracting officer to be subject to that act.[10] The Department's procurement regulations have detailed coverage which was developed by the AEC and DOL for determining the applicability of the Davis-Bacon Act to work performed in DOE-owned facilities.[11]

As no other Government agency has such criteria, this is further indication of the unique relationships involved with management and operating contracts.

However, it is this fluid relationship, which has made possible the accomplishment of the majority of the missions of the successor agencies over the past 35 years. "... the contract (is) not a piece of paper, but a nexus of understanding, imperfectly stated and quite normally more tacit than implicit."[12]

The traditional relationships of the parties envisioned by standard contracts were not sufficiently flexible to achieve the programmatic objectives, utilize the personnel resources and expertise of private industry and the university community, and access the know-how and flexibility of the procurement structure of the contractor's organization.

"Its contractual relations with industry, therefore, must be considered as more than mere commercial arrangements, wherein the public interest is best served by favorable financial terms. Management contracts are instruments of social and economic policy."[13]

The DOE has and continues to study the desirability of direct Government operation of its' facilities when new projects are proposed and undertaken, but the studies point to the continued overall success of the contractor method of facility operation.

The AEC/ERDA/DOE management and operating contracts are, "a class of Government contracts in which the contract document is primarily intended to serve as a useful management tool in getting the job done by parties acting in good faith."[14]

The cost plus type of contract has many simularities to the management contract, but the philosophy underlying the AEC/ERDA/DOE management and operating contract concept is very different. The "AEC administrative contracts are not thought of as involving a seller and a buyer or as a method of arriving at a price for a thing sold or a service produced.... These contracts are drawn and administered in a manner designed to promote a close, cooperative relationship between contractor and AEC."[15]

The management contracts relate specifically to the statutory function of production or research in DOE-owned or controlled facilities, while many other agencies use contracts to require supplies and equipment which they use in their agency function which begin after the contract.

The Statement of Work in the management contract describes in general terms the required work. The specific guidance required to perform the operations necessary under the contract is provided by DOE in annual work programs, project proposals, budget estimates, financial plans, program letters and authorizations.

The annual work program is developed by the contractor based on general assumptions and directions provided by DOE. The Department reviews and approves this plan prior to the period which is covered by it. The formal budget submissions of the contractor demonstrate the allocation of the funds requested. The Department then issues an approved financial plan establishing the amount of funds available for the contract and showing the allocation of funds to the various programs and projects in the work program. Funding for the Management and Operating Contracts is accomplished as a function of the budget execution process.

One of the important and unusual aspects of the management contractor's relationship with the Department is the integration of its accounts with the Department's accounting system. In general, funds provided to these contractors are placed in a "Special Bank Account," title to which funds remains in the Government. The contractor cannot co-mingle its funds with the Governments, and must maintain a separate and distinct set of records which account for expenditures. Indeed, these "bank accounts" of the contractor must be maintained in accordance with the Treasury requirements of 12 USC 265 which are applicable only to accounts for Government funds.

DOE, like its predecessors, is committed to ensuring the appropriateness of the work assigned to the National Laboratories and other Management and Operating contractors. Senior agency management has conducted periodic assessments of the proper role of these special facilities in accomplishing the agency's mission. The specialized nuclear and weapons research, development and production facilities have no parallel in the private sector. Hence, the roles of these Laboratories and contractors are more easily defined and more clearly focused. The DOE Multiprogram Laboratories, such as Argonne, Brookhaven and Oak Ridge exist to perform R&D at the frontiers of knowledge in such diverse areas as nuclear weapons, nuclear energy-high energy physics, basic and life sciences, health and safety and environmental studies related to energy supply and use.

The Laboratories cooperate and interface with industry and academia in those areas where they are the proper focal point for seeking the technological solutions to the Nation's energy problems. Therefore, in order not to have these Government owned and controlled facilities in conflict with the capabilities of the private sector, the Department has developed guidelines and controls for the assignment of work to these contractors. They are continually perused, updated and fine-tuned to reflect the proper role of these unique National assets vis-a-vis industry and academia. Internal management controls range from clear generic role statements and mission area definitions to the high-level agency review and approval of any new or expanded work assignments proposed for the Management and Operating Contractors.

The positive attributes of these quasi-governmental arrangements are not restricted to the Government's benefit; indeed, industry has long ago grasped the significant, "... business and technical advantages -- the opportunity to learn and develop a new art; the acquisition of invaluable technical and engineering information; the establishment of a reputation as a pioneer in an industrial field limitless in its horizons;..."[16] So too with the academic institutions involved with DOE's management and operating contracts have the inducements outweighed the risks.

There are relatively few people inside or outside of Government who are sufficiently well versed in the intricacies of this novel form of Government contracting. The Office of Federal Procurement Policy (OFPP) and others have failed to grasp the very real differences which necessarily exist between these and other Government contracts. As a result, the Office of Federal Procurement Policy (OFPP) over the past few years has periodically attempted to foist upon Federal agencies a policy letter on Federally Funded Research and Development Centers. Lumped inappropriately between the Federal Contract Research Centers (FCRCs) of DOD and the observatories of the National Science Foundation (NSF) are DOE's management and operating contractors. While I have no objection to NSF's identification, for their own annual report to Congress on Federal R&D funding, of DOE's facilities that perform R&D as FFRDCs, this identification does not have and was never intended to have any relationship to the placement of work or contracting procedures with these facilities. In 1972, the Commission on Government Procurement (COGP) recognized this inherent difference and concluded that problems associated with FFRDCs are different for each type and that each type must be treated separately (e.g., "The generally high quality of the work performed by FFRDCs of the operating laboratory type has never been questioned and the value of their work is universally acknowledged. Yet the criticism that has been leveled, rightly or wrongly, at the think-tank and systems management type has unfortunately rubbed off on the operating laboratories as well.")[17]

More recently, the Federal Acquisition Regulation Project Office (FARPO) appreciated the unique nature of DOE's management and operating contracts in stating that, "... we agree that the unusual and highly specialized nature of the contracting method we are contemplating renders inpracticable either the general application of the FAR to it or the detailed prescription of uniform procedures for it." Working closely with the FARPO, this recognition of uniqueness is being formalized into a separate and distinct FAR subpart 17.6, entitled Management and Operating Contracts.

"The technology leadership of this Nation has been significantly enhanced by the partnership of the Government and the private sector in the work performed at and managed by these laboratories."[18]

These Laboratories/Contractors are responsible for the first atomic and thermonuclear weapons as well as designing and developing the Polaris, Minuteman III and Poseidan warheads. They provide the vast majority of the United States nuclear weapons production, testing and safety programs. They are the sole producers in the U. S. of Plutonium-238, heavy water and tritium. They are world leaders in High Energy/Particle Physics, Lasers, Accelerators, fusion research, and nuclear submarine propulsion. They have pioneered neutron cancer therapy. They have developed the plasma atomic emission spectroscopy method. They have developed Tradiscantia, a highly sensitive plant system to monitor and study low-level exposure effects of environmental agents. These are to name but a few of the many scientific and technical advances made possible by a relationship that takes full advantage of the combination of the skill, experience and managerial expertise of American industry and the leadership of the Federal Government.

"Since these contracts were not drafted to achieve a set of predetermined legal or policy positions, significant questions relating to various facets of the concept have required 'ad hoc' solutions, either in response to particular legal or management problems or as a part of contract negotiations. Such questions have included the delegation of program responsibilities, personnel status, procurement authority and requirements, federal-state relations, application of federal labor statutes, and other Congressional-

Executive policies involving the conduct of public operations."[19]

Indeed, for over three decades this relationship has been closely examined in various forums, but continues today due principally to the ability of its defenders (in Government, industry and academia) to rise to the challenges and demonstrate the continuing wisdom and utility of the concept of management and operating contracts as well as the necessarily close relationship of the parties inherent in these contracts.

<u>Note</u>: The views presented are those of the author and should not be construed as representing the official position of any Government agency unless so stated.

<u>References</u>

1. Senate Report 1211, 79th Congress, 2nd Session (1946)
2. Ramey and Smith, "Recent Efforts by the AEC to Improve the Procurement Process" (National Contract Management J 145/1970)
3. Ninth Semiannual Report, U. S. AEC (1951)
4. Drucker, Peter F., "The Age of Discontinuity", 1969, pp. 234
5. Hiestand, O. S. and Florsheim, M. J. "The AEC Management Contract Concept" 29 Fed Bar J. 67(1969)
6. <u>United States v. New Mexico</u>, U. S. Law Week, 3/23/82, Vol. 50, No. 36, pg. 4326
7. <u>Tennecomo System Inc</u>., B-180907
8. <u>Optimum System</u> 54 Comptroller General 767 (1975), B-183039 as well as in B-152946; B-169942; B-170202 and 51 Comptroller General 329 (1971); <u>C-E Air Preheater Co. Inc</u>., B-194119 (1979)
9. 371 F 2nd 705 (4th Cir), 1967
10. DOE-PR 9-50.1804, Labor Standards and FPR 1.18..7
11. DOE-PR 9-9-18.7, Labor Standards for Contracts involving Construction
12. Report of Advisory Board on AEC-Contractor Relationship, May 28, 1948
13. Newman and Miller, "The Control of Atomic Energy: A Study of its Social, Economic, and Political Implications" (1948)
14. Ramey and Erlewine, "Introduction to the Concept of Administrative Contract in Government Sponsored R&D" 17 Fed Bar J 354 (1957)
15. IBID
16. Newman and Miller, "The Control of Atomic Energy: A Study of its Social, Economic, and Political Implications" (1948)
17. Volume 1, Final Report of Study Group No. 11, Research and Development, Commission on Government Procurement (1972)
18. "A Research and Development Management Approach", Report by the Federal Coordinating Council for Science, Engineering and Technology, (Oct. 31, 1979)
19. Hiestand, O. S. and Florsheim, M. J., "The AEC Management Contract Concept," 29 Fed Bar J. 67 (1969)

MANAGEMENT OF MULTINATIONAL PROGRAMS

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ABSTRACT

This paper presents the research results contained in the Joint Logistics Commanders' Guide for the Management of Multinational Programs developed by the author. Results are categorized from conception through follow-on support in the following areas:

- Acquisition Planning Systems,
- National Environment Differences,
- Acquisition Strategy,
- Organization for Multinational Program Management,
- Contract Management,
- Intellectual Property,
- Engineering Management and Technology Transfer,
- Financial Management,
- Foreign Weapons Evaluation,
- Manufacturing and Production,
- Logistics,
- Disclosure of Military Information, and
- Sources of Data

Political, legal, economic and technical problems that have traditionally arisen during international programs are indentified and solutions that have proven successful in the past are included. The focus of the research results is on information that previous program managers felt would have been helpful had they had it at the time. The purpose of this research was to enable a program manager to avoid some of the pitfalls of the past, and increase the military effectiveness of NATO and other U.S. alliances by enabling armament collaboration efforts to succeed. The research stresses the importance of each new program having potential international application to be properly structured "up front" for going multinational.

INTRODUCTION

With the advent of the Rationalization, Standardization and Interoperability (RSI) initiatives within DOD to strengthen NATO, many issues involving the management of multinational programs have developed. Effective management requires not only a comprehensive understanding of the needs and requirements of each nation involved, but also an understanding of the differences in logistics support, financial management, technology transfer, program management, acquisition strategy, organization, test and evaluation, security considerations, and codevelopment. In order to help the program manager deal with the multinational issues, the Deputy Undersecretary of Defense for Research and Engineering (Acquisition Policy) commissioned a research effort through the Defense Systems Management College to produce a guide for program managers to assist in dealing with RSI features of international programs by relating the PM's background in domestic programs to the special and even more complex nature of international programs.

Initially an intense literature survey was conducted and a NATO RSI/Multinational Program Management repository created at DSMC to ascertain the state-of-the-art and to gather relevant information as input to the research effort. It was quite evident from the literature survey that information on multinational program management was fragmented and incomplete. Lessons learned on international programs, except for scattered end-of-tour reports and briefings, and an Army Procurement Research Office report on limited issues, were not being captured. The DSMC course participants in the Multinational Program Manager's Course typified the experiences of multinational program experts; each had limited experience on only one or serveral programs and were coming to DSMC to learn for the first time lessons of other programs. They had typically gathered their experience and expertise through the Foreign Military Sales route and were fighting NATO/RSI because it only created problems with no ready alternatives for solution. Pressures were being applied by OSD and Congress to achieve NATO/RSI, but no compensatory resources were provided to the program office charged with implementing the directives and direction into action. The DOD and Service policies on Multinational Programs were and still are being developed and no clear direction on many issues was evident. In addition, the State Department, Treasury Department, Office of Federal Procurement Policy, and other Federal agencies have an impact on international procurements. Their roles, responsibilities and impact on any specific procurement was not clear. Programs having potential international application were not being properly structured before going multinational, causing severe restructuring for or precluding international involvement.

RESEARCH METHODOLOGY

After an initial literature survey to scope the problem, a topical outline of chapters and issues was developed. A research committee was formed of international experts that were friends of the College and interested in the research project. The research committee added to the topical outline and volunteered to write various sections of the guide in their areas of expertise. Each chapter and section became a separate research project to be tied together during the integration and review process. The research and writing of various sections of the guide was accomplished by use of these experts in the various fields and from interviews with management offices and industry with experience in multinational program management. Coordination of the sections and chapters of the guide was accomplished through the review of this ad hoc committee of experts, and by the multinational program management offices, service headquarters, and at OSD. Logisitics Management Institute wrote the chapter on logistics and edited the other chapters. The Joint Logistics Commanders reviewed and approved the publication of the guide. The guide represents DOD policy, Service procedures, and multinational program management experiences. It is planned that periodic updating will be accomplished by the Defense Systems Management College.

ACQUISITION PLANNING SYSTEMS

Because of similar procedures, the NATO Periodic Armaments Planning system (PAPS) and the DOD Defense System Acquisition Review Council (DSARC) process complement one another. Under DOD Directive 5000.1, a Service identifies needs and develops a draft Justification for Major System New Start (JMSNS) for each of those which may become major programs. The JMSNS is the first coordinated within the Service staffs resulting in a document which represents the Service's position with regard to the mission need and acquisition strategy. The JMSNS is submitted to the Office of Secretary of Defense (OSD) with the service Program Objectives Memorandum (POM). The Secretary of Defense tacitly approves the JMSNS when he approves the POM.

If a particular need has potential NATO application and may represent a target for cooperation within the Alliance, the Undersecretary of Defense for Research and Engineering (USDRE) acting as the U.S. NATO Armaments Director (NAD), forwards the draft JMSNS to NATO as a Mission Need Document (MND) under PAPS. Specifically, the draft JMSNS (now in MND) would be sent to the Assistant Secretary General for Defense Support. The MND would be transmitted to other nations for review and a decision on their degree of initial participation. The DOD review of the JMSNS would proceed as usual, and in parallel a meeting would be called for a Main Group subgroup to take action on the MND.

The results of a U.S. and a NATO review can then be reflected in the final approved JMSNS to provide a sound basis for collaborative R&D from the start. The JMSNS would have a NATO equivalent in an outline NATO Staff Target. If this process is conducted in parallel, time will not be lost; in fact, it may preclude delays in new starts due to concerns raised regarding NATO standardization goals in the JMSNS and specific plans for Concept Exploration.

The process of approval of the System Concept Paper (SCP) and Decision Coordinating Paper (DCP)/Integrated Program Summary (IPS) for Milestones I and II, respectively, in the DSARC process parallels NAD reviews under PAPS. Activation of the PAPS process could form a part of the normal SCP and DCP/IPS coordination process prior to a DSARC, thus providing DSARC/PAPS compatibility from the draft JMSNS to the completion of full-scale development. A detailed chart describing the life cycle of major system acquisitions under the PAPS and DSARC process is shown at Figure 1.

NATIONAL ENVIRONMENTAL DIFFERENCES

Several factors are discussed in comparison of national and international military projects. Comparable factors include: 1) military requirements based on the perceived threat, doctrine and tactics; 2) resources (capital, personnel and technology) and 3) industrial base to support the program. There are also important non-measurable enviromental differences such as culture, attitudes, human behavior, national priorities and other factors which represent differences among the countries involved. The goal to be emphasized for multinational management is measurement of organizational performance. A specification of critical elements for each participating nation and company is required to identify the differences in national and business objectives. These differences represent the environment of the international program manager. Program achievement is determined not only by how effectively and efficiently people work. Technical factors play an important role, sometimes overwhelmingly. The plant, product, product mix, plant and job layout, design of machines and equipment, degree of integration (batch vs. continuous) of production processes,raw materials, research and development management, and scientific and engineering management are all factors in the process technology transfer. User needs, maintenance requirements, and operator training are factors in product technology transfer. Technology transfer and modification of the formal organization to effect technology transfer are accomplished by training programs. The critical elements in achieving program objectives are diagrammed in Figure 2.

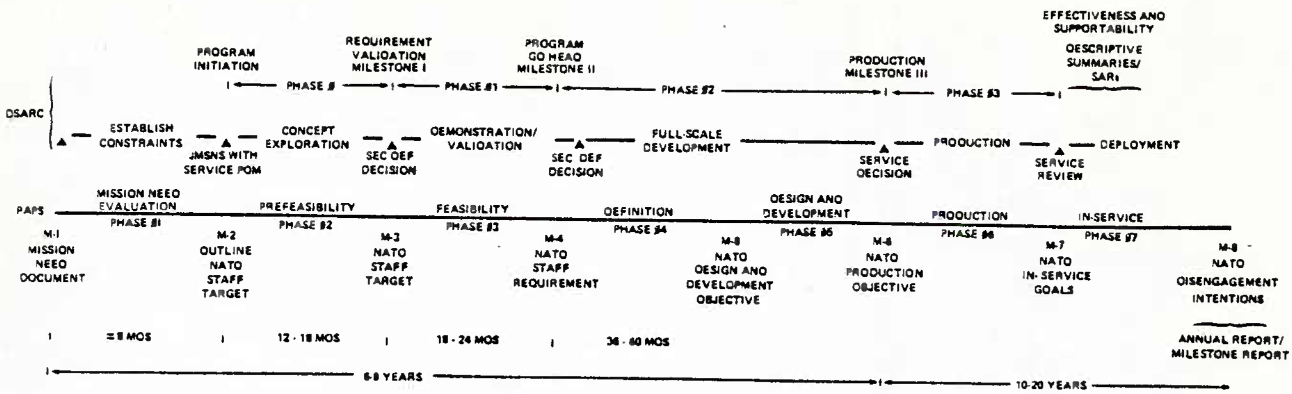


Figure 1. DSARC/PAPS Phases and Milestones

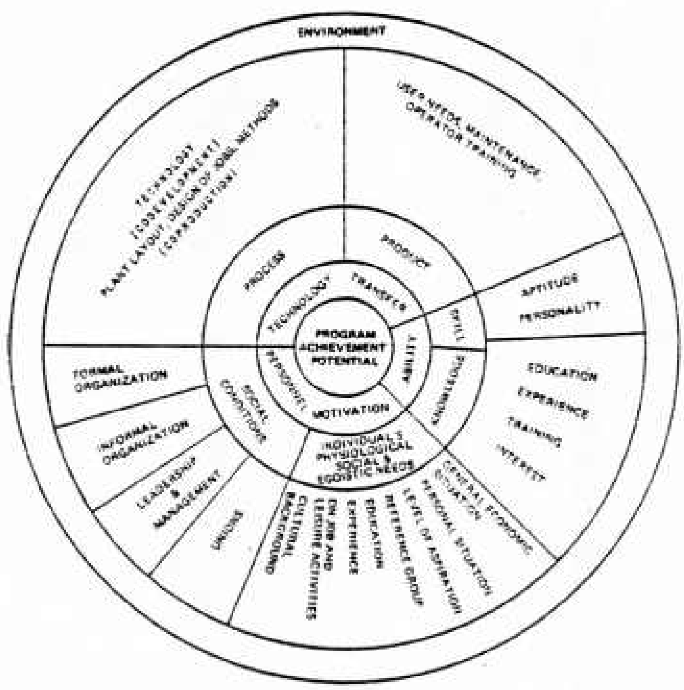


Figure 2. Critical Elements of the
International Program Management Process

On the personnel side, employee motivation and ability are also essential to program achievement. Employees here include executives and managers, the program manager and his staff, and white- and blue-collar workers of the participating countries' governments and businesses. Ability is derived from ability, education, experience, training and interests. Motivation results from a combination of various social forces such as the formal and informal organization, leadership and management, and labor unions. The individual's motivation is also affected by psychological, social, and egoistical needs. Recognizing that all of these factors differ by country, as much in Europe, as between Europe and the United States, detailed knowledge of a country is important in program management.

Differences between Europe in the concept of competition, European defense industry practices, educational systems, taxation, labor stability and compensation practices were examined for the complexities and subtleties embedded in European history, culture, politics, economics, and industrial structure and development.

Various international cooperative arrangements and areas addressed in memoranda of understanding (MOUs) were examined to provide guidance for preparing sections of an MOU. The types of MOUs and cooperative arrangements include:

- o General and Reciprocal Procurement MOUs,
- o Umbrella-Type Research and Development MOUs,
- o Program Specific MOUs,
- o Patent Interchange,
- o Funding Agreements,
- o Security Agreements,
- o Quality Assurance Agreements,
- o Data Exchange Agreements and
- o Standardizatin Agreements (STANAGs).

ACQUISITION STRATEGY

The acquisition strategy (AS) chapter includes a discussion of operations and alternative systems of NATO origin, strategy for acquisition and logistics support of the system, a technology release plan, organization of the management group, test and evaluation plan for foreign systems, and the extent of NATO involvement. The types of U.S. participation with NATO countries range from U.S.-produced/European-purchased via Foreign Military Sales, to joint U.S./European production with different assembly points, to limited European or U.S. licensing agreements for components, and to fully European-produced systems for purchase by the United States.

A discussion of multination program management structure directly related to acquisition strategy is developed. A program can be wholly U.S. managed, joint-consortium managed, or NATO managed. The management organization necessary to facilitate the program usually consists of a part-time NATO program steering committee and a multinational full-time management group. The steering committee controls the program by providing guidance and direction to the management group. A high-level representative from each participating NATO country sits on the committee. Meeting as necessary to make decisions, the committee issues regular reports to the NATO CNAD about program status, and is responsible for liaison with the NATO military authorities for planning integration of the system into the participating country's inventories. Each representative to the steering committee provides his countries' representatives, specifies the form and structure of the management group responsible for detailed management, evaluation of alternatives and planning. The management group may consist of representatives from each participating nation. A policy group may be formed at the military Service level to provide coordinated U.S. policy and guidance to U.S. members. Position guidance is established through coordination with the Department of State, Office of the Secretary of Defense, and military Service staff agencies.

The technical strategy is the approach for achieving the program's system performance, design and reliability goals. Unlike a domestic program, where technology to optimize system performance may be pursued, the program manager might have to attempt to integrate the technological capabilities of serveral different national economies. Programs should be tailored by partitioning the standards and systems specifications to suit that program's complexity. A key consideration in the technical strategy is the degree to which the participating nations will share in technology transfer.

The technical strategy should include a listing of critical pacing technology advances required to satisfy the program thresholds. The initial RSI Acquisition Strategy after approval of the MND and formation of the NATO subgroup may only contain a few of the pacing technology advances required, because not all weapon system alternatives have yet been explored. However, as the Prefeasibility phase (PAPS Phase 02) proceeds, necessary advances become more defined through study of the preferred alternatives. The kind of pacing technology advances required for each alternatives system determines the technology risk used in the analysis of the alternative concepts. Once the preferred system is chosen, and the Staff Target is approved, the technology advances required should be well-defined, and the risks for developing those technologies should be understood in terms of performance, costs, schedule, and supportability thresholds. The PM must then consider these risks in following his program acquisition strategy by assigning and controlling critical resources (time, money, personnel) appropriately, with special attention to the critical pacing technologies.

The technology release plan provides detailed planning actions required because certain technologies needed for production may not be releasable to NATO contractors, or they may pose problems in performing the cooperative effort. Such technologies fall into five categories:
1) security 2) configuration control,
3) critical critical/sensitive advanced technologies, 4) buyer considerations and
5) unconstrained. To build this plan, a work breakdown structure (WBS) is used to decompose the producible end item into its several hardware and software components, which are then classified into one or more of the five categories listed above. For those items in categories 1, 3, and 4, purchase of specific and items from a U.S. vendor is required.

A methodology was developed for review of contract flow-down provisions. Thus, prior to negotiating a contract with a U.S. prime contractor requiring foreign subcontractors or directly with a foreign contractor, it is essential that the following be accomplished:

- o A review by DOD of mandatory flow-down provisions must be undertaken for the purpose of deleting or diluting those requirements which are unworkable or not applicable for foreign procurements.
- o Solicitation Preview Panels must review Request for Proposals or proposed contract provisions prior to instituting discussions with foreign suppliers or governments to determine the necessity/desirability for inclusion of each clause. Results of this review must be made available to the negotiating team, whether from DOD or industry.
- o Government/Industry teams should be tasked to document difficulties in imposing mandatory flow-down provisions on foreign suppliers. This documentation should be made available to DOD personnel for review with the goal of deleting or diluting those deemed to be unworkable or not applicable to foreign suppliers.

Various contracting methodologies were to be considered during the different phases of the life cycle. These included co-development teaming, use of a technology transfer clause, leader-follower arrangement, second sourcing, breakout, and pre-planned product improvement.

Another major component of the AS examined was the business/financial management strategy encompassing all the aspects of the program pertaining to funding and budgeting, investment decisions, utilization of personnel and contractor resources, schedule management, evaluation of the business base, etc. It addresses such issues as the amount, timing and sources of funding; the weapons system developer and manufacturer organization and sources; the extent of competition to be infused into the program; the apportionment of development/production tasks and responsibilities among the various nations' industrial sectors; and potential use of leader-follower procurement or second sourcing.

Logistics planning and programming strategy was developed by stressing planning from a life cycle cost perspective. The logistics strategy should involve achieving the minimum required level of readiness at the lowest possible life cycle cost. The anticipated problems are to be identified as critical technology advances when they are significant enough to affect performance thresholds for the system. In addition, industry capacity to produce critical components, long subcontractor leadtimes, use of commerical systems and components, and use of commercial logistics support are discussed. Centralizing the defense logistics functions via consolidating management of individual nonconsumable stock-numbered items of equipment and expeditiously transferring NATO consumable items to the NATO Maintenance and Supply Organization (NAMSO) or other appropriate organizations, and use of the Standard Integrated Support Management System (SISMS) should be considered for very early implementation in the initiation of the logistics program. By coupling the manpower and logistics functions, support of the weapons system should be emphasized in the acquisition process.

Eight different observed modes for international weapons development and production were identified and examined as used in NATO programs. These included:

- o Mode 1 - Licensed production in one European nation of a system developed in the U.S.;
- o Mode 2 - Licensed production in Europe by a multinational consortium of a system developed in the U.S.;
- o Mode 3 - Codevelopment and coproduction among European nations;
- o Mode 4 - Licensed production in the U.S. of a system developed in Europe;
- o Mode 5 - Transatlantic joint development;
- o Mode 6 - Bilateral offset arrangements for the purchase of a foreign system;
- o Mode 7 - Transatlantic joint production or systems management by a U.S. led consortium; and
- o Mode 8 - Package deals and the "Family of Weapons concept".

ORGANIZATION FOR MULTINATIONAL PROGRAM MANAGEMENT

Organizational structures were examined in the multinational arena for providing the decision making and operational levels required to carry out the acquisition strategy and communications/liason functions. The PM for a foreign acquisition must communicate with a wide variety of organizations. Some are internal to his parent organization and others are external to the program. These contacts require the personal attention of the program manager during initial establishment of formal lines of communication, as well as subsequent followup, to keep all program participants informed of progress, problems, and changes to established program thresholds, constraints, and plans.

The organizational structure exists to provide a disciplined, stable, but flexible approach to dealing with the legal, administrative, and technical requirements of the acquisition process. The organization established by the assigned program manager to carry out program objectives must be adequate to get the job done. If the conventional organizational structure proves unsatisfactory, changes should be made without delay.

In the case of foreign acquisitions, organization is complicated by the introduction of new factors -- laws, language, and customs, to name a few -- which are often unfamiliar and may require special staffing. In an environment where responsibilities often may overlap or not be clearly defined, where guidelines are frequently vague or in the process of being changed, and where even ordinary speech contacts may be difficult, the assigned program manager must seek to establish communciations along three general lines: (1) with those organizations external to control and direction but with influence over the program, (2) with those organizations that are external to program control but responsive to its direction, and (3) with those internal organizations over which the program mamager exerts direct control.

Four management structures were compared in the subsequent discussion.The PATRIOT organization represents a program in the MOU negotiation stage where discussion and negotiation are the objectives rather than program control. ROLAND represents transfer of a foreign weapons system to the U.S. with a separate U.S. ROLAND program manager tied to the European developer countries for configuration control. The NATO Airborne Early Warning and Control (AEW&C) program represents the procurement of a major system by NATO that is owned by the 13 NATO countries participating in the program, with the U.S. System Program Office acting as the agent for NATO (France and Iceland are not participants).

The F-16 program represents coproduction of a U.S. developed system both in the U.S. and Europe by a consortium of contractors with strong U.S. management influence.

The following depicts how some of the operational considerations and policy factors can impact or influence the way a multinational PM office is tailored. Operational considerations are:

- Service Peculiar Organizational Traits. Traditionally, the Services organize PM offices differently.
- Major Program Changes/Configuration Management. Major changes in program direction or design will, in all likelihood, necessitate organizational changes, something for which the PM must be constantly alert.
- Type/Nature/Extent of Cooperative Effort. The degree and level of cooperation between nations must recieve consideration during the tailoring process, with high levels of participation requiring a correspondingly high level of representation.
- Phase of the Program. For example, early-on, the program office may require more technical and engineering staff, while in a mature program, it would call for more Integrated Logistics Support (ILS) and production staff.

Other operational considerations include:

- The Technical Management Process and Controls. The approach to the technical management of the program could dictate the special skills required for staffing the PM office.
- The Financial Management Process and Controls. The more nations involved, the greater the overall financial management problem will be -- compounded by varying exchange rates, balance of trade, and the like -- hence, the greater the need for specialized financial staff.
- The Government/Industry Roles and Participation. The roles, relationships and degrees of participation by both the government and industry could have significant influence on how the multinational PM office is structured. A private contractor with extensive contracts and experience in the international market place will require less specialized attention on the part of the PM than a contractor that has not had that - experience.
- The Structure of Non-U.S. PMOs and Their Modus Operandi. The U.S. PM, when tailoring his office, must give careful consideration to how the participating allied nations have organized their effort to accomplish the program.

CONTRACT MANAGEMENT

Public law restrictions, duties and customs, effect of the General Agreement on Tariffs and Trade, provisions of the waiver of the Buy American Act, the Defense Acqusition Regulations (DAR) on foreign acquistions, and cost accounting standards were examined.

The GATT provides a framework for reducing tariffs and other trade barriers through a series of multinational negotiations that have been ongoing for over fifteen years. Fourteen specific agreements and codes have resulted from the Kennedy and Tokyo rounds of multinational trade negotiations. The GATT was implemented in the U.S. by Public Law 96-39, "Trade Agreement Act of 1979," which became effective on 1 January 1981. Of specific interest to DOD is the Agreement on Government Procurement. Nineteen (19) countries are covered as of
1 January 1981 with 26 lesser developed countries also eligible under the Agreement. The effect of the GATT is to open up an estimated annual $75 billion (based on 1979) market among designated countries to international competition. In the U.S., it is expected that the Agreement on Government Procurement will open up to foreign bidders about $18 billion of DOD purchases, which is about two-thirds of the estimated U.S.G. market of $27 billion/year (based on 1979). The DAR 6-1600 defines a designated country end product as that wholly produced, manufactured, or substantially transformed in the designated country.

At the time the research was conducted, the requirements of the Buy American Act had been waived for all NATO countries (and other participating countries), allowing them the opportunity to compete on a fair and equal basis with U.S. industry for R&D and production contracts. The only major restrictions are those involved with 1) U.S. defense mobilization base requirements,
2) specific U.S. laws and regulations (i.e., the annual DOD Appropriations Act), 3) the provisions of the National Disclosure Policy, and 4) U.S. Industrial Security Requirements.

Defense Acquisition Circular (DAC) 76-25, dated 31 October 1980 completely revised Section IV so that it now incorporates the acquisition objectives and initiatives of the U.S. Government in the RSI arena. There are three types of international agreements which apply to foreign acquisitions: reciprocal agreements, FMS/offsets agreements, and treaty/international agreements. Reciprocal agreements encompass any NATO country which has an MOU or similar agreement with the U.S. These countries are identified as participating countries and are covered by a blanket Secretary of Defense Determination and Finding waiving Buy American Act restrictions. Offset agreements are identified as any foreign country having an offset arrangement negotiated in conjunction with a Foreign Military Sale and which arrangement provides for obtaining a waiver of Buy American Act restrictions on a case-by-case basis. Lastly, treaty/international agreements cover those foreign countries having a defense cooperation agreement, such as Israel or Egypt, and for which a Determination and Finding has been made by the Secretary of Defense waiving Buy American Act restrictions for a list of mutually agreed items. These three types of agreements are extremely important relative to contracting policy since they define the population of what is now termed "qualified countries".

It is DOD policy to obtain the issuance of duty-free entry certificates covering end items acquired through the foreign acquisition process. DAR 6-1302 requires that duty-free entry clauses as contained in DAR 7-104.31 be included in all negotiated contracts in excess of $100,000, and all contracts involving the furnishing of supplies except for small purchases, and contracts for supplies exclusively for use outside the U.S.

The cost accounting practices of foreign business firms vary substantially from country to country and from contractor to contractor. A review by the Cost Accounting Standards Board disclosed that as a result of these wide variations the application of certain accounting standards and rules could cause significant administrative problems. Thus, on
14 November 1978, the Board exempted foreign firms from each cost accounting standard other than Standards 401,"Consistency in Estimating, Accumulating and Reporting Costs," and 402, "Consistency in Allocating Costs Incurred for the Same Purpose." Foreign concerns are still required to file a Disclosure Statement. Contracts and subcontracts awarded to foreign governments and their agencies are exempt from all standards and rules of the Board.

INTELLECTUAL PROPERTY

Research revealed that the laws of our European allies in NATO covering rights in inventions, data, and software are substantially different from those of the United States. The European inventor maintains ownership of inventions with right to use the inventions. Intellectual property rights are usually owned by industry and the individual. However, provisions committing a contractor to enter license agreements are part of the Federal Republic of Germany's development contract regulations and the United Kingdom's regulations in the "International Collabaration Clause." The reasonableness of the licensing fee is addressed in the German regulations.

It is essential to realize that without the cooperation of the holder of the intellectual property rights (IPR), transfer of intellectual property (IP) cannot take place. Firm-to-firm exchanges without interference of third parties are essential to a successful IP transfer, particularly in the key role of know-how and technical assistance. The same problem exists in the transfer of manufacturing drawings in competitive procurements, because the firms that actually expect to follow the drawings, rather than convert the drawings to suit their own shop processes and practices, rarely possess the technology capabilities and the processing knowhow.

ENGINEERING MANAGEMENT AND TECHNOLOGY TRANSFER

The process of international cooperation has an integral element, the transfer of technology among the partners in a cooperative process. As such, there is a need for the program manager to understand, 1) the process by which technology flows from one partner to another, 2) some of the differences in the practices of engineering management between the U.S. and Europe, and 3) some of the problems which arise in the areas of engineering and technology. Research was organized along these lines. The end objective of the engineering process is a complete definition of the design of a system which will represent the most cost-effective set of physical, performance and logistics parameters required to meet the operational need and postulated threat.

In some cases, foreign designs and end items, while exhibiting excellent performance and acquisition cost characteristics, display a variety of technical, software, safety and logistics deficiencies because of a different concept of design control. During the technology transfer and critical design review processes, continued emphases will be required to ensure the following:

- o Foreign designs and equipment have a baseline management and configuration control system in being. If they do not, one must be established at the start of the transfer process.
- o Foreign software programs have a baseline management and configuration control system instituted early-on. The languages used must be acceptable to the U.S. program manager and the software programs must be fully documented and meet standards for quality, terminology, and symbology.
- o Trade-off analyses are conducted as part of the assessment of the baseline system to assure producibility of the equipment, human factors engineering for operator interface and maintainability, reliability of critical components and logistics supportability.
- o Interoperability/standardization is maintained at the level required. The discipline imposed by the Logistics Support Analysis Review (LSAR) is appropriate for structuring this assessment and providing a baseline management and configuration control system.

FINANCIAL MANAGEMENT

The purpose of research into multinational financial management was to document existing policies, agreements and procedures relating to financial management of DOD programs with international involvement and to provide alternatives for improvements in financial operations for multinational codevelopment and coproduction programs. These included:

- o Review of established recoupment, financial management and foreign currency agreements and regulations supporting present international programs,
- o Documentation of the collection and disbursement of foreign currencies and analysis of currency exchange operations,
- o Development and evaluation of alternatives for financial management and currency exchange, and
- o Audit by Department of Defense.

The complex financial management and currency exchange operations for multinational programs are to a large measure the product of the negotiations that place between the U.S. Government and foreign participating goverments prior the the signing of the Memorandum of Understanding (MOU) for a particular program. Competition with similar programs from other countries may be intense and may also be based on the economic concessions the competitors are willing to grant. Specific economic concessions have in the past included "not-to-exceed (NTE)" pricing and business offsets on the procurement value of the production, cost sharing relationships, waiver of R&D recoupments, a fixed rate of currency exchange, a commitment for the U.S. to buy a certain quantity and performance guarantees and goals. The program manager must continually exercise his management role of ensuring that the MOU commitments are met. This responsibility encompasses both a need to monitor and assess the performance of the prime contractor(s), and also to plan independently, where required, direct placement of coproduction work; manage cost sharing projects; manage to design-to-production-unit-cost (DTPUC), research and development costs, and operation and maintenance cost; and direct currency requirements. These requirements exist both to ensure adequate contractor performance and to strive to meet program business objectives which the contractor may not share.

Initially, ground rules for the financial procedures for the codevelopment and coproduction effort must be established in the form of cost sharing arrangements and a payment schedule of the required currencies. This is normally prepared by the prime contractor(s) and agreed upon by the participating nations. Agreement must also be reached on interest on deposits by the participating governments and the sharing basis for interest earned. Normally, interest is shared on the same basis as the amount of each country's deposits. The financial consequences of missing a payment must be specified in the MOU as well as responsiblilities with managing foreign currency transactions and contractual provisions for economic price adjustments.

FOREIGN WEAPONS EVALUATION

The foreign weapons evaluation (FWE) program provides for the technical and/or operational evaluation of friendly foreign nations' weapon systems and technology to determine potential use within the Department of Defense. Candidates are selected for evaluation based upon potential satisfaction of an operational need or correction of deficiency. Evaluations are also run on components and technologies for which there are DOD systems which might benefit from technology unavailable in the United States. In addition, the FWE program provides potential for significant resource savings by avoiding unnecessary duplication in development. For most U.S. defense tactical equipment needs, alternative foreign systems must be evaluated and considered prior to initiation of U.S. development. Through data exchange agreements, information exchange groups, and exchange visits, increased interest has been generated within the U.S. military services and in friendly foreign nations in greater standardization through joint use of like weapons. The number of requests for evaluation of foreign weapons systems has increased greatly in the past year.

MANUFACTURING AND PRODUCTION

The ultimate success of a multinational program is often dependent upon the level of effectiveness attained in the manufacture of the system under development. Research was concerned with a description of the production environment within Europe that can serve as a baseline for an approach to the transfer of process technology between the participants, concepts of manufacture, and product assurance requirements.

One of the most important characteristics of European defense industry is its division among three "tiers" of countries. The three most industrialized countries of Western Europe—Germany (GE), the United Kingdom (UK), and France (FR)—representing only about 54 percent of the population of NATO Europe, account for about 80 percent of its arms industry output. The next three most industrialized and populous states--Italy, the Netherlands, and Belgium,—representing around 25 percent of NATO European population, account for another 12 percent of its arms industry output. The other seven states of NATO Europe--Turkey, Greece, Portugal, Denmark, Norway, Luxembourg, and Iceland—represent about 22 percent of the population and less than 8 percent of the arms industry output of NATO Europe.

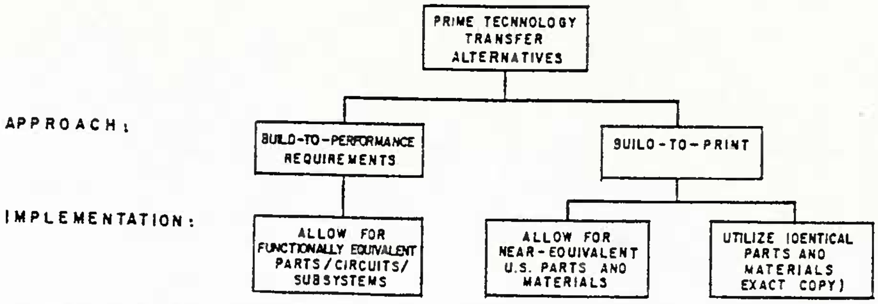
There are two basic concepts of manufacture for transitioned material: build to performance requirement or build to print. The program manager needs to specify carefully the approach which is to be taken on the program to be managed. Figure 3 illustrates some of the fundamental differences in these two approaches:

- o The build to performance concept is used if it is determined that the reciever of the technology transfer, the follower, is to be allowed the obtion of substitution of functionally equivalent parts, circuits and subsystems.
- o The build-to-print approach has two options. One is to allow for near equivalent parts and materials and the second is to utilize identical parts and materials as the original design. The former approach is based on the assumption that total multinational interchangeability usually is not feasible at the repair part or material level.

But this does not mean that standardization of parts and materials is to be ignored. On the contrary, it is commonality of parts, materials and processes that will ultimately determine the degree to which the systems are alike. The formulations of a strategy for parts selection should be of primary concern.

In Figure 3 relative cost for the different approaches are given cost indices which reflect their cost as compared to this baseline. For example, the production and support cost for an exact copy build to print approach is estimated to involve a cost 1.3 times as great as would be incurred for a near equivalent build to print approach for the same system. For other comparisons, such as national standardization and program risk, a particular case is shown in Figure 3 as representing the nominal case and the other approaches are measured relative to the baseline approach.

The research identifies a structured, phased process technology transfer approach for transferring process know-how from the leader to the follower. The process is illustrated in Figure 4. Shop practice



INTERNATIONAL STANDARDIZATION	INTERCHANGEABLE AT WEAPON SYSTEM LEVEL ONLY	INTERCHANGEABLE TO LOWEST REPLACEABLE ASSEMBLY LEVEL	INTERCHANGEABLE TO BIT AND PIECE LEVEL
NATIONAL STANDARDIZATION (PARTS AND MATERIALS COMMON WITH EXISTING U.S. INVENTORY)	HIGH	NOMINAL	LOW
TECHNOLOGY TRANSFER, FABRICATION AND TEST (TTF&T) COSTS	0.95 TO 2.0	1.0	1.5
PRODUCTION AND SUPPORT COSTS	0.95	1.0	1.3
MODIFY FOR U.S. PRODUCIBILITY	CURRENT WITH TTF&T	CONCURRENT WITH TTF&T / SUBSEQUENT TO TTF&T	--
PROGRAM RISK	HIGH	NOMINAL / LOW	LOW
EURO TO U.S. TECH. TRANSFER EXAMPLES	GERMAN-FRENCH AN/TPS-58 GROUND RADAR (ITT-GILFILLAN); BRITISH CANBERRA (B-57 MARTIN)	ROLAND (HUGHES)	DUTCH MARK 92 FCS (SPERRY)

Figure 3. Alternatives for Technology Transfer, Fabrication and Test (TTF&T)

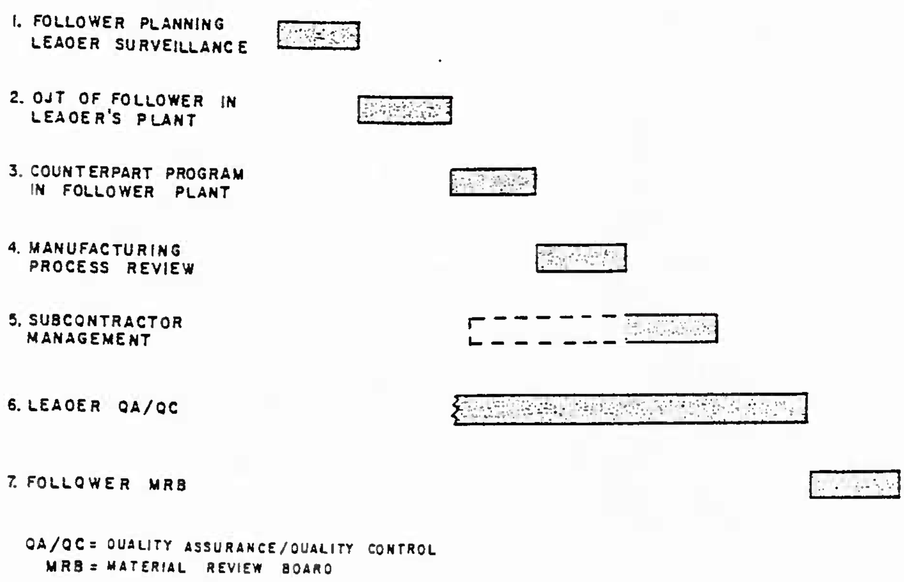


Figure 4. Phased Process Technology Transfer

differences are identified in broad categories. Product assurance testing procedures and publications for application to the basic contractual arrangements are also discussed.

LOGISTICS

With the advent of the rationalization, standardization, and interoperability (RSI) initiatives within DOD to strengthen NATO, many issues involving maintenance and support responsibilities and logistic management have developed. This research considers the tailoring of the integrated logistic support process and procedures to ensure operational readiness within the constraints imposed by foreign design. Differences in the NATO allies approach to maintenance and support responsibilities and the problems these create are identified.

The framework required for an international integrated logistics support (I^2LS) plan are:

- o Requirements harmonization
- o Early identification and quantification of program requirements
- o Support program planning and test equipment
- o Configuration control and support documentation
- o Support plan for coproduction/licensed production
- o Personnel, training, and training equipment
- o Provisioning and supply support
- o Technical data including intellectual property rights issues
- o Computer resources support
- o Facilities

There are differences between each NATO ally in practically every aspect of support. These differences include organization structure, levels of maintenance, and type of support available at each level, skills, training, test equipment, and facilities. The vital role in reconciling the I^2LS requirements within the support capabilities is discussed.

The use of an I^2LS planning conference and in-country supplier surveys are appropriate methods for determining support capabilities. The difficulty of achieving cooperation increases as the program matures. The three tier logistics review team approach is examined with application to I^2LS.

DISCLOSURE OF MILITARY INFORMATION

According to the National Disclosure Policy, classified military information is a national security asset which must be conserved and protected, and which may be shared with foreign governments and international organizations only where there is a clearly defined advantage to the U.S. Advance planning by a program manager to assure prompt compliance with the National Disclosure Policy will contribute to the success of cooperative international programs and the sharing of information with our allies.

The purpose of the research on information security was to give the PM a good grounding in such policy to facilitate his conformance with it. The topics covered include the National Disclosure Policy as it affects release of classified information to foreign governments, visitation procedures, foreign attendance at meetings, and industrial security. The Services' information security procedures are documented as well as criteria that must be satisfied before deciding to disclose classified military information to a foreign government or international organization.

To help keep track of disclosure decisions, the Foreign Disclosure Automated Data System (FORDAD) was established as a central repository for such decisions. A system, called the Foreign Disclosure and Technical Information System (FORDTIS) is being developed to replace FORDAD. Both FORDAD and FORDITS are discussed. FORDITS represents a tremendous improvement over FORDAD as it will provide an interactive, real time terminal at each disclosure office. This system is to also include decisions on Foreign Military Sales, Munitions cases and Commerce licenses.

SOURCES OF DATA

Finally, the guide returns to a more general feature of international programs, and that is the problem of communication given national differences in languages and in patterns of behavior. This research area covers communications occurring in meetings, negotiation, translation and interpretation, and lessons learned in communcation experiences. In addition, because of the importance of information to the Program Manager is such communications, a section is included on sources of information about foreign weapon systems, economy, technology, and DOD arrangements for international communication.

The success of a cooperative international program depends in a large measure on effective two-way communication and a sharing of information. Poor communication and a lack of relevant data have been blamed in the past for what was actually poor program management. Thus, the complications of differing languages and the variety of available data sources have been used as an excuse for such international program failures. Actually, there is an orderly, systematic manner to tailor reasonable program goals and objectives and to develop the appropriate management organization and structure to meet these goals and objectives. The organization established to accomplish the program management tasks should also assure that effective communications is taking place. Interface/communications management becomes the task of the program manager as requirements are defined.

CONCLUSION

The guide also contains the following appendices:

- o Sections of an MOU,
- o Life Cycle of Major Systems Acquisitions Including NATO Considerations,
- o Rationalization, Standardization, Interoperability (RSI) Plan Outline,
- o Initial Militarily Critical Technologies List,
- o Summary Assessment of Data Sources,
- o Selected References, and
- o Glossary of Abbreviations and Definitions.

Technology & Taxes

(A conceptual sketch of reality)

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Abstract

Technology is placed in the clusters of the industrial base and the clusters are defined. The clusters are blended with different sets of economic condition and the preservation of earning power established as the objective function for any investment. The link between the clusters, the environment and the objective function is established through taxes and the tax impact on depreciation time and replacement value is analyzed. This analysis is used to discuss the decision process for industrial-technological investment. The observations made in the analysis are summarized and suggestions are made on how to respond to reality.

Objectives

The first objective of this paper is to explain how a specific tax structure and PROFIT DEFINITION, can operate as incentive or disincentive toward investment in manufacturing technology. The second objective is to explain why the same tax structure and profit definition produces different impacts on different companies and under different economic conditions

Scope

The scope of this paper is restricted to a few selected RUDIMENTARY CONCEPTS, able to make or to break the potential success of innovations in manufacturing technology. All concepts are presented in a rudely simplified and linearized form; the concepts are not tools for calculation, but models designed to enhance the understanding of reality. Accordingly, only conceptual results are offered and no subjective value judgments are made. The entire presentation is made in a non-mathematical form.

Approach

The paper is subdivided into two parts (with five chapters) and delineated as shown in *fig. 1:*

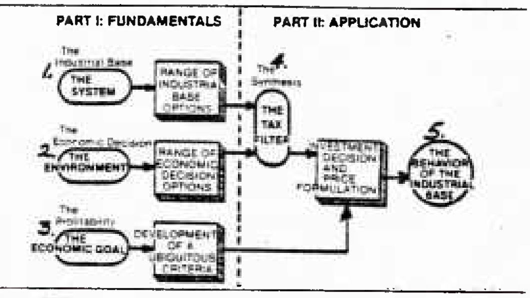


Fig. 1 Approach

PART I deals with the fundamentals and tries to define and describe (1) the system, where the technology of manufacturing is embedded; (2) the environment (in economic terms) which influences the system and, finally, (3) the economic goal which must be the basis for any enterprise.

Chapter 1 explains and defines the Industrial Base and shows that the base is not a uniform homogeneous entity, but a collection of diversified and pluralistic elements with a wide range of behaviour patterns. Each element can be considered in itself stable but different from all other elements.

Chapter 2 describes the permanent changing environment, where each element is in constant flux and where the relationship between the elements is constantly changing. This chapter will explain the conditional value of all business decisions and, in turn, why today's correct decision might well be the wrong one tomorrow.

Chapter 3 searches for a neutral line between profit and loss in order to extract the two concepts (of profit and loss) from our belief system and to shift them into the analytical arena, by developing a ubiquitous criteria for these two concepts.

PART II uses the results of PART I and attempts to develop a synthesis between the system and the environment by channeling both the system's elements and the environment's elements through a tax-filter toward the investment decision and the price formulation. The result of this synthesis will be the determination of the unavoidable investment behaviour of the defense industry.

Chapter 4 is dedicated to an analysis of the U.S. tax concept as it relates to depreciation time and replacement cost for capital investment. The impact of the profit cap (as frequently applied in defense contracts) is related to the return on investment and to the economic goal (Chapter 3).

Chapter 5 finally relates the analyses of Chapter 4 to the managerial decision process regarding investment in technology and the often observed decision behaviour connected to the causes for such behaviour.

The paper closes with a section on General Observations and Suggestions. This section stands for what normally would be called findings and recommendations. However, the paper covers only a small part of a much wider picture and hence the term "recommendations" would be too presumptuous.

ORIENTATION

1. Communication

The trend toward low investment for defense contracts has been widely recognized and some of the causes for this trend have been identified[1]. However, this identification has (to my knowledge) never proceeded beyond editorial statements bare of conceptualization and hence quantification in its entirety. Only a few selected causative aspects have been quantified[2] and some hesitant steps have been made to conceptualize the problem in part[3]. Hence the practitioners of acquisition—in industry and government—have considerable difficulties to communicate with the lawmakers beyond the level of lobbying for the perceived needs of the industry. And as long as this communication gap persists, the industry—and in turn the government contractors—will never get this particular legal environment which is the foundation for a flourishing industry, including a healthy defense industry.

All of us in the acquisition business, in and outside of the government, have failed to do our homework: We have never quantified to the lawmakers just how much the legal disincentives for investment (which, we pronounce, exist) really cost us on the company level or as a nation. We are only complaining that they exist. How then can we engineers and economists expect to be taken seriously by the lawmakers when we are not even able to quantify our complaints?

What sense does it make to feel intimidated by the laws (pertaining to acquisition), laws which we make ourselves through our representatives? But instead of reaching an agreement, we set out to minimize, to bypass and to compensate for the legal disincentives by payment provisions and contract incentives like termination provisions, award fees, shared saving provisions and technology funding. Of course, those actions are better than none, but they are not a cure for the problem of "not investing."

I think it is overdue to stop lobbying and complaining and to break out of the vicious circle to shift the blame around for the predicament of our industry and, more specifically, for the present predicament of the industrial base. So let's forget all our rhetoric, our beliefs and preconceived opinions and let's start with our analysis of facts which exist *today*—without being concerned with how they come into being. Those facts can support, in themselves, a consistent and testable theory or concept[4]. Such analyses could be the start toward the creation of a legal environment which permits and supports the conscious rebuilding of our industrial base, the health of which is in everybody's mind. The tragedy is that we are not held down by physical barriers, but by our mental barriers concerned with existing paradigms borrowed from the past[5]. Maybe Secretary Lehman's closing words of his last address may give us the guts to overcome those barriers. Speaking about the rebuilding of the Navy he said, "It might be our last chance."[6]

Now, I will stop my own rhetoric and introduce you to an analysis which will justify what I said until now. The analysis which I bring forth in this paper is only a sketch, a condensation and a cross-section of a very small part of an analysis which I pursued for years[7]. When I unfold the analysis you will see into an exciting world of "integrated reality" where engineering, economy and law work together and can communicate across disciplinary boundaries. Unfortunately, this reality might not conform to what you *think* the truth is.

2. Legenomy

Not only was I always fascinated with what I called above the "integrated reality," I also was privileged to experience it in my professional life and foremost to teach it[8]. In order to highlight the integrated reality I coined years ago my pet acronym, *legenomy*[9], which implied the inseparable interaction of *leg*al aspects with *en*gineering aspects and aspects of econ*omy*.

We find this inseparability of aspects in all human activities and especially pronounced in all industrial activities: "We are conducting all industrial activities within the framework of the existing law and we are using all appropriate engineering know-how in order to reach an economic (or political) goal—either as a society or as an individuum." Without the law we would have anarchy; without the engineering know-how we could not have our modern industries, and hence our economic goals could not be what they are. It remains only to question if the three aspects of law, engineering and economy have in their intellectual perception progressed simultaneously or if one might have outrun the others, leading to organic incompatibilities, to stress and ultimately to confusion[10]. In order to achieve true success, all three aspects of legenomy must march together in an ever-changing mode and form together the total picture with all their interacting links as sketched in the interface matrix in *fig. 2*.

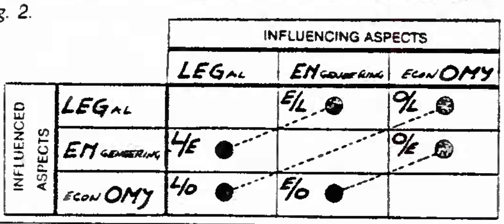


Fig. 2 Legenomy Matrix

The interface matrix is, of course, symmetrical, indicating the double direction of all interfaces and this direction changes back and forth over time, forming the historical path toward this "what-is" today. And with this I will concern myself. More specifically, I will search for an explanation of the behaviour of the defence industry as it appears today in the USA as the result of existing laws, the manufacturing technology used, and the applied economic scales. Let's call this the general goal of this paper.

This general goal, however, is too broad to be pursued with any resemblance to completeness in a short paper. Hence I will select in each of the three categories of aspects (law, engineering and economy) a few specific elements which I consider as representative for each category as shown in *table 1*.

CATEGORY	ELEMENTS
Legal Aspects	—Depreciation Rules —Permissible Profit —Admissible Cost
Engineering Aspects	—Manufacturing Methods —Labor versus Capital Intensiveness
Economic Aspects	—Investment & Investment Criteria —Return on Investment —Replacement Cost & Inflation —Necessary Profit —End Cost

Table I Representative Elements

I consider these selected representative elements as the absolute minimum to be analyzed in order to get at least some coherent picture about the investment behaviour of the American defence industry. In turn, the existing behaviour can be equated to the necessary management decisions as *de facto* made in the industry.

PART I
FUNDAMENTALS

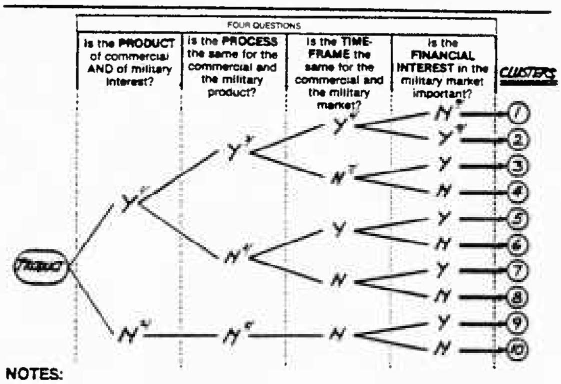
1. THE SYSTEM: The Industrial Base

The industrial base—all shipyards, the supply industry, subcontractors, etc., are all parts of it. Therefore, we can *define* the industrial base as the sum of all industries which provide goods and services to the armed forces[11]. The base, however, is not uniform, but consists of a wide spectrum of many heterogeneous members. On the one side of the spectrum the base might include the company who works for defense only (like some shipyards) and on the other end of the spectrum might be the company who sells one of its shelf items to the government only on occasion.

Although each member of the industrial base is different from all other members, it will still be possible to cluster the participating companies into groups with strong similarities. In turn, it might be possible to deal with all members in a specific cluster in a fairly uniform way. I suggest to subdivide the entire spectrum of the industrial base into ten clusters and describe each cluster with four criteria[12]: (1) the type of product, (2) the process or technology used to make the product, (3) the time frame (or duration) for which this product will remain in production or stay on the market, and (4) the financial interests which a company has in making such a product. Thereafter I ask one question with regard to each criterion to be answered with YES or NO. This leads to a criteria-tree with 16 end branches. However, only 10 of those 16 branches are meaningful. This is demonstrated in *fig. 3*.

With the relatively simple criteria-tree we have a handy tool to describe ten industrial clusters in a non-ambiguous way (of course, the tree can be extended to satisfy any analytical need). For example, Cluster #1 describes a product useful for the military and civilian market, made in the same process for the same duration of time, but the manufacturer has no particular interest in the military market segment. Cluster #10 would be an exclusively military product, made in special facilities according to the life of the military market, but the product is without financial interest to any manufacturer.

The product of Cluster #10 would be a perfect candidate for an arsenal operation—and this might be the only way to get the product in the first place. Products belonging to Cluster #1, on the other hand, will be a typical commercial product and supplied to the market on a strictly competitive basis, irrespective of its origin, i.e., it might be made in and imported from Hong Kong. And this brings us to two other criteria not mentioned yet: There exist military products which *must* be manufactured domestically for security reasons irrespective of costs and possible competitive advantages of foreign sources. Industries catering to this type of product are defined as political industries, while producers of items which can be made domestically or abroad shall be candidates for the common industries which operate on financial principles only.



NOTES:

[1] The product will be of military and commercial interest.

[2] The product will be of military interest only.

[3] The product will be manufactured with the same process for civilian and military customers.

[4] The product goes to the military and the civilian market but two different processes are used because of special quality standards for the two markets.

[5] The military product requires a process not used for commercial markets (i.e., tank turrets).

[6] The life of both markets has the same length (i.e., 3 years in production).

[7] The market time for both productions will be different (i.e., the commercial product will change after two years, however the military usage will extend over ten years.

[8] The manufacturer has *no* financial interest in the military market.

[9] The manufacturer has financial interests in the commercial *and* the military market.

Fig. 3 Criteria Tree

A strong relationship can be established between military industries (Cluster #10) and political industries. An equally strong relationship can be established between commercial industries (Cluster #1) and common industries[13]. This permits us to limit the *range* of the industrial base with four non-ambiguous borderlines as shown in *fig. 4a*: (1) the commercial industries, (2) the military industries, (3) the common industries and (4) the political industries. In this entire field, only the points *A* and *B*, approximating Cluster #10 and Cluster #1 are non-ambiguous. All other points inside the range (represented by Clusters #2 through #9) are *mixed* industries with increasing density toward point *B* and decreasing toward point *A* as shown in the cluster diagram in *fig. 4b*. An analysis indicates[14] a normal distribution between point *A* and point *B*, representing the industries' inclination to invest as a function of their location within the range: Industries of a clearly commercial/common type *might* have the inclination to invest, but industries of a clearly military/political type *will* not have any inclination to invest. The inclination to invest is shown in *fig. 4c*, indicating an increase in inclination to invest in the direction of *B* and a decreasing inclination to invest toward point *A*.

I have underscored the "might invest" in order to indicate that the placement of a particular cluster (or individual industry) is only a necessary condition toward investment, but not in itself a sufficient condition. Whether this "might" will be transformed into a "will invest" depends upon the environment and other conditions to be sketched in the next chapters.

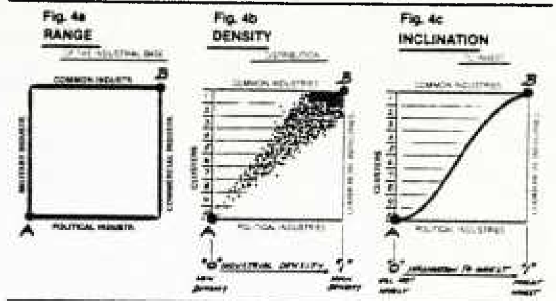


Fig. 4 Spectrum of the Industrial Base

2. THE ENVIRONMENT: Economic Determinants

No question: technology can reduce labor cost and will increase labor productivity. This is a simple truth, but not a sufficient argument for an investor to spend money on technological improvements. Even assuming that a healthy market exists—the *sine qua* non for any industrial investment—the following environmental factors will enter (next to many other factors) into any investment decision: (1) the Availability of Labor (AL), (2) the Cost of Labor (CL), (3) the Cost of Capital (CC), and (4) the Competitive Return on Investment (CRI).

None of these four factors are a constant; each will change in time and at different times, and so will the ratios between the factors. Hence today's correct decision might be—with changed values of the factors—the wrong decision tomorrow. I will explain this in *tables II, III* and *IV*. In *table II*, I combine the availability of labor with the cost of labor; in *table III*, I combine the cost of labor with the cost of capital, and finally in *table IV*, I combine the cost of capital with the competitive return on investment. For each factor-set I use four combinations: (1) high-high, (2) high-low, (3) low-high and (4) low-low. With this I cover the entire trade-off spectrum (for investment in technology) on a one-to-one basis for the key combinations in *tables II, III* and *IV*. The key combinations will permit one to formulate the logic for all other possible combinations, including multiple factor combinations, as shown in the determinator-tree in *fig. 5*. In reality, all factors are mutually related; this makes the problem of investment complex, despite that each factor in itself is simple. (Complexity in this context is defined as the existence of multiple, often divergent, objectives.)

#	(AL)	(CL)	*Investment Consequences*
1	high	high	Neutral. Investment decision will depend upon views toward the future[1].
2	high	low	Clear *disincentive* for investment[2].
3	low	high	Clear *incentive* to invest in technology[3].
4	low	low	Neutral to investment[4].

[1] This is essentially an unnatural condition. High labor availability and high labor cost at the same time occur only because of institutional barriers against an adjustment between supply and demand.

[2] No one will invest if labor is plenty and labor cost low—as long as the job can be done.

[3] This is the ideal condition for investment.

[4] This situation is as unnatural as the high/high combination above. However, such condition might be a mobilization scenario—making investment in technology mandatory because of labor shortage—but not for economic reasons.

Table II Availability of Labor (AL) and Cost of Labor (CL)

Before I go to the next table, I have to explain the term of Competitive Return on Investment (CRI). In the context of the present notes I *define* (CRI) as the after-tax return on investment, whereby the investment is not made in manufacturing, but in other more profitable and less risky investment opportunities—for example, in money markets or in condominiums.

#	(CL)	(CC)	*Investment Consequence*
1	high	high	Neutral to investment[1]
2	high	low	*Highest* possible investment *incentive*
3	low	high	Absolute *disincentive* for investment[2]
4	low	low	Neutral to investment[1].

[1] If both, (CL) and (CC) are high or both are low, the investment decision is driven by many considerations.

[2] Investment will be kept to the absolute minimum as necessary to execute the manufacturing job

Table III Cost of Labor (CL) and Cost of Capital (CC)

#	(CC)	(CRI)	*Investment Consequence*
1	high	high	No investment in production[1].
2	high	low	No investment anywhere[2]
3	low	high	Marginal investment incentive[3].
4	low	low	High incentive to invest in production[4]

[1] High (CC) and high (CRI) go for institutional reasons hand in hand. Since the (CRI) has normally less risk than production (or investment in manufacturing technology), the investment moves to nonproduction-oriented endeavors.

[2] This situation is purely hypothetical.

[3] Not much more realistic than case 2 before.

[4] The ideal condition for investment in production technology.

Table IV Cost of Capital (CC) and Competitive Return on Investment (CRI)

If we inspect *tables II, III* and *IV*, we will notice that only one simple, clear and non-ambiguous set of conditions exists which will provide an incentive – within the market opportuniry – to invest in manufacturing technology. This set contains (1) a low availability of labor, (2) a high cost of labor, (3) low capital cost and (4) lack of other more attractive investment opportunities. Only and *only if* those four conditions – plus a market – exist, will investors invest "without reservation" in manufacturing, and hence productivity will increase appropriately. Next to this ideal set (1) of conditions, nine other valid sets can be determined as shown in *fig. 5:*

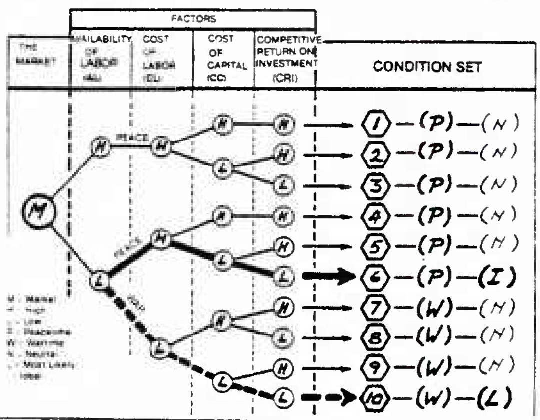


Fig. 5 Condition Tree

From the total of 10 sets of economic conditions, two groups evolve: the first six sets valid for peacetime conditions (P), and one of these sets as the ideal set (I); the second four sets valid for wartime conditions (W) with one most likely set (L). This means that only sets #6 and #10 are reflecting clear and non-ambiguous conditions for investment in technology, while the remaining eight sets are either neutral (N) to investment or of such nature that investment decisions will be made outside the identified set. I prefer to call those eight sets "undetermined."

It is important to note that the condition for investment can clearly be separated in peacetime and wartime conditions; in both cases, however, the question must be raised about the possibility of shifting the undetermined cases into a positive position for investment. We will find that an appropriate tax structure has this shifting power – with the result that a wide range of condition sets might be able to produce a "profit" – the only motivator for private industry investment.

3. THE ECONOMIC GOAL: Profit

Profit is the flywheel of a free economy and of the capitalist system. Profit equates to growth. Hence one could assume that in a free society everyone appreciates profit and, of course, everybody knows exactly what profit is and how to define it. Unfortunately, these assumptions are wrong: Any discussion of profit brings out a plethora of contradictory and uncoordinated feels – from admiration to condemnation. We are still replaying all philosophical and moralising disputes from Aristotles' time and presumably even before him[15] up to modernity[16]. With regard to a definition of profit, we are faced with a surprise: We have no defiinition – at least no ubiquitous analytical definition of profit. Nevertheless, our army of tax accountants calculates with great precision our profits according to the legislative definition of the day. And this is it – where the trouble starts – because in today's environment, where rapid inflation makes a mockery of conventional accounting, where for more than a century companies have calculated their profits and losses on the basis of historical cost[17]. Contemporary attempts to search for a guaranteed purchasing power[18] by indexing depreciation, shifting to a system based on the replacement cost, immediate expensing[19] and full current cost accounting, are all in essence a search to define profit in a way acceptable to business and, in particular, to industry, as well as to investors in general.

Profit is an extremely elusive concept which may well defy a universal definition altogether. Using an analogy from *General Systems Theory*[20], zero-profit (or zero-loss) might be the borderline between the entropy of the system and the metabolism of the environment[21]. With this analogy we by-passing the definition of profit and shift the search for the definition toward the search for a condition, which guarantees an economic *status quo* in perpetuation. I associate this *status quo* condition, or condition of economic stability, with the PRESERVATION OF EARNING POWER[22] and I stipulate any economic operation which guarantees this earning power as free of loss and profit; any operation which results in an increase of earning power shall be associated with profit and any operation which reduces the earning power shall be associated with a loss.

The concept of the PRESERVATION OF EARNING POWER is an extreme abstraction which cuts across all problems related to a specific *numéraire* of a currency, to problems of inflation and depreciation. The concept can embrace all previously mentioned attempts at incentive taxes and may even open the door for the conjecture of the existence of a biological foundation of economy[23] as we have discovered the biological foundations for many other human behaviours[24] and even for the human value systems[25]. From a practical point of view, the concept of the PRESERVATION OF EARNING POWER can consolidate the needs of investment in production, in services and in rent with depleting values of the source of earning power. With this, even the need for an ideological context (of profit) can be eliminated and the discussion be shifted into the politically neutral analytical arena.

Two examples might illustrate the concept of PRESERVATION OF EARNING POWER. First, a most homely example of a truck-owner-operator and second, an example of ocean transportation[26].

Example #1: Let's assume a trucker buys at time zero a 20-ton truck for cash and the truck will have a lifetime of three years. Now, he starts to operate his truck industriously and intelligently and also saves money in order to replace his truck with a new one after three years. If he is then able to replace it with a new one (and only by using his own savings), then we may say that he was able to preserve his earning power. However, if he is only able to buy a 10-ton truck with his own savings after three years, then he lost half of his earning power. Whether this loss has occurred because of inflation, because of tax laws which prevent accumulation of sufficient means for full replacement, or because of competitive pressure (which prevents billing his clients for his cost "in full") is irrelevant. On a variation of this example, let us assume that our honourable trucker decides after one year to give up the trucking business and he sells his truck. If at this time the resale value of his truck plus the saved money *would* enable him to again buy a 20-ton truck, we may again say that he preserved his earning power. If he *could*, however, buy only an 18-ton truck, he lost 10% of his earning power. Again the reasons for his loss are irrelevant.

Example #2: This historical example compares the new building cost index for a commercial ship over a 15-year period with the resale value index for the same ship purchased in 1945, shortly after the end of World War II. This is shown in *fig. 6:*

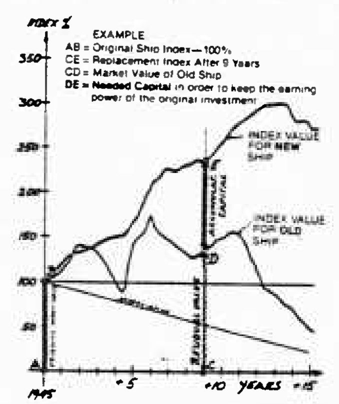


Fig. 6 Ship Index 1945-60

The two examples enable us to phrase the rules for the preservation of earning power in the following way: "The earning power of any tool, representing such earning power can only be preserved if, at any time in the life of such a tool, the disposal amount thereof, plus the accumulated capital, permits the replacement of the tool of earning in full." If this rule cannot be met, a loss of earning power occurs—and only if the original earning power can be increased in these transactions, does a profit occur.

In turn, this rule permits us to define valid competition as this competitive condition which permits a price formulation according to the rules of the PRESERVATION OF EARNING POWER. Competition, or pressure of competition, which does not permit achievement of this rule is "invalid competition," and must lead to the destruction of the involved industry[27]. Large parts of our national industrial base and, last but not least, the shipyards, are a perfect example of self-destruction through invalid competition—with the later explained result, why those industries cannot and do not invest in technology beyond the absolute necessary minimum.

PART II
APPLICATION

4. THE SYNTHESIS: The Tax-Filter

Let us start the synthesis with a summary of what we have determined in the first three chapters: *first,* we determined that the industrial base is composed of ten different clusters, where each cluster has its distinct characteristic. Only one one of the clusters (namely the common/commercial Cluster #1) has a definite inclination for probable investment in technology, and only one cluster (the military/political Cluster #10) has a definite resistance or disinclination for investment. *Second,* we determined that only one single set of environmental conditions exist, which favours investment in peacetime and one in wartime, while five, respectively three sets are neutral to investment in peace or war. *Third,* we have determined that the preservation of earning power is the unalterable goal of any economic operation and profit is associated with income beyond the need for stability.

In the search for a synthesis of the first two chapters, we can combine the criteria-tree (*fig. 3*) with the condition-tree (*fig. 5*) and determine thereafter the profit potential of one hundred end-branches. This profit potential (or profit) provides us with the inputs for the investment decision through the feedback loop into the "process." If we recognize now that the "profit" is surrounded by taxes, then we may state that the after-tax profit will determine the *de facto* investment. The combinations and the feedback loop are shown in *fig. 7.*

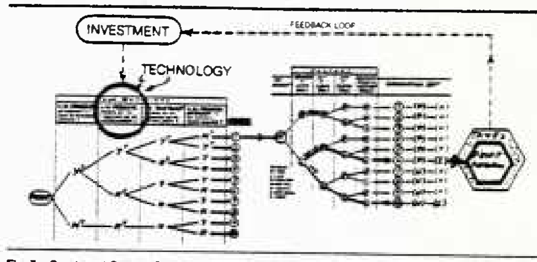


Fig. 7 Combined Criteria/Condition Tree

For a quantitative analysis the schematic of fig. 7 can be computerized as sketched in the block diagram in *fig. 8.* The schematic describes an iterative search process with a feedback loop into the market based upon an increased productivity; the schematic also shows the options to accommodate changed environment conditions and changes in the tax law.

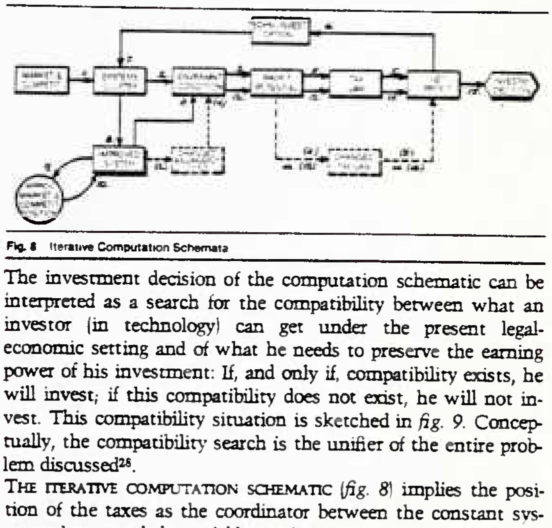


Fig. 8 Iterative Computation Schemata

The investment decision of the computation schematic can be interpreted as a search for the compatibility between what an investor (in technology) can get under the present legal-economic setting and of what he needs to preserve the earning power of his investment: If, and only if, compatibility exists, he will invest; if this compatibility does not exist, he will not invest. This compatibility situation is sketched in *fig. 9.* Conceptually, the compatibility search is the unifier of the entire problem discussed[28].

THE ITERATIVE COMPUTATION SCHEMATIC (*fig. 8*) implies the position of the taxes as the coordinator between the constant systems cluster and the variable conditions of the environment. In this position, taxes are able to transform a neutral investment condition into a favourable one, or they can destroy all hope for investment even though inclination for investment might exist. Taxes can rescue a bad situation and can kill a good one. *De facto* taxes are cutting through all ideological rhetoric and dogmatic smokescreens and reveal the true thinking and attitudes of a nation toward business[29] like the driving habits reveal the

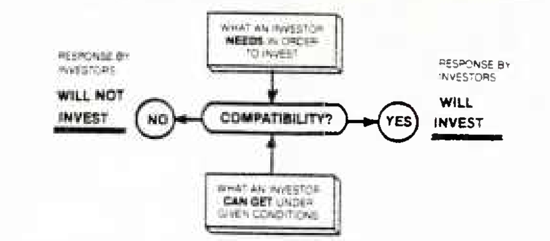


Fig. 9 Compatibility for Investment

true character of a man. Taxes reveal a nation's priorities, ideosyncrasies, aspirations, beliefs and superstitions in a most brutal way[30], especially if portrayed in a comparative way for selected and highly specialised tax aspects[31]. Hence, it seems to be justified to consider taxes as the centerpiece in any investment decision searching for growth and, in our particular case, increase in industrial productivity. In short, taxes *are* the synthesis of the problem as sketched in *fig. 10*.

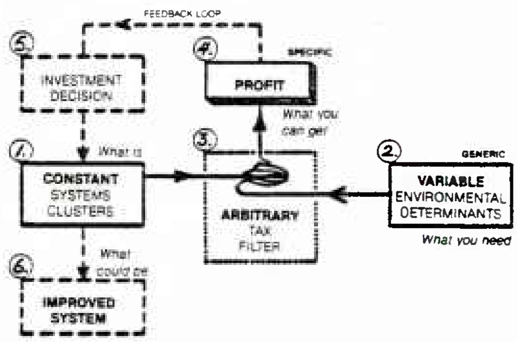


Fig. 10 Synthesis of Problem

The complexity of the investment decision is underscored by the unique combination of (a) a stable system, (b) a *variable* economic set, and (c) an *arbitrary* tax filter, which synthesises the problem (*fig. 10*). The encouraging aspects in this synthesis is the arbitrariness of the tax filter, because whatever is set up arbitrarily can also be changed if necessary. With arbitrariness I do not imply that the existing tax filter has been constructed by happenstance but rather by applying uniformly a specific tax philosophy uniformly to a non-uniform industrial world, whereby non-uniform means "being not the same in *all* aspects."

In order to illustrate the non-uniformity with regard to the tax impact between the civilian and military worlds, I have selected first the problems of depreciation time and second the problem of replacement cost for discussion. Both problems will be sketched in their conceptual forms, but otherwise simplified and linearised.

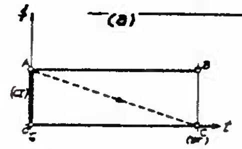
Depreciation Time

The depreciation time is determined in the United States uniformly for all economic activities by the tax laws for a few categories of facility investment. Presently we recognise three categories of facility investment while already over 50 years ago studies on less sophisticated technologies (than today) have identified over sixty prevailing replacement patterns and therefore depreciation needs in the industry[32].

The state purpose of depreciation is to recuperate tax-free the invested capital (IC) in the depreciation time (DT). The non-stated assumption (in departure from reality) behind this tax rule is first that the investment in equipment has a useful life (UL) which is exactly as long as the depreciation time (DT) and second, that said investment has at any time during its lifetime (LT) a market value (MV) equal to the remaining non-depreciated amount (ND). This assumption is commonly used as basis for commercial investments and might be valid for companies belonging to Cluster #1 – the commercial/common industries. However, neither of these two (never clearly stated assumptions) holds through in defence acquisition, where quite frequently first the contract time (CT) is shorter than the depreciation time (DT) and second, where uncertainties in the contract history might not permit utilisation of equipment for its entire useful life (UL) and where said investment has no market value (MV) whatsoever.

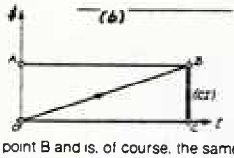
The differences between investment in commercial and military products lie in "assigned investment" and not in "dedicated investment" like jigs and fixtures made and purchased in pursuance of a specific contract where cost allocation for a single contract is permitted in full. Assigned investment is defined as an investment (i.e., in manufacturing technology) which enhances productivity in a plant or a shipyard beyond the duration of a specific government contract, made (or initiated, or encouraged) only in the context of a specific government contract, and which would not have been made without the existence of such contract at hand. Assigned investment might be triggered by a specific government contract, but is in itself the crucial contributor to industrial improvement and, therefore, the problem of assigned investment needs discussion. The problem is imbedded in the following five assumptions: *first*, a company invests capital (IC) in manufacturing technology in order to increase the productivity for a specific contract in the hope of increasing its competitive position; *second*, the new equipment is assigned investment or invested capital (IC) of such nature that the equipment cost *cannot* be allocated in full to a specific contract – only the normal depreciation costs are allowable costs; *third*, the contract time (CT) is shorter than the depreciation time (DT); *fourth*, the investment (IC) has no market value at the end of the contract time (IC) or at any time before, meaning it cannot be sold to somebody else like a used car, and *fifth*, absolute uncertainty exists about the possibility of a follow-up contract which would enable the utilisation of the investment (IC) for the entire depreciation time (DT).

The five assumptions can be connected through a set of often overlapping events (observations, actions, reactions, etc.) as sketched in their rudimentary forms in the picture series of *fig. 11*. The picture series starts with the elementary explanation of depreciation time[33] and ends up with the newly developed term of SIMULATED INVESTMENT (SI)[34] and, more specifically, with the simulated investment needed to cover the penalties resulting from a contract time (CT) being shorter than the depreciation time (DT) in a given defence contract. The simulated investment (SI) is *defined* as (or describes) this particular imaginary investment level toward a company having to accumulate capital in the contract time (CT) in order to carry all penalties resulting from the time differences as described above without losing the earning power of its investment.

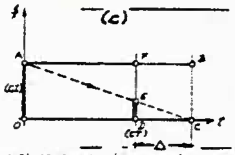


The entire problem plays in the coordinates formed by the Time-Axis (*t*) and the Cost-Axis (*$*). At the time T_0 (*point 0*) an assigned investment (see text for definition) or, generally speaking, a capital investment (*CI*) is made. The amount of this investment goes from point 0 to point A. The value of this investment is depreciated along the arrowed broken line from point A to point C at the end of the depreciation time (*DT*) at point C. There the investment is finally depreciated to zero. (Linear depreciation is used and the scrap value at the end of the depreciation time is neglected.)

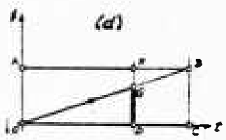
(Part 1 of 2, continued)



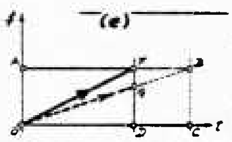
At the same time, when depreciation takes place (*fig. 11a*), capital can be accumulated tax-free from point 0 toward point B along the arrowed full line and at the end of the depreciation time (*DT*), the entire capital (*CI*) is recuperated. The amount of the recuperated capital goes from point C to point B and is, of course, the same as the amount between point 0 and point A.



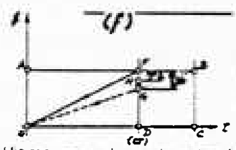
In this figure we introduce the contract time (*CT*). The contract time stretches from point 0 to point D, while the depreciation time stretches from point 0 to point C. The figure shows a contract time (*CT*) shorter than the depreciation time (*DT*) by the amount *D*. For the investor of assigned investment, the picture is only of interest from the time T_0 at point 0 to the contract time (*CT*) at point D; the part of the picture right of the line from point D to point F goes into oblivion. We notice that at the time (*CT*), the capital investment between point D and point E is not yet depreciated. Of course, the depreciation goes along the arrowed broken line from point A to point E and the continuation of this line to point C is no longer of interest.



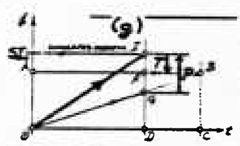
The investor not only loses interest in the depreciation beyond the contract time (*CT*), he loses interest also on the imagined capital recovery after this time. But he notices that at the time (*CT*) he has only recuperated capital in the amount from point D to point G along the arrowed full line from point 0 to point G.



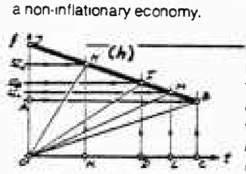
Since the investor expects no contracts with any reasonable certainty beyond the contract time (*CT*), he should have recuperated his investment (*CI*) in full in the contract time (*CT*) along the arrowed broken line from point 0 to point F (or along the arrowed dotted line from point 0 to point G, as permitted by today's laws). The true capital recovery toward point F must be the investor's goal (in an ideal environment without inflation).



If the investor decides to accumulate capital toward point F in the contract time (*CT*) in the hope of recuperating his investment, he is in for a surprise: The tax law declares the amount from point G to point F as "profit (*P*)" on which he has to pay taxes (*T*), providing him with a recuperated capital at point H. His recuperated capital reaches from point D to point H and he still has not recuperated the capital between point H and point F.



The investor will find that he has to accumulate capital in the contract time (*CT*) toward a tax-determined point I along the arrowed heavy line from point 0 to point I in order to recuperate his investment (*CI*) in full. If he accumulates capital toward point I, the amount between point G and point I will be declared as profit (*P*). From this "profit" he can now pay his taxes (*T*) and ends up at point F with fully recuperated investment, reaching from point D to point F and the amount from point F to point I are *taxes on unused investment* because of the time difference between the depreciation time (*DT*) and the contract time (*CT*). Point I determines for the contract time (*CT*) the time-dependent *simulated investment*—SIT toward which the investor has to accumulate capital in order to preserve the earning power of his investment in a non-inflationary economy.



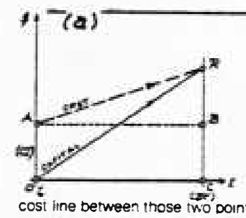
Now we can put a straight line (in our linearized model) through point I and point B. This line crosses the vertical $-axes of our coordinate system in point J and the line from point J to point B is the geometrical *location for all simulated time-dependent investments* between a contract time (*CT*) of zero and a contract time (*CT*) which equals the depreciation time (*DT*). For example, for the contract time (*CT*), equal to point L or point K on the time-axis (*t*), a simulated investment of SIT will result in point N and point M respectively.

Fig. 11 Depreciation—Simulated Investment

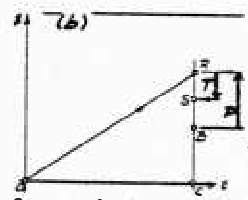
Replacement Cost

Having made an investment and thereafter recuperating and accumulating capital toward the replacement cost of the investment is the monetary behaviour which coincides with the concept of the preservation of earning power. One of the most debated questions in accounting in the United States today is the tax-free capital accumulation toward the original investment or toward the replacement cost of such investment. However, since no decision is made, we have to concern ourselves with the present rule which determines that the difference between replacement cost and original investment must be covered out of profit. It should be noted that our foreign competitors can accumulate capital tax-free toward the replacement cost[35] which points toward the fact that, for example, the European tax philosophy, based on cost theory[36], defines profit quite differently than the American philosophy, which is based on price theory.

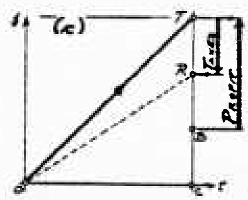
The American view toward replacement cost is outlined in the picture series of *fig. 12* and, as before in the discussion on depreciation time, we end up with the determination of a SIMULATED INVESTMENT FOR REPLACEMENT—SI_R.



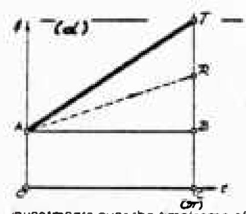
At the time T_0 (*point 0*), an investment (*CI*) is made in the amount between point 0 and point A on the cost-axes ($) and after the depreciation time (*DT*) plotted on the time-axis (*t*); the replacement cost has increased to the amount between point C and point R. This means that the cost is increasing from point A to point R (if linearity of the increase is assumed) and as shown with the arrowed cost line between those two points. This, of course, means that the capital needed to replace the original investment should be accumulated along the arrowed capital line from point 0 toward point R and not toward point B, which corresponds with point A.



As before in the discussion of the depreciation time (*fig. 11f*), a capital accumulation toward the replacement value point R will not work for the investor because the amount between point B and point R will be declared as profit (*P*) from which the tax (*T*) must be paid, so that the investor arrives at point S, representing the accumulated after-tax capital between point C and point S. This means he is still short of the amount between point R and point S.

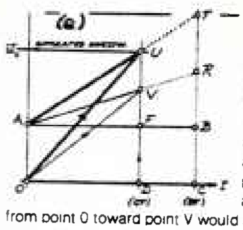


If the investor really wants to accumulate capital, he must select a tax-dependent point T toward which he accumulates capital and point T must be high enough above point R so that he can pay the taxes (*T*) on his profit (*P*) and still end up at point R, the replacement cost for his original investment. This means he has to pay *taxes on inflation*, because the increase in replacement cost from point B to point R is a function of inflation; everything else, like replacement quality, is considered as equal to the departure condition at the time (T_0) at point 0.



Having determined point T, representing the necessary accumulated capital in order to arrive at a net accumulation for the replacement cost at point R, we can now connect point T and point A with a straight line (because we are using linearized assumptions), and the line from point A to point T represents the geometrical *location for all simulated inflation-dependent investments* over the timeframe of the depreciation time (*DT*), represented by the distance between point 0 and point C.

(Part 1 of 2, continued)

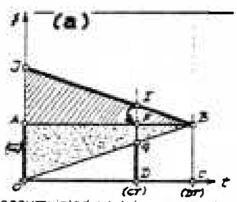


If we now introduce the contract time *(CT)* at point D, then we are in a position to determine the necessary simulated investment for the contract time *(CT)* at the level SIR. We are also able to determine the necessary capital accumulation along the arrowed heavy line from point 0 toward point U. Without tax on inflation, a capital accumulation along the arrowed broken line from point 0 toward point V would suffice.

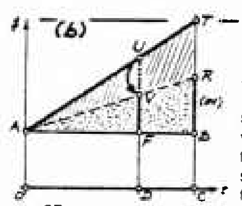
Fig. 12 Replacement—Simulated Investment

Depreciation Time and Replacement Cost

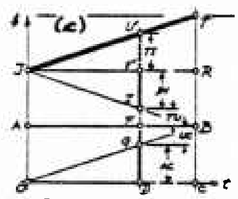
Having determined the simulated investment for the depreciation time *(fig. 11)* and for the replacement cost *(fig. 12)* we can now combine both considerations into a single behaviour pattern as shown in the picture series of *fig. 13*.



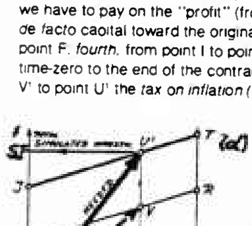
SIMULATED INVESTMENT TIME
This figure repeats the result of *fig. 11* and shows the line for the simulated investment from point B over point I to point J. In the contract time *(CT)* at point D we have accumulated tax-free the capital between point D to point G, we have paid taxes for non-utilisation, indicated by the distance from point F to point I; we have accumulated a total capital in the amount of the distance from point D to point I, paid tax on the "profit" from point G to point I and ended up with the capital at hand from point D to point F. *Result:* We have recuperated the investment *(CI)* in the contract time *(CT)* in full.



SIMULATED INVESTMENT—INFLATION
In the same way as we have shown the simulated investment for the timelag in *fig. 13a* above, we are showing here the simulated investment necessary to cope with inflation or to accumulate capital toward the replacement value. The simulated investment follows on the line from point A to point T and at the contract time *(CT)* at point D the total inflation amounts to the distance from point F to point V; however, to achieve the capital accumulation toward point V, capital must be accumulated toward point U in order to pay the tax (on "profit") in the amount of the distance from point V to point U.



TOTAL SIMULATED INVESTMENT
In order to combine the simulated investment for time and inflation, we put the triangle A-B-T from *fig. 13b* on top of the triangle O-B-J of *fig. 13a* and get the geometric *location for the total simulated investment* and the present figure shows the segments of the total simulated investment for the contract time *(CT)* at point D. The segments are: *first*, from point D to point G, *the tax-free accumulated capital (AC)*; second, from point G to point F, the capital which cannot be recuperated in the contract time *(CT)* or the *unused capital (UC)* of the investment *(CI)*; *third*, from point F to point I the *tax on unused capital (TU)* we have to pay on the "profit" (from point G to point I) in order to recuperate *de facto* capital toward the original investment *(CI)* at the contract time *(CT)* at point F, *fourth*, from point I to point V', the *inflation (IN)* which occurs from time-zero to the end of the contract time *(CT)* at point D, and *fifth*, from point V' to point U' the *tax on inflation (TI)* we have to pay in order to cover inflation.



CAPITAL ACCUMULATION
The three capital accumulations an investor has to consider are summarised in this figure: *first*, he has the tax-free *allowable capital accumulation* (or capital recovery for his investment) along the arrowed dotted line from point 0 to point G, *second*, he has the *necessary capital accumulation* along the arrowed broken line from point 0 to point V which represents his need to preserve the earning power of his investment, and *third*, he has the *needed capital accumulation* in order to achieve the necessary capital accumulation after paying taxes on his *de facto* costs which are presently declared as profit.

Fig. 13 Total Simulated Investment

5. THE MANAGEMENT DECISION: The Investment

The industry's sensitivity toward taxes and foremost toward the DEFINITION OF PROFIT is not always the same. In a time of explosive growth, of low interest rates and no disturbing inflation, no one will really care how profit is defined, especially if the market permits a large and comfortable profit margin. However, in times of market stabilisation without potential growth, in a time of high interest and rapid inflation, the sensitivity toward taxes will increase—especially concerning the definition of profit. When, in addition, the profit potential is minimised either through fierce competition or to an institutionalised profit cap[37], then the definition of profit becomes critical. And in such critical circumstances the first question an investor (or manufacturer) has to answer is how to produce—labor intensive or capital intensive? And the second (directly related) question will be how the decision on production methods influences the future value of the investment. The answer to both questions will determine the investment decision and we will address both questions in sequence.

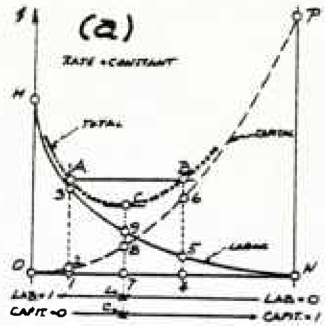
Production Decision

In the commercial industry an investment in facilities for manufacturing is made upon two fundamental market forecasts: first upon the forecast of the production rate and second on the length of the production run. The risk of the investment is, of course, directly related to the quality of the forecast and the actual acceptance of the product by the market[38]. This "market risk" is reduced for major military acquisitions down to the timeframe of a specific contract and hence, the production rate (and often the production run) can be considered as a requirement. In turn, those requirements can be satisfied with many combinations of labor and capital allocation to the manufacturing process[39] as shown in *fig. 14*. Here, the conceptual presentation of the allocation problem is compared with (and translated into) the classical economic form of presentation[40].

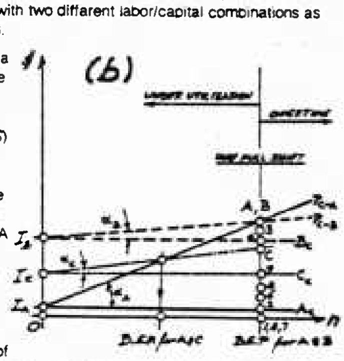
Profit Cap

The cause for a profit limitation really does not matter (by law or under competitive pressure). Therefore we call any profit limitation superimposed to the manufacturer or contractor a profit cap. Now remember that in government contracts profit is defined as a percentage of all costs and the costs have two components: first the fixed cost for capital and second the variable or proportional cost for labot and material. For the present discussion we ignore material and assume that it might either be government-furnished or included in labor. This permits us to sketch the profit cap as shown in *fig. 15*.

Now let's return to the total simulated investment *(fig. 13)* and recall (from *fig. 13d*) that the profit plus the allowable capital recovery in the contract time must equate to the simulated investment. Hence, only this *de facto* capital investment (IC) can be justified, which satisfies this equation and, in turn, the justifiable labor elevation will follow by necessity. To calculate this process is an involved iterative search, working at the same time with many interdependent variables, with the high chance that only an approximate solution exists. This, however, shall not be presently explained further; instead I will try to explain the process in a sketch in *fig. 16*. I hope this will suffice for the "understanding" of the concept. Also, please do not be disturbed that I start the explanation with price instead of cost.

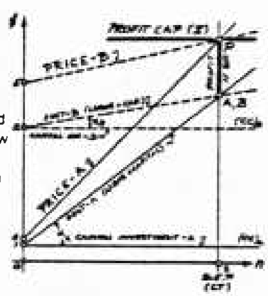


A given constant production rate can be achieved with a continuous changing combination of labor-*effort* and tooling- or capital-*effort*. Accordingly, the labor cost will follow a Lorenz curve from point M over point 3 and point 5 to point N, while the tooling cost will follow a Lorenz curve from point 0 over points 2, 8 and 6 to point P. The combination of both Lorenz curves will result in a total cost curve starting with point M and going through points A, C and B toward point P. The important considerations are: (1) only one optimum exists, point C with minimum cost for a given production rate; (2) outside of the optimum, most cost levels can be achieved with two different labor/capital combinations as shown by point A and point B.



While the behaviour in *fig. 14a* has been portrayed in a close space, the present sketch uses an open space formed by the coordinates for cost ($) and the production quantity (*N*) and points A, B and C of *fig. 14a* now appear all on the break-even line with C at the lowest possible location and A and B in the same location. The important considerations are: (1) the optimal solution from *fig. 14a* is only valid for one single production rate—and *not* for a multiple of it as expressed by the N-axis, and (2) the identity of A and B is only related to the break-even point.

Fig. 14 Labor and Capital Allocation

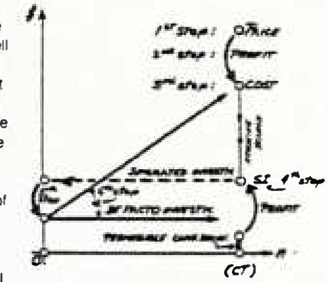


We are carrying forward the two systems from *fig. 14b* and assume that both systems at the break-even point (*BEP*), point 3, result in the same cost, points A and B. We further assume that the break-even point, expressed in number of units (*N*) produced is reached at the end of the contract time (*CT*). Now we put a profit cap on top of the cost and arrive at the same price (*P*) for both systems A and B. With system A we have a low capital investment and a steep labor elevation—a_A and for system B a high capital investment and a flat labor elevation—a_B.

Fig. 15 Profit Cap

Present and Future

The decision process sketched in *fig. 16* covers only the present situation, where "present" shall be defined as the association with one definite contract at hand. Unfortunately, the decision which is correct for the "present" does not have to be correct for the "future," meaning for any timeframe going beyond the presently known contract time, and a good decision for today, may well be a bad decision for tomorrow. In order to explore this, let's make the possible (but unlikely) assumption that at "present" the same price and the same cost can be aligned with three different production methods: Method #1 would employ only the absolute minimum amount of capital investment and a maximum labor elevation; Method #2 would employ a fair capital investment and a moderate labor elevation, and Method #3 would employ a fully automated operation without any labor allocation. Of course, we assume for all three methods a predetermined profit cap on top of capital cost plus labor cost. The assumed three methods and the implications are sketched in *fig. 17*.

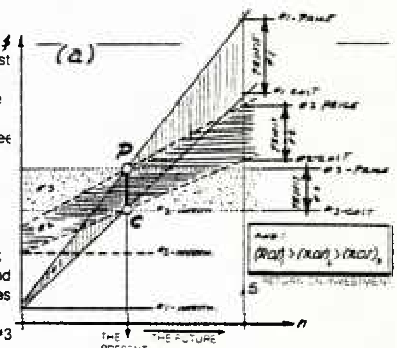


It is a valid assumption that a contractor searches first for the price where he thinks he can sell a specific product to the government. Therefore, we start the explanation with setting the price (*P*) as the first step. For the second step we deduct from the price the allowable or possible "profit" which leads us to the third step to the determination of the cost (*C*), which the manufacturer must achieve in order to be, within the (competitive) price, a successful bidder. Now, as the fourth step, he determines the simulated investment which he can accommodate with the recuperated capital (*CR*) plus the profit (*P*). For the fifth step, he searches for this *de facto* investment which he can make within the umbrella of the simulated investment. Having decided this, the necessary labor elevation, a, follows as the sixth step.

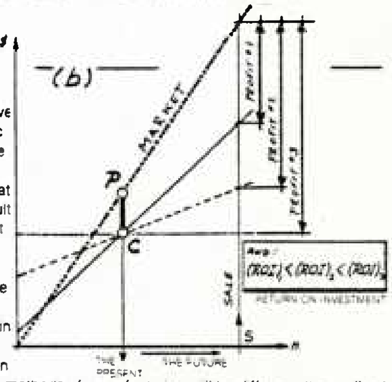
Fig. 16 The Investment Decision—"Present"

Decision Trends

Although I worked (in *fig. 17*) only with the most fundamental economic tools, the decision trend for military acquisition and for commercial acquisition should be clear.



MILITARY ACQUISITION
Between the three cost lines #1-C, #2-C, and #3-C (representing the three manufacturing methods), and the three price lines #1-P, #2-P and #3-P, *three profit bands* are formed: for Method #1 the band with vertical lines between two full lines; for Method #2 the band with the horizontal lines between two broken lines and for Method #3 between the two dotted lines and the dotted band. Notice that band #1 opens up considerably by moving into the future; band #2 opens up moderately by moving into the future and band #3 stays constant at the present end in the future.



COMMERCIAL ACQUISITION
In commercial acquisition no legal profit cap exists and we can assume a specific market will acquire the products. Again as before, we assume that all three methods result in the same cost (*C*) at the present, but that the market at present permits the same price (*P*) as in the case for military acquisition. If in the future a sale (*S*) can be generated, then the profit for the three methods of manufacturing will be different: the profit #1 for Method #1 will be the smallest and the profit #3 for Method #3 the largest.

Fig. 17 Two Systems—Present & Future

• *The investor for military acquisition*, presumably belonging to an industry in or close to Cluster #10 (the military/political industry) has no choice then to search for the ABSOLUTE MINIMUM INVESTMENT he can get by with. He has no other choice than to select the MOST LABOR-INTENSIVE operation he can afford and still be competitive against competitors who are all in the same predicament as he is.

• *The investor for commercial acquisition*, presumably belonging to an industry in or close to Cluster #1 (the commercial/common industry) will mostly search for the MAXIMUM INVESTMENT he can afford and for the MOST CAPITAL-INTENSIVE operation which he can blend with his risk assessment of the future in order to increase his profit potential.

It is important to note that each decision process is based on two time references: first on the present "as is" and second about the investor's view of the future. The present time includes the belonging to a specific industrial cluster (Chapter 1), the existing environment conditions (Chapter 2) and the tax structure for investment (Chapter 4). The future time includes in the defence industry the expected contracts as the market surrogate, expected contract forms, change in the environmental conditions, possible competition and many other elements. Common to all those future elements, however, is the uncertainty which translates into risk and its corollary, the profit which must be measured against the baseline as established by the requirements for the preservation of earning power (Chapter 3).

Taking the "present" and the "future" simultaneously into account makes the decision process complex because of the existence of many opposing forces and because of many subtleties, neither calculable with standard methods[41], nor otherwise, because the probability of the future is undeterminable[42] and does not behave like the probabilities used in mechanistic problems in classical decision theory[43].

GENERAL OBSERVATIONS: Suggestions

1. USA and Europe

First, in order to show how different tax laws can influence industrial behaviour, I compare the average defence industry in the United States and Europe[44] with regard to summary indicators. This is shown in *table V*.

	Average For USA	Average For Europe
1. Sales Per Company in $Million	3.000	2.200
2. Assets Per Company in $Million	1.200	2.500
3. Net Income Per Company in $Million	110	37
4. Sales/Asset Ration	2.5	0.9
5. Net Income as Percent of Sale	3.6	1.7
6. Net Income as Percent of Assets	9.0	1.5

NOTE: (Sales/Asset) × (% Income on Sale) = % Income on Asset

Table V Industrial Averages

The table shows clearly that in a place where all and any expenses can be called "cost" and where profit is used exclusively for growth, a relatively small profit (but true profit) will lead to a capital intensive operation.

2. Uniformity

It appears that something like a uniformity within the industrial base does not exist. I have suggested ten different clusters but any other clustering process – more detailed or less detailed – is absolutely possible. We do not know what a clustering of reality would be. However, it should be clear that no panacea *can* exist and, if forced upon the industrial base, must produce questionable results.

3. Labor and Capital

Before and even in the time of early industrialisation, all work was labor-intensive. Increase in agricultural productivity freed the labor force for rapidly growing industry, itself originally labor-intensive. This time, however, has long passed. Nevertheless, in past days the models for our accounting systems have been institutionalised and carried forward to the present, where we still associate profit on the sum of labor plus capital; also, return on capital takes its special place in the accounting system. Looking at today's reality, it appears that labor and capital follow their own rules and hence should be separated in their considerations. I therefore suggest in-depth investigation into the practicality of changed contract procedures in the private and government arenas:

- *Separate* each contract into two distinct parts:
  - Part 1, the LABOR CONTRACT
  - Part 2, the CAPITAL CONTRACT
- Assign a RISK FACTOR to the labor portion of the contract.
- Assign a CAPITAL PRESERVATION FACTOR to the capital portion of the contract, provided this amount will be used to improve productivity at its source.
- Assign a PROFIT MARGIN to the total contract and make this portion of the profit tax-free, which is reinvested in the source for the purpose of growth.

(MATERIAL would be the third contract part. However, this is too involved to be included in the present paper. Reference 12 will deal with it in detail.)

4. Quantification

Industrial analysis is difficult because we seldom have the data we need (being mostly proprietary information). Nevertheless, attempts should be made to develop a database for the industrial base sector which permits an analytical validation of new approaches.

5. Systems Approach

I started this paper with a plea for LEGENOMY, the consideration of the inseparate *legal* aspects, *engineering* aspects and aspects of econ*omy*. I return to this plea. I am fully aware that we cannot separate the defence aspects from their political, social and economic environment. Hence simplistic solutions to complex problems will not exist. On the other hand, we have to conceptualise the complexity in order to deal with it. We have to understand the dynamic structure of our military products and we have to know Maxwell's demons inside the black box before we can give meaning and interpretation to statistical input-output models[45], the only developed tool we have at the moment. We have to search for tools which are appropriate to our reality of today instead of hiding behind yesterday's formalistics. We have to learn to respect all disciplines and have to learn how to cooperate. More specifically, the subject I have addressed is not for engineers alone to solve, not for lawyers and not for economists. Only working together will bring success. We have to learn to think interdisciplinarily – and even teach it as a new subject; applied operation research might be the first step in this direction.

6. Return to Technology

I agree completely with the statement that "we stand upon a threshold of a bright future as new production technologies become available and are implemented. . . (It) will be a positive step in the program of reindustrialising American industry by introducing smarter machines and making our factories more productive."[46] But technology – and this is my contention – cannot grow, flourish and be effective as long as the environment does not permit it to be fully utilised. The economic clime is the prerequisite for the effectiveness of technology. Of course, how we prepare it may be a political rather than a "scientific" question. Scientific analysis can duly bound the problem by sketching the three extreme options as outlined in *fig. 18*. This figure uses the two extreme Clusters #1 and #10 (see Chapter 1) which is the pure commercial/common cluster of industries and the military/political cluster. One extreme option exists for the first cluster and two for the second.

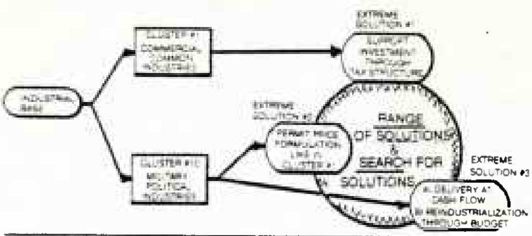


Fig. 18 Toward Re-industrialisation

Not much has to be said about Solution #1, however, Solutions #2 and #3 are of interest for military acquisition: In Solution #2 we are handling the industrial base exactly like a private industry, where it must be the industries' responsibility to rejuvenate themselves by permitting a price formulation which can accomplish this. In Solution #3, however, we are taking the entire responsibility for rejuvenation out of the industry and putting the burden on the budget side of the Federal government. In this case we would pay in real time for the cashflow (or pocket cost) only and postpone respectively shifting the burden for reindustrialisation to the government. Unfortunately, the differences between Solutions #2 and #3 are more cosmetic than real; the difference is rather the preference for how to pay the bill which ultimately must be paid anyhow.

References

[1] *Producing More for Less. A Guide for Writing Cost-Reduction Contracts.* Airforce Systems Command, 1980.

[2] Kaitz, Edward M., "Retention, Cashflow, and the Ship Contracting Process." *Contract Management Journal,* August 1981.

[3] Frisch, Franz A. P. and Acker, David, "Financing Defense Systems Programs." in *Concepts.* The Journal of Defense Systems Acquisition Management, Winter 1981.

[4] Popper, Karl R., *The Logic of Scientific Discovery.* Hutchinson. London, 1959–1977.

[5] Kuhn, Thomas S., *The Structure of Scientific Revolutions.* The University of Chicago Press, 1970.

[6] Lehman, John, "SECNAV on Freedom of the Sea." Secretary of the Navy John Lehman's address to the Society of Naval Architects and Marine Engineers, 20. Nov. 1981. *The Observer,* 10. Dec. 1981.

[7] Frisch, Franz A. P., *Technocratic Economy: Structural Concepts.* John Wiley & Sons, forthcoming.

[8] Frisch, Franz A. P., *Lecture Notes on Integrated Transportation, Ocean Freight Rates,* etc. MIT, AU, Columbia Univ., VPI&SU, 1958–1981.

[9] Frisch, Franz A. P.; Huth, John H.; Paulisch, Eugene B., and Piersall, Charles H., Jr., *Is Engineering Education Enough! The Problem of Interdisciplinary Education.* 14th Annual Technical Symposium, ASE, 1977.

[10] Weber, Max, *Wirtschaft und Gesellschaft—1922.* Edited, annotated and translated by Max Rheinstein and Edward Shils: *Max Weber on Law in Economy and Society.* Simon and Schuster, 1954.

Bell, Daniel, *The Coming of the Post-Industrial Society.* Basic Books, Inc., 1973.

[11] Frisch, Franz A. P., *The Commercial Sector of the Industrial Base.* NAVSEA staff paper, April 1977.

[12] Frisch, Franz A. P., *Structural Concepts of the American Industrial Base.* With an introduction by Jacques S. Gansler, special edition of *Concepts,* The Journal of Defense Systems Acquisition Management, Fall 1982.

[13] *ibid.*

[14] *ibid.*

[15] Polanyi, Karl, "Aristotle Discovers the Economy," in (Essays of) *Primitive, Archaic and Modern Economies.* Edited by George Dalton, Beacon Press. Boston, 1968.

[16] Wogaman, Philip J., *The Great Economic Debate: An Ethical Analysis.* The Westminster Press, 1977.

[17] School brief, "Sharing the Public Purse." *The Economist.* London, 6. Jan. 1982.

[18] Laffer, Arthur B., Interview, "What Went Wrong with Supplyside Economics?" in *U.S. News & World Report,* 18. Jan. 1982.

[19] Edsall, Thomas B., "How a Lobbyist Group Won Business Tax Cut." *The Washington Post,* 17. Jan. 1982.

[20] Bertalanffy, Ludwig von, *General System Theory.* George Braziller. New York, 1968.

[21] Roegen, Nicholas Georgescu, *The Entropy Law and the Economic Process.* Harvard University Press, 1974.

[22] Frisch, Franz A. P., *Economic Considerations for Commercial Ship Replacement.* Center for Naval Analyses: (NWS)261-64, Aug. 1964.

[23] Frisch, Franz A. P., "Search for the Biological Foundation of Economy," in *Technocratic Economy: Structural Concepts.* John Wiley & Sons, forthcoming.

[24] Lorenz, Konrad, *Das Sogenannte Böse.* Dr. G. Borotha-Schoeller Verlag. Wien, 1963.

Lorenz, Konrad, *Behind the Mirror.* Translation of *Die Rückseite des Spiegels* by Ronald Taylor. Helen and Kurt Wolff Books. New York, London, 1973.

[25] Pugh, George Edgin, *The Biological Origin of Human Values.* Basic Books, 1926 & 1977.

[26] Frisch, Franz A. P., *Lecture Notes on Industrial Economy.* VPI&SU, 1977.

[27] Frisch, Franz A. P., "European Overview (Part I): Competition, Education, Taxes." In *Concepts,* The Journal of Defense Systems Acquisition Management, Spring 1982.

[28] Frisch, Franz A. P., *The Understanding of Communication Systems, Sect. IV: Compatibility.* Research report for NTDS Office NAVSEC, April 1973.

[29] *see ref. 27.*

[30] Mann, F. K. von, *Steuerpolitische Ideale.* Gustav Fischer Verlag, 1937 & 1978.

[31] *Maritime Subsidies.* U.S. Department of Commerce, Maritime Administration, Jan. 1981.

[32] Kurtz, Edwin B., *The Science of Valuation and Depreciation.* The Ronald Press Co., 1937.

[33] Salvatore, Dominic, "Microeconomic Theory." In *Schaum's Outline Series in Economics.* McGraw-Hill, 1974.

[34] Frisch, Franz A. P., "European Overview (Part II): Comparative Investment Pattern." In *Concepts.* The Journal of Defense Systems Acquisition Management, Summer 1982.

[35] *see refs. 3, 27, 34.*

[36] Mellerowicz, Konrad, *Kosten und Kostenrechnung.* Vols. I, II & III. Walter de Gruyter & Co., 1963.

[37] *Vinson-Trammel Act* of March 1934. Act #135, 73rd Congress, H.R.6604.

[38] Frisch, Franz A. P., *Risk in Construction and Production.* Lecture notes #6 & #7, Technical Management, Defense Systems Management College, 1979.

[39] Frisch, Franz A. P., *Production and Construction: A Comparison of Concepts in Shipbuilding and Other Industries.* Paper at the 5th Annual DOD Procurement Research Conference, Nov. 1976.

[40] Riggs, James L., *Engineering Economics.* McGraw-Hill, 1977.

[41] Dianich, David F. and Hurta, Donald W., *The Application of Decision Analysis to Unstructured Management Decisions.* Manuscript for publication, DSMC & Navy War College, 1977.

[42] Beer, Stafford, *Decision and Control: The Meaning of Operational Research and Management Cybernetics.* John Wiley & Sons, 1966.

[43] Raiffa, Howard, *Decision Analysis.* Addison-Wesley, 1968.

[44] *Joint Logistics Commanders' Guide for the Management of Multinational Programs.* Handbook for program managers involved in international acquisition. Defense Systems Management College, Fort Belvoir, July 1981.

[45] Frisch, Franz A. P., "Rambling Through Economics," In *Defense Systems Management Review,* Vol. III, No. 3, Summer 1980.

[46] Blond, David L. (OSD), *On the Adequacy and Inherent Strength of the United States Industrial and Technological Base: Guns Versus Butter in Today's Economy.* Data Resources, Inc., 1982.

COMPETITIVE OPTIONS FOR THE MEOIUM RANGE AIR TO SURFACE MISSILE PROGRAM

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I. INTROOUCTION

The Medium Range Air-to-Surface Missile (MRASM) program, like all new Department of Oefense (DoD) programs, is faced with limited resources. The program manager must decide how best to allocate those resources to provide a viable weapon system. The purpose of this paper is to explore the competitive options available to OoD and to demonstrate how competition could be used to reduce the cost of a program such as MRASM. At present, there is no prescribed basis or method for the OoO to decide if and, or when to introduce competition.

The concept that competition reduces acquisition costs of military weapons systems is generally accepted; however no definitive methodologies exist to determine net savings to be expected. Several studies have been done of weapons systems under competitive acquisition procudures; however, the number of systems reviewed is inadequate to provide a high degree of statistical confidence that competition does in fact result in savings. Consequently, each program manager is faced with the task of analyzing the specific circumstances of the system at hand and proceeding as appropriate.

The problem of determining if, when and how competition should be introduced for a specific weapon system requires more than a simple analysis of procurement costs. Savings must take into consideration the difference in hardware prices, cost and benefit of second source facilities, the cost of second source qualification testing, the cost of transferring production skills and procedures to the second source, the cost of delays due to competition, and administrative costs. If the analysis indicates that cost savings are likely, the question of when and how to introduce competition remains. Should competition be introduced before, at the beginning of or during the procurement phase? Should it be introduced at the weapons system level or at the component level? These and many more questions must be addressed before a program manager can make a rational recommendation for a particular weapons system.

The importance of the to compete or not to compete decision increases as resources become more limited as they have within the OoO in the past few years. The issue is critical for a new major weapon system such as the Medium Range Air-to-Surface Missile (MRASM) with an estimated acquistion cost of over two billion dollars. MRASM is a family of air-to-surface tactical, subsonic, winged air vehicles, carrying conventional warheads, designed for launch from Navy and Air Force attack aircraft. Because the MRASM has gone directly into Full-Scale Engineering Oevelopment (FSED) without the normal extended Advanced Oevelopment Phase, less time than usual is available to analyze the competition alternatives. This shortage of time coupled with extremely limited funding increases the importance of an analysis of the option open to the program. The purpose of this paper is to demonstrate the process of evaluating competitive options for a missile system.

II. BACKGROUNO

A. History of Competion in OoO

Competition, a cornerstone of our economic system, has been instrumental in establishing the preeminence of the United States. Competition in the private sector leads to technological advances, lower prices for the consumer and better quality. Congress has recognized the value of competition in statutes such as the Armed Services Procurement Act of 1947, many yearly OoO Appropriation Acts and frequent Committee Reports.

In November 1969 Congress created the Commission on Government Procurement to find solutions to the problems created by development and procurement of costly and complex weapon systems. The result of years of study, OMB Circular A-109 was published in April 1976. The two significant changes which A-109 made were a requirement for a mission needs approach to approval of new weapon system acquisition programs and a requirement for extended use of competition beginning early and continuing through the acquisition process as long as it is economically beneficial. While competitive contracts are not used for all major weapons systems in OoD, competition at some point in the life cycle is the rule rather than the exception. Most programs grow out of a competitive validation and prototype design phase. Because of the high cost, Full Scale Engineering Oevelopment has rarely been considered for competition. One program, the Air Launch Cruise Missile, had a completely competitive FSED. The implications of this effort will be covered later in this paper.

While competition in production has been common historically, its primary goal has not been cost reduction. During World War II and the Korean period, the primary objective was to achieve a rapid buildup of war material production. For example, the B-17 was produced by Boeing, Douglas and Lockheed. The B-24 was produced by Convair, North American, Ford and Douglas. The B-29 by Boeing, Martin and Bell. During peace time second sources have been established to insure that production would not be interrupted by strikes or sabotage and competition has been created to increase quality and reliability. As weapon system costs increased in the 1950s and 196Ds, cost came to be a major focus of competition decisions. This is especially true of competition in the production phase. Congressional and OMB direction has stressed the need for competition both in system and in subsystem procurements. For example, on strategic cruise missiles, procurement of guidance components and engines is made from more than one qualified contractor and approximately 75% of the total weapons system at the component level is exposed to competition.

Since 1962 when Robert McNamara, then Secretary of Defense, testified before Congress that competition yields 25% savings, Congress and DoD have been trying to save that 25%. While no one has proved that the savings can be obtained, DoD and Congress continue to act on the assumption that the savings can in fact be obtained if only the correct method of competition is introduced.

B. Dual Sourced Tactical Missiles

The identification of programs the experiences of which would be relevant to MRASM was not easy. In addition to the obvious choices of the other cruise missile programs, no clear cut parallels existed. Since the program was already entering FSEO only competition in FSED and procurement were relevant. Both leader/follower and dual sourcing using a reprocurement package have been used by a very large number of programs; however, it was decided that cruise and tactical missiles were the most directly relevant programs. A number of studies of the of the cost implications of second sourcing weapons systems have been made at the request of the DoD. I will review in some detail the cost implications of second sourcing on 7 missile systems for which significant analyses are available. (Table 2-1)

SUMMARY OF STUOY RESULTS*
(PRICE IN MILLIDNS OF FY 72 DOLLARS)

PROGRAM	QUANTITY PROCUREO	ACTUAL PRICE	ESTIMATED SAVINGS (LOSS) PRICE	PERCENT
STANDARD MISSILE	5,927	$307.1	$ (11.7)	(3.9)
SIDEWINDER MISSILES:				
AIM-9B GCG	67,D54	171.2	(6.7)	(4.1)
AIM-9D/G GCG	9,955	68.8	(4.4)	(6.5)
BULLPUP AGM-12B	45,05D	200.7	38.3	16.D
WALLEYE I	9,179	73.2	(19.9)	(21.4)
SHRIKE MISSILES				
DASH 1 GUIOANCE	691	2.5	2.5	51
OASH 2 GUIOANCE	250	D.9	2.0	68
DASH 3 GUIDANCE	15,217	54.9	16.8	23
CONTROLS	15,790	33.9	81.7	71
WINGS, FINS, ELEVONS	16,947	3.9	4.2	52
TDW				
MISSILE	25,240	UNK	61.3	8.5
LAUNCHER	959	UNK	83.4	30.2
ORAGDN				
RDUND	49,393	UNK	8.0	2.7
TRACKER	4,D31	UNK	12.0	12.0

*Source: Army Procurement Research Office

Table 2-1

In March 1978 the Army Procurement Research Office published the results of second sourcing in procurement of TOW and DRAGON missile systems.[1] While these systems are technically much less compex than MRASM, they were examined for the lessons learned concerning competition. The 1978 investigation included review of actual cost data as well as discussion with Government and contractor personnel. Factors explaining the actual savings due to competition were identified and analyzed. Gross costs were calculated by determining the pertinent cost factors and making adjustments for inflation and learning. The forcasted savings methodology is complex since it includes a regression model to provide an estimate of the cost of the system after the first competitive award, had no competition taken place.

The available TOW cost data, according to the study, made it difficult to distinguish non-recurring from recurring costs. Furthermore, material and subcontract costs were a substantial portion of costs, roughly 70% just prior to second sourcing and approximately 60% of the split competition. (Some conflicts in the various data sources reduce the reliability of these estimates.) The results of savings of 8.5% for the TOW missile and 30.2% for the TOW launcher do not include non-recurring start up costs for the second source, administrative costs for carrying two contractors, or the administrative costs of the competition incurred by the Government. The greater savings on the launcher were attributed to the Government not incurring an expense to educate a second source. The limited complexity of the launcher was such that a capable contractor could bid competitively at a reasonable risk based on the technical data package.

The DRAGON contractor cost data base has the same shortcomings as the TOW data only to a greater degree. Consequently savings projections were developed off of the Baseline Cost Estimate developed by Government personnel visiting the initial contractor's plant, reviewing cost and accounting records, and interviewing contractor personnel. The calculations using this data resulted in an estimated savings of 2.7% for the DRAGON round and 12% for the tracker. Again, these savings do not take into consideration other costs incurred in order to establish competition.

In August 1978, Tecolote Research Inc., on contract to the Army Procurement Research Office, published 6 additional analyses of weapons system second source impacts.[2] Five of these systems were tactical missile systems and will be examined for implications for procurement strategy decisions for the MRASM system.

The Standard Missile, while considerably smaller than MRASM, is also produced by the General Dynamics Company. Initial production was awarded to General Dynamics under a directed buy contract for 860 missiles. A competitive buy for continued production was subsequently awarded to General Dynamics, which produced all missile equipment except the warhead and propulsion systems. The missiles are manufactured and delivered as sections with the Navy performing final assembly and test prior to delivery to the Fleet. The cost data for this program is complicated by the fact that some contract lots overlapped in terms of production. This makes separation of learning related cost factors less reliable. Otherwise the data is available to evaluate costs. It is not clear that the competition had any significant impact on the cost of Standard Missile. An analysis of the data indicated that the competitive buy resulted in slightly higher costs. The net loss is estimated at $11 million or 4%. Actual costs include recurring costs, non-recurring costs incurred during the competitive buy contract, and the settlement cost of claims brought against the Government. The non-recurring costs incurred were associated with rate tooling increases, quality control improvements and improvements in the production process. Claims on the order of forty million dollars were brought against the Government which were settled in FY 1976 for a total of $12 million for a faulty data package. It should be noted that a later study by TASC for JCMP indicated that savings for Standard Missile were 59.2%.[3] At the request of the Government, TASC was asked to determine if raw data used included the cost of claims and other non-recurring costs. No response was provided. The administrative costs of competition were not included in the Tecolote analysis which means that true losses were even higher than stated.

The Standard ARM production contracts were awarded to General Dynamics concurrent with Standard Missile. The ARM program was a high priority program because of the missile's use in Viet Nam. For this reason some Navy personnel feel that the relatively generously funded ARM program may have subsidized the Standard Missile program. Even if there hadn't been a high degree of commonality between early configuration, the increased business base reduces overhead and G&A costs. Supporting the belief that ARM was responsible for keeping Standard Missile costs low is the fact that the coincident with termination of Standard ARM production, General Dynamics submitted its first notice of cost overruns on the Standard Missile program. This further substantiates the lack of cost savings resulting from the competition. When price is already as low as is consistent with private industry profit margins, no further reductions are likely.

The Sidewinder is an air-to-air missile designed for both Navy and Air Force fighter aircraft carriage. The missile has been in use since 1956 and has evolved through six versions. It is a small missile that has been produced at rates of 4,000 to 14,000 per year. The missile has been produced by Philco-Ford, Raytheon and General Electric. An analysis of the cost data available led Techolote Research Inc. to conclude that there was no dramatic evidence in the "data to suggest that Philco responded to the competitive split-buy".[2] The General Electric data indicates that the learning curve is shallower in slope (92%) during the split-buy phase and "abnormally steep (72%) during the later sole source phase".[2] This is exactly counter to what would be expected in a competitive environment. While Raytheon data indicates that for two years after competition was established, costs were going in the right direction, this trend didn't last. Techolote was unable to gather very much qualitative data because the contractors were generally reluctant to discuss contracts that were as many as twenty years old. Raytheon, however, stated that the Government had limited the contractor's ability to compete by constraining planning to one year contracts. Competition appears to have cost the Government 4-6% and undetermined administrative costs incurred in second source procurement depending on the Sidewinder version.

The Martin Company was the original sole source prime contractor for the Bullpup missile. The Maxson Company shared the production for a three year period from 1961 through 1963. These contractors competed for and were responsible for guidance and control equipment. Other subsystems were Government furnished. The data indicates that the Martin Company trend line is slightly depressed during the competitive period; however, because of the higher Maxson costs, significant cost savings were not achieved. Savings of $38.3 million (16%) do not include administrative costs. It must be kept in mind that 4,000-14,000 missiles were produced each year.

The Walleye missile was produced in four versions. Techolote analyzed the cost data for the Walleye I missiles produced. The reliability of the cost data is limited. While the missile was produced by NAFI (a Government facility in Indiana), the Martin Company and Hughes Aircraft Company, a loss (-21%) rather than a savings appears to be the result of multiple sources. This loss is based solely on the Martin and Hughes production units and was heavily influenced by a Martin claim against the Government. Were it not for the claim, the competition would have resulted in savings on $19 million (16%) excluding the administrative costs.

The Shrike missile, a Navy developed air-to-surface missile, first entered production in 1963. The subsystems were purchased from contractors under competition and assembled by the Navy prior to deployment. Texas Instruments and Sperry-Rand competed for the majority of the production lots of guidance, controls and subsystems. The Techolote analysis of 20 production contracts indicates extensive savings that averaged out to 51% after taking into consideration contractor incurred second source startup costs of $ 4 million. Government incurred costs of carrying two sources are not available. From the beginning it was the intention of the Navy program manager to have a competitive production program. Techolote reports that the Government had to insure that the bidding contractors were aware of the competitive nature of the market. Over the years the prices of the two competitors tended to converge. Discussions with Sperry Rand indicated that the company eventually elected to remove themselves from the Shrike competition because Shrike was less profitable than other business opportunities.

Competition for the initial procurement has frequently occurred where a Government laboratory developed the system. A winner take all buy-out has been the norm, thereby eliminating continuous competition and the opportunity to extend the mobilization base. The ALCM Competitive FSED resulted in a competitive initial procurement with the winner taking all. The advantages of dual sourcing both in terms of mobilization base and competive pricing are eliminated as soon as the winner is announced. The administrative cost and time involved in competition are barely recovered by the competitive savings in the first buy. While there is considerable question as to how much subsequent price increases are due to Government induced causes vice contractor induced causes, there is ample evidence that price frequently does go up.

In general, the literature is not conclusive that competition results in cost savings at the system level. Government mismanagement frequently turned potential savings into actual losses and the tactical missile data provides a strong indication that long production runs are necessary to cover administrative and start up costs. The data is inconclusive on the cost effectiveness of second sourcing.

Only those programs with a large volume, long production run with sufficient lead time to qualify a second source seem to be candidates for dual sourcing. A review of the systems studied by the Army Procurement Research Office indicates that with respect to tactical missile programs the taxpayers have not always benefited appreciably from competition. Cost savings accrued in large production runs such as BULLPUP, TOW and DRAGON. Large savings were also found in SHRIKE which in effect was dual sourcing of the components with the Government serving as the prime integrating contractor. On the surface MRASM's planned production is far too low to expect cost savings from dual sourcing of the prime contractor.

It also appears that to have a second source costs more when one company, due to price pressure, is forced into bankruptcy or drops out of the production to avoid bankruptcy. The Government, having paid for tooling and start up costs for two companies, is back in a sole source environment.

A frequent cause of costs exceeding savings has been problems with the reprocurement data package. While MRASM would have to be a leader/follower transfer due to complexity, some of the same problems could result. The data package can be put together either accidentally or deliberately in such a way as the peculiar procedures and manufacturing techniques are not readily transferable to the follower. The second source has difficulty with the procedures. This has in the past resulted in claims against the Government, excessive numbers of change orders, or additional Government time and money to bring the second source on line.

C. Competitive FSED: Lessons Learned from ALCM

In 1977, Congress agreed that the Air Launched Cruise Missile program would have a competitive Full Scale Engineering Development flyoff between the General Dynamics/Convair Division and the Boeing Aerospace Company. Dual prime contracts for complete full scale development were awarded to the companies on February 1, 1978. Both companies were advised that after the competitive fly-off, only one design would be selected for production. The General Dynamics Company began preparation of the AGM 109 missile, a modification of the Sea Launched TOMAHAWK Cruise Missile. The Boeing Aerospace Company modified the AGM 86 missile which had undergone Advanced Development under Air Force sponsorship.

In order to understand the magnitude of dual full scale development one must consider the areas where duplicate efforts were required. These included engine, guidance, warhead, mission planning, carrier aircraft, support equipment, and the myriad of program management functions. The competition included a test program of ten free and ten captive flights for each contractor. Development Test and Evaluation (DT&E) and Initial Operational Test and Evaluation (IOT&E) were postponed to commence after source selection. The DT&E/IOT&E plan consisted of nine flights by the winning contractor. Leader/Follower procurement options would be investigated for the purpose of retaining competition during the production phase of the program. Development of the B-52 carrier aircraft equipment was to be accomplished for each competitor. Two B-52G Aircraft were fully modified by each competitor to support the test program. A total of 14 flight test missiles were initially planned for fabrication by each contractor to allow for immediate initiation of DT&E/IOT&E after source selection. The W-80 warhead was fully integrated into each version of the missile.

A Review of the ALCM files and discussions with personnel involved in the ALCM Competitive Fly-off resulted in some information that would be of use to any program manager contemplating a competitive FSED. The ALCM competitive FSED cost $692 million. A review of the files indicates that the competing contractors controlled costs. Almost all cost growth, excluding inflation, was in the non-competitive contracts. Nevertheless, the great cost of duplicate effort appears to outweigh the savings in the air vehicle area. Perhaps if the entire missile system was competitive, cost control would have extended further. It is unlikely that savings would be adequate to justify competition on a cost basis alone. This researcher is not qualified to judge the value of technical improvements that arose from the competition.

Under the auspices of the Cost Panel of the ALCM Source Selection Evaluation Board, The Analytic Sciences Corporation (TASC) developed a model for projecting cost savings in second sourcing decisions. This model was based heavily on historical data including Scherer's studies of World War II multisourced bombers. The TASC model assumes that competition is the primary cause of a steep learning curve. However, a possible alternate cause for the steep learning curve slope experience in World War II is a higher initial

All problems were immediately surfaced and brought to the attention of JCMP. A single manager was designated in the JCMP for both the leader and follower to work with. JCMP corrected the procedural problems that had occurred with the WRC technology transfer. Monitoring and motivating the contractors became paramount JCMP strategies.

I believe that there were additional reasons that the RMUC/INE second sourcing was successful while the engine attempt was filled with problems. The JCMP Engine Directorate is located half in Dayton and half in Washington, DC, whereas the Guidance Directorate is located entirely in Washington, DC. Lines of responsibility are less subject to confusion without geographical separation. The second reason was the fact that the leader company was satisfied with follower and vice versa for the RMUC/INE. Teledyne's HARPOON engine had been the original SLCM engine. Teledyne resented the loss of their original design. Furthermore, there are very few engine competitors, whereas there are many competitors for guidance components.[5]

III. ANALYSIS OF OPTIONS

A number of attempts have been made to develop a framework for analysis of competition options. Under the sponsorship of the Air Force, Charles W. N. Thompson and Albert H. Rubenstein developed a Leader/Follower Second Sourcing Model.[6] LCDR Rosemary E. Nelson, S.C., USN, published her master's thesis in 1980 critiquing the Thompson-Rubenstein model if applied to the ThompsonRubenstein implementation of competition by JCMP.[7] The JCMP abandoned both the model and the TASC model because they failed to provide an adequate framework for a program manager to use as a cookbook to make a decison. This paper grew out of attempts to bring together enough properly analyzed and assembled data to allow the MRASM program manager to make a decision without having to himself become an expert in the area of cmpetitive strategies. This proved to be a complex process.

A framework for analyzing competitive options requires a delineation of what is meant by competition. An economist's definition of competition assumes that four conditions exist: 1) a homogeneous commodity: 2) numerous buyers and sellers; 3) perfect information about prevailing prices and 4) entry into and exit from the market by suppliers. Perfect competition cannot be achieved in business-Government transactions in the major weapons system acquisition area. A limited number of qualified sellers exist. Excluding foreign military sales, only one buyer exists (DoD). While competing seller have little knowledge of their competitors' prices, they have conside rable knowledge of the Services' budgeted funding by weapon system. Entry into the market by suppliers is limited due to enormous startup costs. Consequently, for the purpose of this paper, competition will be defined as the existence of at least two suppliers of a weapon system, each willing to and capable of producing at least 60% of the planned annual procurement. Ability to produce exact duplicates of the weapon system is not always necessary for competition to exist. However, commonality may be required to ensure that all of the items procured to perform a specific function will not only perform the function interchangeably, but are also identical for logistics purposes such as simplifying tranining, operations and support.

A. Competition Alternatives

If competition is determined to be desirable, a number of second sourcing techniques are theoretically available for qualifying more than one contractor to produce a system or subsystem. In theory, a program manager should first decide if a second source should be established, then decide which method of second sourcing will most efficiently and effectively achieve his second sourcing objectives. Because the Senate Appropriation Committee reported out on November 19, 1980 a recommendation that the Department of Defense consider extension of the competitive procurement philosphy of other crusie missile to the MRASM program, both if and how have became a combined decision.

The program manager, in theory, could consider the following second sourcing options: Technical Data Package (TDP), Form-Fit-Function (F3), Directed Licensing, Leader/Follower, Contractor Teaming and Component Dual Sourcing.

1. Technical Data Package. This method require the Government to own or purchase technical data and rights to use this data. This data package is then used to solicit proposals for production of the system. The Government assumes the responsibility for inadequate and/or faulty specifications that makes production costly or impossible for the contractors.

2. Form-Fit-Fuction. The second source contractor is given performance specifications and if the item is a subsystem fit or interface requirements. Any design that will fit and perform at the desired level is acceptable.

3. Directed Licensing. Under this method the designer is paid royalty fees on each unit the second source contractor produces and the designer is responsible for

the transfer of production technology. Eventually the second source may become the independent producer; however, royalty fees frequently keep the cost above that of the designer. Licensing may be required when the designer owns rights in data and cannot produce an adequate quantity.

4. Leader/Follower. Leader Company Procurement is a technique under which the developer or sole source of an item or system (the leader company) furnishes manufacturing assistance and know-how to enable a follower company to become a source of suppply for the item or system. The purpose is to ensure rapid development of a second source either to ensure an adequate supply or to reduce costs through competition. The leader/follower concept in acquisition is found in Defense Acquisition Regulation (DAR) provisions 4-701, 4-702 and 4-703.

When competition exists for the system design, development of the leader/follower roles normally must await the selection of a leader. Direct contacts between competitors can create either actual or apparent collusion that is considered in violation antitrust laws.[8] This limits the usefulness of the unsuccessful offerer becoming an immediate viable second source. If continous or nearly continous comoetition is desired, contractor teaming can be used.

5. Contractor Teaming. Contractor teaming consists of two contractors jointly designing, producing and testing the Full Scale Engineering Development missiles. This is a new concept that is being tried by the Airborne Self-Protection Jammer program. Two teams of contractors are competing in the FSED for the production contract. Initially, production is divided based on a formula and later each contractor competes for a share of the annual production buy. Contractor teaming is a very new concept believed to expedite the development of a competitive second source. Data on the success or failure of this program is not yet available.

6. Component Dual Sourcing. The integrating contractor develops multiple production sources for each major component of a weapon system. Because there are many more providers at the component level, competition is stiffer and theoretically should result in lower costs. The startup costs for small components should be more than proportionately lower than for total weapons systems.

B. Decision Criteria

A variety of options were considered for MRASM including single sourc, multi-source, paired teams, leader/follower and component dual sourcing. In order to determine which methods of second sourcing are potentially and effectively applicable to MRASM, a number of factors must be considered.

1. Quantity. Very large quantities, particularly over an extended production period, have the potential for cost savings through development of a second source and competition. However, large numbers may not provide a cost advantage if the unit price is very low compared with the cost of developing the second source. Very large items with a tight delivery schedule may justify or require the use of a second source even with relatively smaller procurement quantities. The effectiveness of second sourcing is dependent on the total procurement dollars as well as quantity. The larger the dollar value of the program, the more likely a seller is willing to compete for a portion of the buy by reducing his profit rate.

2. Relationship to Other Programs. From a mission requirements point of view, a weapon system may range from one of many competing systems to essentially the sole source to meet the requirement. If the system has competitive alternative systems, leader/follower may be useful; however, as George S. Schairer, Vice President of the Boeing Company, pointed out in Congressional testimony in 1975, competition among weapons systems to fill the various mission requirements is where the real improvements in capability are made. Schairer believes that at least two competitive solutions to each requirement are essential to provide adequate mobilization alternatives.[9] In those few cases where a weapon system is itself the sole means of meeting a need, it would appear that a second production source to expand the mobilization base would become an overriding concern even where cost reduction is questionable.

3. Technology. The level of technology will affect the difficulty of transferring the technology to a second producer. In the extreme case of a technology so new, difficult and complex that the developer has difficulty putting it into production, development of an early second source may further delay deployment and increase costs. In other cases there are multiple suppliers capable of producing solely based upon a reprocurement data package. The leader/follower method of second sourcing is primarily applicable in the middle area where active assistance from the leader to the follower can decrease the time required to establish follower production capability, decrease front end costs to the follower, decrease the differences in performance and/or design and increase the ability of the follower to price competitively.

Another area in which technology is a consideration is the divisibility of a system. Dual sourcing key components produced by subcontractors may achieve price decreases with minimum effort and startup costs. If performance interface is the only requirement, then procuring identical units is not required and a leader/follower procurement is less likely to be useful. If maintenance or repairability dictate commonality a greater level of leader assistance may be required for the second source even in the area of subsystems and components.

4. Program Stability. Early establishment of program requirements in terms of quantities and delivery schedules is essential if leader/follower or competitive procurements are to be cost effective. Fluctuations in quantities or delivery schedules make it difficult to estimate potential cost savings and to introduce a follower or second source early enough to ensure that the initial startup costs can be recouped. Moreover, industry interest in a program and its ability to plan its participation requires sufficient knowledge of the program parameters for the industry to believe that participation will be profitable.

5. Reprocurement Data Base. If there is or will be a reprocurement data base or technical data package sufficiently complete to allow a second source to effectively compete and produce, leader/follower procedures are unnecessary. Only where assistance from the leader is needed to supplement the technical data package is leader/follower necessary. Extremely complex systems may be too difficult to transfer technology at a reasonable cost.

6. Technical Data Rights. Even where the Government has paid development costs and believes it has obtained "rights in data", issues concerning proprietary data and procedures may still be raised. Also where there is no question of ownership, the developer may still be either unwilling or unable to transfer the necessary data to the follower. Provisions for assistance will need to include not only funds for time and effort expended and for the value of the proprietary information provided, but also motivators to insure the transfer of technology. Licensing fees may be useful in motivating a leader to help a competitior to become a viable producer, however an alternative system that the Government could switch to is generally the best motivator. In the area of aircraft and major air weapons systems, transfer of technology to and from subcontractors is a normal incident of the companies' commercial business and should present no problems. For example, General Dynamics/Convair builds aircraft bodies for both Boeing and McDonnell Douglas. However, the literature indicates that without adequate (financial) incentives the leader will not cooperate in developing a viable competitior.

7. Characteristics of Potential Contractors. In general, the interest in and capability of developing and producing are key characteristics of both leader and follower contractors. Initially, large procurement potential will interest a number of competitors; however, this pool of potential contractors will not necessarily continue throughout the life of the program. The defense industry is not monolithic. The shipbuilding, aircraft and munitions areas hav different problems and potentials. All, however, lack significant competition at the major system level. There is a relatively small number of major system integrating contractors and because of the single domestic buyer (the U.S. Government) that also controls foreign sales, the market does not allocate resources efficiently. In the aircraft and missiles area, one third of the plant capacity is owned by the Government. This plant as well as the privately owned plant and equipment is aging and inefficient. Because maintenance is a directly chargeable expense and investment in new equipment and methods is not, there is a bias toward retaining outdated manufacturing methods and equipment. In the aerospace area there is considerable excess and inefficient capacity. Excess capacity seems to extend to excess management overhead, neither of which is cost effective. Since Government negotiators tend to be concerned with the fee (profit) percentage rather than the base cost of Government contracts, defense contractors are usually able to pass on to the Government the cost of these inefficiencies and retain a return on investment comparable to the industrial average.[10]

Experience gained by JCMP in second sourcing the cruise missile engine indicates that early planned second sourcing would have yielded a smoother development of Teledyne as an engine second source. The development of motivating factors involved in successful leader/follower transfer of technology must be accomplished. When the Government owns rights in technical data, the leader company can be better motivated to transfer technology because, while time consuming and costly, the Government could reprocure from a second source without the leader company's cooperation. An alternate motivator the Government can use is a quantity guarantee to the leader. This quantity guarantee, however, will tend to reduce price competition.

8. Characteristics of the Procuring Agency. The administrative resources of the procuring agency must be reviewed. Relevant experience is required or the administrative costs and the costs of mistakes in procedures

can grow enormously. Many of the cases reviewed indicate that claims against the Government frequently eliminated the potential savings that competition could bring. The technical resources to assist in the transfer of technology, preparation of reprocurement data and/or the technical data package, and ability to qualify the second source are required.

9. Time. Except where competition is clearly not desirable, provision for competition in production should be developed early in the development phase. This is especially true if capacity must be developed to meet delivery schedules.

C. Application of Oata to MRASM

Before it was possible to utilize data from programs whose experience would be relevant to MRASM, it was necessary to determine and analyze the distinguishing MRASM program factors.

Quantity. The JCMP is planning for a total procurement quantity of 35D0 missiles, 1000 for the Navy and 2500 for the Air Force. Discussions with the program office staff indicate that unless a major armed conflict develops, these quantities are maximum procurement goals. As of December 1980 the projected development budget was $246 million. Procurement of 3,500 missiles was estimated to cost $3.7 billion. One thing that immediately becomes apparent is that the quantities are considerably lower than those of the tactical missiles that have previously had multi-source production. The total cost, however, is considerably higher than for those same tactical missiles, even after taking inflation into consideration. The total quantities are comparable to the ALCM (3400 units); however, MRASM has two variants. Furthermore, since separate learning curves are required for pricing, sufficient differences apparently exist to indicate that quantity comparison to ALCM is also limited, especially for the Navy variant. From a manufacturing viewpoint, one manufacturer (GD/C) is capable of meeting the planned production schedule. Second sourcing is not required to meet schedule.

Relationship to Other Programs. From a mission requirements point of view, MRASM has no exact competitor; however, aircraft are capable of handling some of the same missions using gravity bombs. Because anti-aircraft defenses make the use of fighter-bombers very costly in terms of aircraft losses, MRASM, as the sole tactical stand-off weapon currently under development, is very critical for the defense of this country. This leads one to prefer dual sourcing to protect the production base. Since dual sourcing is likely to increase costs, the DoD and Congress will have to decide how much "protection of the production base" is worth.

Technology. While the technology is based on already designed, tested and produced cruise missiles, the complexity is such that second sourcing would probably require a leader/follower technology trasfer approach to introduce competition beginning with the initial production buys in accordance with the currently directed schedule. The commonality of the various parts with other cruise missiles make feasible the second sourcing of components along the same lines as the other missiles.

Program Stability. The RDT&E funding has been a here today gone tomorrow issue within the DoD since the program's inception. Once the political issues are resolved, the MRASM program has a relatively strong chance of being able to pass the OSARC III milestone and get into production because it is the sole candidate for a standoff weapon in the required timeframe. Program stability in no way approaches that of the ALCM program. Because MRASM exists at the margin between funded an unfunded, annual production quantities will most likely fluctuate. If production begins FY 83/84 as planned, the 1984 election could bring a new administration into power with shifting program emphasis.

Reprocurement Data Package. A reprocurement data package could be developed; however, due to the system's technical complexity, it will be difficult for a second contractor to develop production capability in a reasonable length of time without the direct assistance of the developing contractor (General Oynamics).

Potential Contractors. It is the understanding of the program manager that several Defense contractors are interested in bidding as the second source for MRASM. Several of these companies, even with the assistance of General Dynamics, probably cannot become independent producers in time for a first production buy in 1983. In the area of subsystem second source alternatives, it is more likely that viable competitors are available. Lower cost guidance options will be competed and it is highly likely that more than one production contractor could be found for the winning design.

JCMP Office Characteristics. While the JCMP office has a relatively larger and better trained staff to handle the contractual procedures required by second sourcing, the MRASM program is not being staffed at the level ALCM, SLCM or GLCM have been. The JCMP manufacturing staff is fully employed on the second source options being exercised for the other programs. Nevertheless, initial planning for a potential second source could be accomplished with the manpower available and the experience and lessons learned from the other programs. If MRASM is delayed, as is likely, the staff will be available by the time MRASM enters production.

Timing. Perhaps the most important issue is timing. The MRASM program is situated between pressure for an early operational capability and limited funding. To the extent that the IOC slips due to funding constraints, adequate time to develop a second source will become available. The requiremen for cost savings would be even more important if the program slips due to resource limitations. In general, the literature indicates that when tradeoffs are made between schedule, quality and cost, cost generally is of lower concern to DOD officials and consequently increases.[11]

Most of the examples of second sourcing available in the literature are of tactical missiles that are considerably smaller and less costly that MRASM. Furthermore, these missiles were procured in considerable larger quantities than MRASM is likely to be. SHRIKE, the most cost effective dual source missile procurement, was actually procured as subsystems which were then assembled by the Naval Weapons Centers. ALCM, while slightly higher in price, is more comparable to MRASM. Quantity, technology, procuring agency, contractors and timing are quite similar It appears that lessons learned by the DoD on ALCM would be the best guide for the MRASM decison. The success of SHRIKE and ALCM indicate that subsystem dual sourcing should be considered.

IV. CONCLUSIONS

1. Competitive FSED. The cost of a competitive FSED, estimated to be roughly $690 million including administrative costs vice $260 million, greatly exceeds the value of expected improvements to the system. Based on ALCM experience, running a competitive FSED would delay Initial Operational Capability (IOC) for MRASM at least one and possibly two years beyond its current planned IOC. This would be due to the time required to obtain Congressional approval and funding as well as time to bring a second contractor up to speed to compete with General Dynamics. A competitive FSED is irrelevant to production cost control. Bringing a second source up to speed to compete beginnig with the first production buy can be done without a competitive FSED.

2. Missile Dual Sourcing. The evidence does not support the belief that second sourcing the entire MRASM is likely to be cost effective. The estimated cost of second source development and management, $55 million, is likely to exceed the benefit of competition. While there is some evidence that competition can lower the profit and increase learning, several factors, which MRASM does not have appear to be necessary. MRASM lacks sufficient quantity, the program is relatively unstable, and insufficient trained staff is available to insure a smooth technology transfer. Furthermore, it is extremely difficult to provide motivation for an efficient technology transfer coupled with a cost reduction on an unstable program.

If second sourcing is determined to be necessary for technological, mobilization base or political-economic reasons, then it is recommended that follower selection and qualification be made early in the Full Scale Engineering Development phase so that technology tranfer may be accomplished while the threat of program cancellation can still be used as a motivator to both General Dynamics and the follower. Furthermore, the second source should be retained throughout the full production run, so that initial startup costs can be recovered.

3. Component Dual Sourcing. It is recommended that major components of MRASM be dual sourced. The DSMAC unit from the guidance system is common with the SLCM unit. The combined total number of units planned for DSMAC procurement should be adequate to recover second source start up costs. The engine is not likely to yield cost savings through second sourcing the Teledyne design; however, the possibility of a form, fit and function alternative should be investigated. The possibility of an alternative engine will redue the tendency of the contractor to recommend high cost, nice to have features for addition to the engine. Even the WRC engine that is produced by both WRC and Teledyne would be useful toward the end of the MRASM production run because by then the ALCM and GLCM production will be completed and WRC will have excess capacity. The aft end of the missile airframe is common with SLCM and GLCM and would be a likely candidate for second sourcing even though final assembly and integration of the total airframe does not appear likely to yield cost savings.

4. Form, Fit and Function. Second sourcing efforts should be shifted from duplicating the components to development of alternatives that meet form, fit and function requirements. Because the MRASM will have a wooden round maintenance concept, internal identicality is not necessary.

5. Motivation. Shifting contractor motivation from gold plating to lowering the total development and production costs is desirable. The contractor will be motivated if actual total profits and return of equity would increase when total costs to the Government declines. To do this in the face of the current excess profits statutes may be impossible; however, as much movement in this direction as possible should be attempted. This will be very difficult since the selection of Boeing as the ALCM winner has reinforced the industry perception that the Government really prefers the technologically best item regardless of cost.

6. Life Cycle Costs. In order to reduce total life cycle costs, greater emphasis on operational cost reduction should be made. While the current political environment restricts the availability of research and development funds, greater emphasis within the financial constraints will produce greater cost savings than can be expected from competition.

7. Stability. A lack of stability in either the design or program is the major cause of cost growth. Any progress in stabilizing the performance requirements and program schedule will greatly contribute to lowering total costs.

FDDTNDTES

1. Army Procurement Research Office. "Impact of Competing Sole Source/Non-Competitive Contracts". March 1978.

2. Kluge, A. J. and R. R. Lieberman. "Analysis of Competitive Procurements". TM-93. Tecolote Research, Inc. August 1978.

3. Drinnon, J. W. and J. R. Hiller. "Predicting the Costs and Benefits of Competitive Production Sources". TR-1511. The Analytic Sciences Corporation, Arlington, VA. December 31, 1980

4. Drinnon, J. W. "Predicting the Costs and Benefits of Competitive Production Sources for the Air Launched Cruise Missile". TR-1511-1-5, The Analytic Corportation, Arlington, VA. March 17, 198D.

5. JCMPO. Navigation/Guidance Procurement Plan No. JCM-79-D2-DD. JCMPO files. Washington, DC. 1979. For Official Use Dnly.

6. Thompson, C. W. N. and A. H. Rubenstein. "The Leader/Follower Concept in Acquisition". Contract No. F33615-79-C-5073. Reports. International Applied Science and Technology Associates, Inc. Evanston, IL. November 15, 1979.

7. Nelson, R. E., LCDR, USN. "Leader/Follower Second Sourcing Strategy as Implemented by the Joint Cruise Missiles Project Office". Thesis. Naval Postgraduate School, Monterey, CA. September 198D.

8. Fredman, T. F. JCMP Submission to the General Accounting Dffice in Response to the Protest by the Singer Company, Inc. In RE:B-193270. April 3, 1979.

9. U.S. Congress, Senate. Committee on Government Dperations. The Subcommittee on Federal Spending Practices, Efficiency and Open Government Major Systems Acquisition Reform. Hearing. 94th Congress. 1st Session. June 16, 2D; July 8, 22, 23, 24, 1975. Washington, DC. 1975

10. Gansler, J. S. The Defense Industry. Cambridge, MA. 1980

11. Scherer, F. M. The Weapons Acquisition Process: Economic Incentives. Boston, MA. 1964

NEW TECHNOLOGY AND ECPs - INSIGHTS PROVIDED BY UNDERLYING LEARNING CURVES

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ABSTRACT

The underlying learning curve technique provides insights into the impact upon the cost improvement curve of both engineering changes and new technology. An analytical procedure for deriving this impact prior to the costs being incurred is presented. It is shown that the overall impact of new technology is to flatter the cost improvement curve.

INTRODUCTION

The purpose of this paper is to provide insights into the impact of both engineering changes and new technology. This paper is divided into three parts. The first section of the paper reviews the underlying learning curve technique. The second section addresses the impact of both engineering changes and new technology upon the underlying learning curve. The last section summarizes the paper.

THE UNDERLYING LEARNING CURVE TECHNIQUE

The underlying learning curve technique is a method of using both parametric and engineering methods to define the manufacturing direct labor "should cost." "Should cost" as used in this context is the number of hours required to manufacture each unit excluding nonproductive time which has not been historically documented. The "standard learning curve" is calculated using the total actual hours required to manufacture each unit. The "underlying learning curve" is defined as depicting the "should cost" values for each unit. Figure 1 shows how the underlying learning curve and standard learning curve would appear if undocumented nonproductive time were present. The parametric portion of the technique establishes the

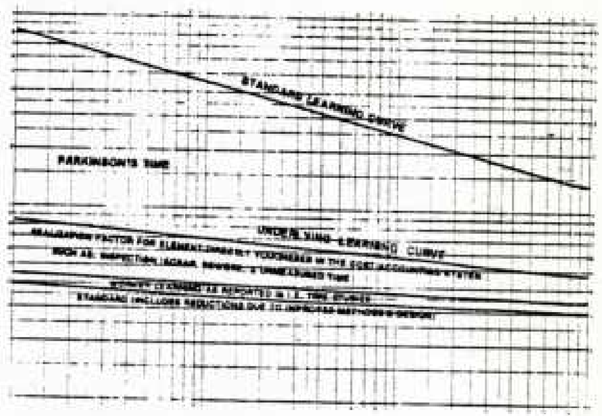


FIGURE 1. RELATIONSHIP BETWEEN THE STANDARD AND UNDERLYING LEARNING CURVES WHEN PARKINSON'S TIME IS PRESENT AND THE AVERAGE WORKER EFFICIENCY IS BELOW 100% (SHOWN ON LOGARITHMIC GRID)

learning curve slope for each element of the underlying learning curve and provides the relationships among the first unit standard, the underlying learning curve, and the standard learning curve. The engineered portion of the technique establishes the standard for the next production unit. The direct labor is then projected using the parametric relationships.

The first step of underlying learning curve analysis is to review the contractor's work measurement system. It is important that each industrial engineer setting time standards via time study be required to demonstrate rating proficiency within an accuracy of plus or minus 10% of the true rating every year.

The second step in the analysis is to gather the data required for the underlying learning curve analysis. This requires an understanding of the contractor's cost accounting system as well as an understanding of the work measurement system.

The third step is to perform the underlying learning curve analysis. This consists of four different learning curve calculations:

(a) The earned hours learning curve.

(b) The worker learning curve.

(c) The underlying learning curve.

(d) The standard learning curve (actual hours).

The learning curve technique is used for earned hours because the industrial engineers use a classic Pareto analysis in implementing methods improvements. The learning curve technique is used for worker learning because a tremendous number of studies suggest that the power form of the learning curve describes workers learning. The analysis of the worker learning is based upon a regression analysis of the reciprocal of the ratings in the time studies. This provides a reliable method of measuring the actual worker learning during a production program, providing the industrial engineers maintain their capabilities to accurately rate the worker's efficiency through proficiency examinations. However, the worker efficiency measured by the cost accounting system is an unreliable measure of worker efficiency since it may contain nonproductive time due to Parkinsons Law (Parkinson's time). Parkinson's time can be eliminated by changing the target hours. The legitimate nonproductive time that is charged to nonproductive cost account codes cannot be eliminated so easily; it can only be reduced through aggressive management. Parkinson's time exists because management believes that the workers perform at a lower level of efficiency than the level experienced as an average efficiency in the time studies. These expectations concerning worker efficiency exist because any analysis using standard learning curves also contained Parkinson's time. Underlying learning curves provide management with a tool which can be used to establish realistic targets for (1) methods improvement; (2) worker efficiency; and, (3) total manhours.

This tool is made more valuable because of the statistical nature of the regression analysis. The error functions for the (1) earned hours; (2) worker efficiency; and, (3) total hours can be used to establish tolerance bands for management by exception using traditional statistical quality control methods.

NEW TECHNOLOGY & ECPs

The underlying learning curve can provide new insights into how to evaluate new manufacturing technology. A technological innovation normally reduces the standard manhours, the scrap rate, the rework rate and/or setup. These improvements occur at the first unit produced on the new machine. However, a technological innovation is a double edged sword. While technological innovation in manufacturing promises reductions in direct labor, flexibility in design, and stabilized manufacturing processes, it also normally increases overhead because additional manhours are required for the planning function, software development, and management. The advances in manufacturing technology are less susceptible to improvement without the introduction of additional new technology. Further reductions in direct manhours become more difficult due to the physical limitations of the machine, and both the physiological and psychological limitations of people. In the final analysis, one must face the reality that in practice there is some level of scrap, rework, and inefficiency which will continue to exist despite the best efforts of management, and that there are physical limitations to the manufacturing processes. While these limits have not been reached for the contractor studied, it is important to note that they do exist because those limits can be used as a basis for understanding the shape of the underlying learning curve for a new process.

If the learning curve for a single process is placed on log-log paper, it is a straight line. If it is thought of as being "pinned" at the limit of "learning" (say unit 100,000,000), it becomes obvious that the slope of the curve becomes flatter when the elements of the realization factor which comprise the underlying learning curve are reduced at unit number 1. Thus, the concept of an underlying learning curve provides some insight into the shape of the learning curve for new manufacturing processes. A steeper slope for a single manufacturing process means a less efficient or less effective method. It could mean that the "Parkinson effect" has not been removed from the process, that scrap and/or rework is higher than the current process, or the workers are "learning" their jobs. It definitely means that a detailed industrial engineering study is required to determine why it is steeper.

The insights gained from considering the improvements generated by a single process are useful in defining the effect of both engineering changes and manufacturing technology improvements upon the underlying learning curve. An engineering change is a change in the basic work content after the first unit which is generated by a design change. A manufacturing technology improvement is a significant change in the manufacturing methods which occurs as a result of a technological innovation and lies outside the bounds of normal methods improvements. Some examples of such a change are numerically controlled (NC) machine centers, photogrammetry, and laser drilling. Usually, these changes in manufacturing technology are phased into the production program rather than introduced at a single unit. This phasing of the manufacturing technology results in a learning curve which will be similar to the one shown in Figure 2 (when presented on log-log paper). Notice that there are two major attributes of the introduction of new manufacturing technology when the learning curve is shown on log-log paper:

(1) There is an immediate reduction in manhours.

(2) There is a curvilinear learning curve.

These two characteristics are shared by engineering changes, except that instead of an immediate reduction in manhours, there may be an immediate increase in manhours. Figure 3 shows a typical ECP.

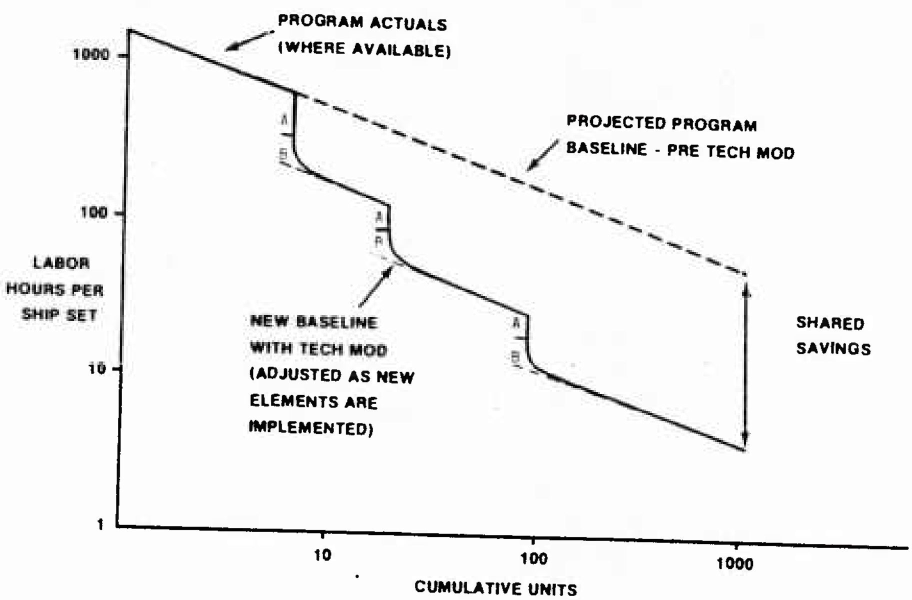


FIGURE 2. EFFECT OF MANUFACTURING TECHNOLOGY IMPROVEMENTS UPON LEARNING CURVES

The curvilinear portion of the learning curve would have been a straight line if the new technology or the ECP had been introduced at the first unit. The curvilinear property is a characteristic of a change which occurs at a unit other than the first one. Figure 4 demonstrates that this curvilinear effect is a result of presenting the learning curve on log-log paper. If the same learning curve had been presented on a Cartesian coordinate system, the learning curve for the new manufacturing technology would have been the same shape at any introduction point. It is upon lot data from the learning curve in Figure 2, either a learning curve with a steep slope or with an S-shaped curve would result. If an S-shaped curve were used, the slope of the center portion of the curve would be steeper. This has led some people to assume that technology improvements cause this steeper slope. However, the steeper slope is an artifact resulting from the cumulative effect of many manufacturing technology improvements. The fundamental slope of the curve is normally

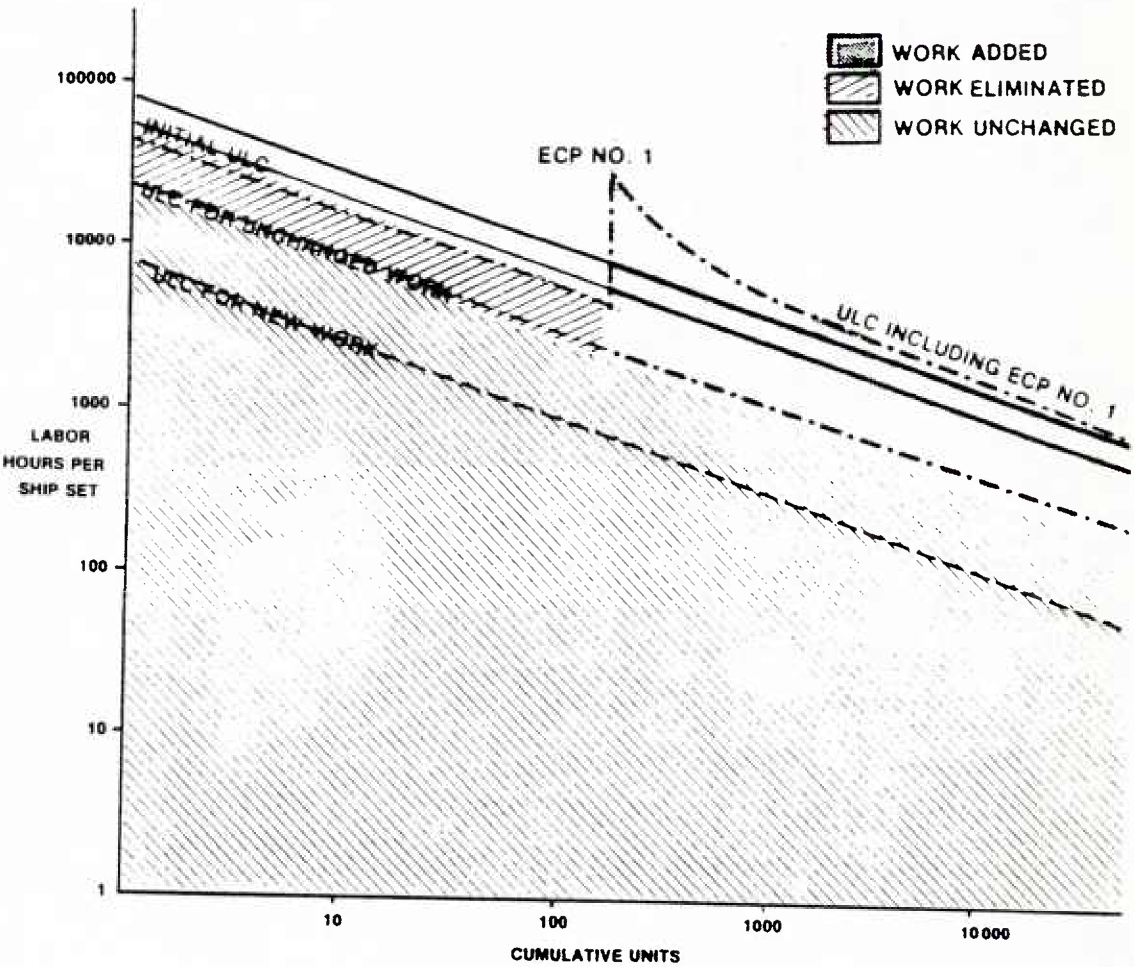
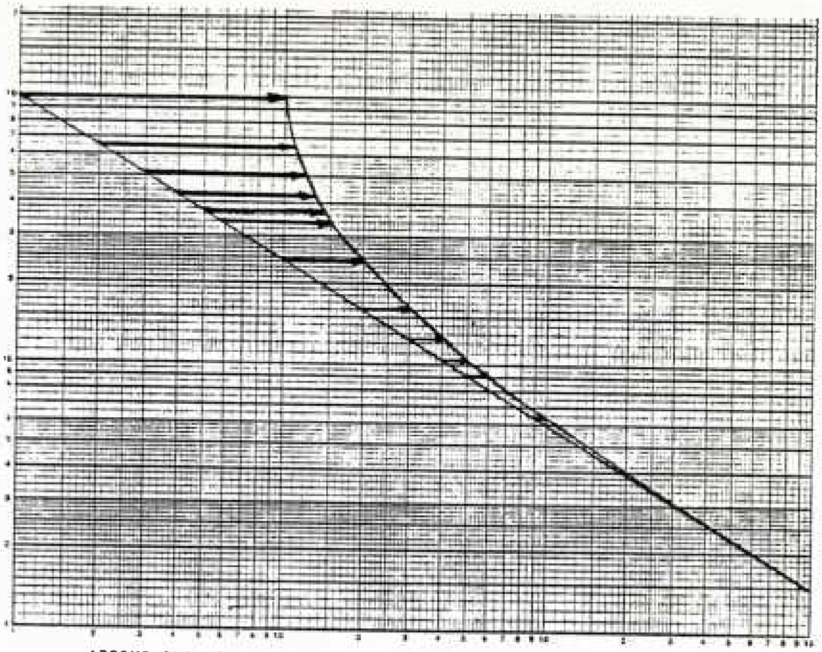


FIGURE 3. IMPACT OF AN ENGINEERING CHANGE PROPOSAL UPON A LEARNING CURVE DRAWN ON A LOGARITHMIC GRID



ARROWS SHOW THE IMPACT OF MOVING TEN UNITS ON LOG-LOG PAPER.

FIGURE 4. EFFECT OF MOVING THE UNIT ONE VALUE TO ANOTHER UNIT

flatter after the introduction of manufacturing technology than it was previously. Historically, when this effect was not recognized, either the S-shaped learning curve or a learning curve with a steeper slope was used to define the learning curve for new programs. This caused the number of manhours projected for the new program to be unrealistically high. Thus, it is important to analyse the effect properly.

The technique for analyzing engineering changes and the introduction of new manufacturing technology is similar. It consists of the following steps:

(1) Identify the underlying learning curve for the production program.

(2) Identify the underlying learning curve for the new manufacturing technology or engineering change. This will require determining of the magnitude of each element of the realization factor at the first unit and the slope for the learning curve associated with new work. For an engineering change where similar manufacturing processes are used, the slope of the learning curve for the new work will remain the same as that of the old work. For new manufacturing technology, the learning curve slope will generally be flatter than that of the old work.

(3) Subtract the work eliminated from the underlying learning curve for the production program at the unit at which either the engineering change or the manufacturing technology improvement will be implemented. Add the first unit cost for the engineering change or new manufacturing technology at this unit. An engineering change will generally lie above the previous underlying learning curve, while new -anufacturing technology improvements will lie below it.

Thus underlying learning curves provide an analytical method of forecasting the impact of change. This capability is not only useful for contract negotiation and program management, but also provides a useful framework for both analyzing the benefits of the Tech Mod Program and negotiating the business deal. The Tech Mod Program is a DOD initiative to strengthen the industrial base of the United States through incentivizing capital investment in new manufacturing technologies which will reduce the acquisition cost of military systems. The specifics of the incentives are established through the negotiation and constitute the technology modernization buainess deal.

SUMMARY

The underlying learning curve concepts provides a basis for tracking the changes caused by new manufacturing technology and engineer changes. In doing so, it provides a technology for contractual negotiation and program management. It provides a frame work for both tracking program cost benefits and negotiating the business deal for technology modernization.

PRICE COMPETITION: GOALS AND TECHNIQUES

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ABSTRACT

In this paper we present a discussion of DoD procurement goals and associated techniques. We attempt to clarify when price competition, the preferred procurement technique, is possible and desirable. We first review procurement goals, and the techniques by which the acquisition community works toward these goals. Next, we discuss conditions for and the desirability of price competition and present performance results in various commodity areas. In the assessment of performance by commodities, we include methods of contracting used in lieu of price competition, such as source selection based on design and technical considerations. However, the focus of this paper is price competition, and its use as a technique to meet procurement goals. We conclude by indicating where the inability to define clearly the goods or services desired and/or the lack of industry capability to supply them reduces the potential for or desirability of price competition.

PROCUREMENT GOAL AND PRICE COMPETITION

The goal of the procurement system is the acquisition of needed goods and services on the basis most favorable to the Government. Generally, this corresponds to the goal of acquisition at lowest price to the Government. However, there are other goals such as the maintenance of industrial capacity for mobilization and socio-economic programs which occasionally override acquisition at lowest price to the Government. Even so, there is a deep seated and historic national belief that procurement goals are best achieved through solicitation of price offers from the maximum number of qualified sources.

The preference for the use of price competition through sealed-bid formal advertising is traceable to the enactment in 1861 of Section 3709 of the Revised Statutes. The Armed Services Procurement Act of 1947, now codified in Title 10 of the United States Code (10 U.S.C. 2304 (a)), provides: "Purchases of and contracts for property or services covered by this chapter shall be made by formal advertising in all cases in which the use of such method is feasible and practicable under the existing conditions and circumstances." The subsection then lists 17 exceptions under which purchases or contracts may be negotiated in lieu of formal advertising. The law goes on, at 10 U.S.C. 2304(g), to require "In all negotiated procurements in excess of $10,000 [with stated exceptions]...proposals, including price, shall be solicited from the maximum number of qualified sources."

On 17 March 1982, Executive Order 12352 was signed by the President. Section 1(d) provides that executive agencies shall "establish criteria for enhancing effective competition and limiting noncompetitive actions. These criteria shall seek to improve competition by such actions as eliminating unnecessary Government specifications and simplifying those that must be retained, expanding the purchase of available commercial goods and services, and, where practical, using nationally-oriented specifications or otherwise describing Government needs so as to permit greater latitude for private sector response."

Price competition refers to source selection and the setting of price based on lowest offer from two or more independent suppliers. Whether by sealed-bid formal advertising or negotiation, it is the preferred procurement technique since it utilizes market forces to ensure reasonable price and access to the Government business without favoritism. Price competition is the procurement technique which accomplishes the goal of acquisition at lowest price. This identification usually carries over to judging the procurement system's performance by a single statistic, the percentage of total procurement dollars awarded as a result of price competition.

OVERRIDING GOALS

There are numerous instances where other goals are more important than lowest price. In these circumstances the selection of a source and the setting of price of performance is often accomplished on a basis other than unrestricted price competition. These circumstances are related to either national security considerations or other overriding goals.

Mobilization Base

The DoD is authorized to negotiate noncompetitively when industrial mobilization factors influence the selection of the supplier. For this purpose there were about 3,700 actions covering $2.85 billion in 1980 and about 5,400 actions covering $4.06 billion in 1981. These purchases are allocated to keep industrial capability available for possible mobilization. Frequently these are awards allocated to two or more sources. In other circumstances price competition is used and a larger share is awarded to the low cost offeror. The DoD thus obtains the benefit of price competition to some degree and also has the continued availability of a potential source.

Time Urgency

Requirements for DoD contract actions are sometimes of such urgency that it is necessary to negotiate promptly with the most available supplier. There simply is not time to arrange for rigorous price competition. (Under these circumstances, the contracting officer's awareness of the market will help him select the supplier most likely to be able to meet the need at acceptable terms.) About $2.2 billion in 1980 and $2.69 billion in 1981 were negotiated noncompetitively on the basis of public exigency including time urgency.

Standardization

Complex operational and/or maintenance requirements can argue for continued acquisition of a product from an established source. Although similarly performing substitute products might be available elsewhere, the benefits of competition would be outweighed by the high cost of duplicate operational and maintenance training and associated logistics support. In effect, a standardized product is acquired to economize on the cost of operating and support.

Socio-Economic Goals

Sometimes the DoD restricts the nature of the competition which is sought and thereby the intensity of the competition obtained. Restrictions are intended to direct Government work towards groups or locations to meet social goals. Major programs where such restrictions are imposed are those by which contract awards are set aside for performance by small business firms or firms owned by designated minorities. Awards under these programs are competitive, but the competition is within a restricted community of potential suppliers. (If competition cannot be obtained within this community, other suppliers are also allowed to compete.) It is not possible to quantify the extent to which this limitation on the intensity of competition may have precluded the DoD from obtaining more advantageous prices. The small business set-aside program resulted in awards of $4.79 billion in 1980 and $8.32 billion in 1981. Directed awards to minority contractors through the Small Business Administration are non-competitive but the Government is not obligated to pay unreasonable prices.

Another example relates to wage floors in construction and certain service contract awards falling under the Davis-Bacon Act and the Service Contract Act, respectively. These constraints effectively limit the extent of price competition by eliminating some potential wage differences. Although price competition is possible and indeed occurs, differences in offered price are mainly due to non-labor input categories such as materials, management salaries, or profit.

Legal Prohibitions

There are a number of legal or regulatory prohibitions applicable to the economy or Government at large which affect the use of price competition by the DoD.

To encourage investment in research and innovation, a private firm can be granted a patent which amounts to a limited monopoly franchise for a new product. While the patent is in effect, the DoD and all other buyers must buy at prices established by the patent holder. To the extent substitute products are available at lower price, this constraint may be avoided.

Another major category of awards where price competition is not sought is in regulated utility services. Awards in this category amounted to $1.8 billion in FY80 and $1.7 billion in FY81. The Government is viewed as one of many buyers of these services and pays the price determined by responsible regulators. Regulated price based on allowable costs incurred plus profit occurs typically for services such as utilities where costs decline with quantity. Under these circumstances regulation is used to take advantage of scale economies.

A final example in this category is the acquisition of architect/engineer services. Under Public Law No. 92-582, the prescribed procedure (DAR 18-300) is to have a preliminary competition on the basis of credentials, and to select three or more qualified firms to participate in a second competition, in which concepts and approaches to the job are evaluated. A selection is made on the basis of the best evidence of qualification to perform the particular task. Price competition is forbidden. About $162 million was spent in 1980 and $200 million in 1981 on architect and engineering services.

PRICE COMPETITION IN DoD AWARDS

With the exception of situations described above, price competition is the preferred acquisition technique. The following tables present the array of goods and services procured by the DoD in 1980 and the methods of procurement used in acquiring them. Table 1 displays, for major categories of awards, the fiscal year '80 dollar totals, the percentage that each category bears to the total and the percentage of award dollars procured by price competition, design and technical competition, follow-on to these methods, and noncompetitively.

Contracts for research and development (13 percent of the total) were awarded predominately by design and technical competition, either initially or as subsequent awards following an initial design competition. Table 2 displays research and development awards by more detailed subcategories. The phased, sequential nature of the R&D process is evident as progressively greater percentages of award dollars are placed as follow-ons to design and technical competition.

TABLE 1. SCOPE OF DoD PROCUREMENT IN FY80: TOTAL AWARDS

NATURE OF PROCUREMENT	TOTAL AWARD DOLLARS (MILLIONS)	PERCENT OF AWARD DOLLARS	PERCENT OF AWARD DOLLARS BY: PRICE COMP.	DESIGN TECH. COMP.	FOLLOW-ON TO PRICE COMP.	FOLLOW-ON TO DESIGN TECH.	NON COMP.
Research & Development	$ 9,398	13	1	33	1	22	43
Other Services & Construction	17,129	23	44	5	1	8	42
Supplies & Equipment	40,814	56	23	4	3	24	46
Purchases of above items of under $10,000 each	6,186	8	41				59
Subtotal	$73,527	100	26	8	2	18	46
Intragovernmental/FMS	10,159		NOT AVAILABLE				
TOTAL	$83,686						

TABLE 2. DoD PROCUREMENT IN FY80: RESEARCH AND DEVELOPMENT AWARDS OVER $10,000

NATURE OF PROCUREMENT	TOTAL AWARD DOLLARS (MILLIONS)	PERCENT OF AWARD DOLLARS	PERCENT OF AWARD DOLLARS BY: PRICE COMP.	DESIGN TECH. COMP.	FOLLOW-ON TO PRICE COMP.	FOLLOW-ON TO DESIGN TECH.	NON COMP.
Research	$ 644	7	1	6		6	87
Exploratory Development	868	9	2	34	1	9	54
Advanced Development	1,834	19		42		19	39
Engineering Development	3,936	42	1	42	1	25	31
Operational System	1,083	12	2	15		37	46
Management and Support	1,033	11	1	33		21	57
TOTAL	$ 9,398	100	1	33	1	22	43

The next category in Table 1 is other services and construction representing 23 percent of award dollars. Within this category construction, real property maintenance, and transportation and travel experience extremely high rates of price competition (see Table 3). Professional, technical and management services, contracts for the operation of Government facilities, technical representative services, and regulated utility services are mostly not price competitive.

The largest major category in Table 1 is supplies and equipment, representing 56 percent of the dollar total. This category includes major weapon systems such as aircraft, ships, missiles and engines, subsystems and components such as electronic aircraft components, fire control systems, engine accessories and instruments, and consumable items such as fuel, subsistence and clothing and textiles (see Table 4). Above average rates of competition were achieved in 1980 in subsistence, clothing, ammunition and ships, while little or no price competition was obtained in missiles, engines and accessories, and fire control systems. A substantial percentage of awards for aircraft, engines, engine accessories were follow-on production awards from initial contracts placed via design and technical competition.

TABLE 3. DoD PROCUREMENT IN FY80:
OTHER SERVICES AND CONSTRUCTION AWARDS OVER $10,000

NATURE OF PROCUREMENT	TOTAL AWARD DOLLARS (MILLIONS)	PERCENT OF AWARD DOLLARS	PERCENT OF AWARD DOLLARS BY: PRICE COMP.	DESIGN TECH. COMP.	FOLLOW-ON TO: PRICE COMP.	FOLLOW-ON TO: DESIGN TECH.	NON COMP.
Equipment Maintenance & Modification	$ 3,628	21	28	3	2	14	53
Construction	2,807	16	93	1	1		5
Utilities & Housekeeping	2,361	14	19			1	80
Professional, Technical and Management	2,294	13	8	17	3	15	57
Real Property Maintenance	1,761	10	89		1	1	9
Operation of Government Facil.	1,548	9	13	12	2	6	67
Transportation & Travel	1,316	8	95		1		4
Technical Representative Service	600	4	2	3	2	29	64
All Other (none over 250)	814	5	28	8	4	15	45
TOTAL SERVICES (other than R&D)	$17,129	100	44	5	2	7	42

TABLE 4. DoD PROCUREMENT IN FY80:
SUPPLIES AND EQUIPMENT AWARDS OVER $10,000

NATURE OF PROCUREMENT	TOTAL AWARD DOLLARS (MILLIONS)	PERCENT OF AWARD DOLLARS	PERCENT OF AWARD DOLLARS BY: PRICE COMP.	DESIGN TECH. COMP.	FOLLOW-ON TO: PRICE COMP.	FOLLOW-ON TO: DESIGN TECH.	NON COMP.
Fuels, Lubricants	$ 7,026	17	22				78
Aircraft	5,696	14	10	11	9	60	10
Communication Equipment	4,793	12	13	12	6	24	45
Missiles	3,228	8	5	2		28	65
Ships	3,091	8	29	3	1	4	63
Engines	2,921	7	4			70	26
Subsistence	1,525	4	59				41
Ammunition	1,364	3	37	1	1	11	50
Electronic Components	806	2	28	4	1	8	59
Instruments	744	2	25	6	3	16	50
Aircraft Components	722	2	17		5	24	54
Fire Control	716	2	8	3	9	19	70
Vehicles	696	2	18			28	54
Clothing	602	1	96				4
Engine Accessories	573	1	18		1	61	20
Weapons	568	1	22	1		14	63
Training Aids	507	1	13	41	1	9	36
All Other (under 500 each)	5,236	13	45	2	1	21	31
TOTAL	$40,814	100	23	4	3	24	46

FEASIBILITY AND DESIRABILITY OF PRICE COMPETITION

Procurement by price competition depends upon two necessary conditions: (1) the ability to describe the requirement in a rigorous but not overly restrictive fashion and (2) the existence of and access to several independent suppliers, with available technical know-how and facilities, willing to satisfy the requirement. The first condition enables source selection to be based exclusively on offered price. The second condition usually requires the existence of a competitive market for a commercial product closely related to the DoD requirement.

Enhanced use of price competition requires changes in one or both of these conditions through direct Government actions. However, satisfaction of the two conditions is not always desirable in terms of risk incurred or benefit/cost to the DoD and society. Instead, source selection based on considerations other than, or in addition to, price (such as product performance factors) and pricing based on estimated cost of performance is sometimes necessary and indeed, sometimes preferred. Procurement of goods and services from a sole source with estimated costs used to establish price has many precedents and acceptance in other sectors of the economy. Public utility service is an example. Such situations are characterized by high levels of fixed investments giving rise to scale economies. Competitive entry would be undesirable since excess capacity would result in higher unit prices. Establishment of market price based on costs incurred and level of investment is used in lieu of competition. There are analogous circumstances within the DoD environment.

Consideration of the feasibility and desirability of price competition can be addressed through examination of the two basic necessary conditions for price competition.

Description of Requirement

Competition in the classical sense requires a statement of a requirement so that offers for identical or identically performing products or services can be evaluated exclusively on the basis of offered price. When products have known but differing operating costs or performance, offered price and lifetime ownership costs can be and are considered together to evaluate best buy. However, there are situations when descriptions adequate for price competition are not possible, not available, or not cost-beneficial to obtain. Such instances are:

1. For many services, including those of a routine low-skill nature, it is difficult to specify and subsequently verify the quality of performance. Consequently, the focus on lowest offered price may necessarily lead to unacceptable or degraded quality as competitors vie for work by offering the lowest price.

2. On some occasions, the desire for price competition leads to the use of detailed Government descriptions so that offers can be judged exclusively on price. Acceptable commercial products not conforming to the Government description ironically cannot qualify under the detailed specifications.

3. The development and initial acquisition of complex systems or components often involve parallel development efforts by competing contractors. The high cost of development and uncertainty associated with technical and market risks usually require that competing development efforts be funded by the Government. Source selection for initial production may be based on a combination of design and price considerations. However, the pricing is for a design that may undergo substantial change so that prior pricing for initial production may not be realistic or meaningful.

4. Reprocurement of complex end items or components from a source other than the original producer requires complete technical data. Often these data may be incomplete or not of sufficient detail to describe shop and manufacturing processes. The transfer of production to a second source may not be economically or technically practical.

5. Logistic support of an end item requires the acquisition of parts, components and subassemblies. To get competition multiple approved vendors or adequate drawings and specifications are required. These are not always available or when available may not attract competitors because reprocurement quantities are low.

Several Independent Suppliers

For situations where the Government possesses adequate but not restrictive description of its requirement and there is an available industry capability to meet the requirement without substantial incremental investment or technical risk, competition is likely to be beneficial. Under these circumstances costs to the Government (mainly administrative for assurance of data and to conduct a competitive procurement) are likely to be outweighed by the cost-saving benefits from competition. Although these benefits are difficult to assess, recent believable evidence suggests that savings in the range of 15 to 30 percent obtain.[1] Savings of this magnitude are achievable in instances where the requisite technology is well known and capability exists; however, extrapolation to other situations is not appropriate.

Major systems acquisition presents a very different set of characteristics and underlying environment from that described above. For major systems or related components and subsystems, the Government is forced to pay explicitly for all attributable costs of their development, and for unique facilitization for production. At the outset of the acquisition process, these products typically do not exist, and indeed their specification is stated in terms of desired performance characteristics. The Government is the single buyer of these products and controls the eventual size of the market and the products' market share relative to other similar classes of products. The environment is inherently risky from two viewpoints: whether a design can be developed and manufactured to satisfy the Government's performance requirements, and whether levels of demand will materialize in the budget process to meet DoD and contractor expectations.

Competition in the classical sense entails a statement of requirement by the buyer (Government) and offers by independent suppliers. For this to occur suppliers must have or be willing to develop suitable products and associated production facilities at their own expense. Offered price would then reflect incurred or anticipated development, investment and recurring costs with fixed costs amortized over current and anticipated production quantities.

Classical competition for either initial production or follow-on reprocurement of weapon systems is unlikely to occur without explicit funding of multiple sources by the Government. Before initial production, several qualified contractors are usually funded to develop, in parallel, competing concepts to satisfy performance requirements. Concurrent parallel development can occur as development proceeds even to the point of requiring competing prototypes for test and evaluation. Source selection, no matter how well-developed and stable the competing design and prototypes, involves tradeoff consideration of technical and performance aspects of the competing products as well as offered price.

[1] Smith, C. H. and Lowe, C. M., Jr., Sole Source and Competitive Price Trends in Spare Parts Acquisitions, Army Procurement Research Office, April 1981.

Once a product has been selected for initial production, it is then possible to consider the introduction of a second source to vie for follow-on procurement. Such competition is typically for identical copies of the incumbent's design and requires a number of difficult and costly steps to create. The steps consist of transferring the incumbent's design and manufacturing process to a second source, the extra cost of the higher than necessary price paid for learning buys to qualify a second source and place him on a competitive footing with the incumbent, and any replication of unique facilities and equipment associated with the program. These costs must normally be borne directly by the Government if a competitive situation is to be created.

The characteristics associated with the acquisition of major systems are by no means uniform and differ by degree across a spectrum. At one extreme are programs with high technical and market risks and requiring large expenditures for unique manufacturing facilities. To interest a single qualified firm to undertake the facilitization of this type of program often requires guarantees by the Government either of a market or of recoupment of the associated unique facilities costs. The Government may even provide some or all of the production facilities or contract with a firm to produce in a totally Government-owned facility. The costs of duplicate facilities, whether reflected in the DoD's budget or borne elsewhere, are unlikely to be justified by competitive savings.

At the other extreme are products which can be produced at any number of available facilities, requiring only slight modification to change from commercial to military production or from one related military program to another. In these situations competition is more likely to be cost-effective.

CONCLUSIONS

There is a natural correspondence between the procurement goal of acquiring goods and services at lowest price and the use of price competition. However, there are situations where other goals, not consistent with price competition, are elevated to a dominant position. These goals are related to national security requirements or social objectives.

For acquisition by price competition, two necessary conditions must obtain. The buyer must be able to describe the requirement adequately and there must exist access to several independent suppliers with available capability to satisfy the requirement. Generally, direct and costly actions by the Government are required to establish these conditions when they are not otherwise present. A case-by-case analysis of costs and benefits of competition is generally required to identify desirable competitive situations. Only in those cases where costs of achieving competition do not exceed the benefits of competition is price competition desirable.

MINIMIZING THE COST IMPACT OF TECHNICAL RISKS AND UNCERTAINTIES PRESENT IN THE FULL SCALE ENGINEERING DEVELOPMENT OF MAJOR SYSTEMS

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ABSTRACT

This paper examines the continuing problem of identifying and assessing technical risk and uncertainty, and resultant cost uncertainty, for major systems entering Full Scale Engineering Development (FSED). A history of changing DOD concepts over the past twenty years concerning the treatment of FSED is presented, together with the implications of these concepts for current problems. Non-technical barriers to the identification and assessment of technical risk and uncertainty, including the problems of "buying in", advocacy and professional discipline orientation are described. Acquisition system modifications are proposed which meet or ameliorate the problems presented and which force increased recognition of, and programmatic planning orientation toward, the degree of technical risk and uncertainty present in each situation.

INTRODUCTION

It is widely recognized that major systems, especially weapons systems, tend to end up costing a great deal more than their original estimates, and, in a number of cases, also fail to attain the performance or operating life capabilities projected for them. For many years, three primary approaches have been advanced toward reducing the cost of major systems:

1) Multi-year funding

2) Buying simpler mechanisms

3) Not performing development and production effort concurrently.

All of these approaches are generally recognized as desirable. Multi-year funding can, by avoiding time stretch-out in the production phase, significantly reduce unit costs. By definition, simpler systems have less problems than complex ones, take less time to develop and produce, and cost less. Concurrency has long been an onerous term to those desiring to reduce major system acquisition costs, because of the cost impact of the risks and uncertainties of not having a fixed design before entering production.

Office of Management and Budget (OMB) Circular A-109 describes the currently prescribed process for acquiring major systems. A large portion of A-109 deals with the steps to be taken to establish and validate the need for a major system; the balance of the circular addresses the overall criteria to be met and the phases to be utilized in the acquisition process. A-109 envisions four phases in the acquisition of a major system:

1) Alternative System Design Concepts

2) Competitive Test and Demonstration

3) Full Scale Development and Limited Production

4) Full Production.

A-109 states that the above phased approach should be employed except when the demonstration of alternatives is either physically or financially not feasible or when the urgency of need dictates starting with a single design system.

Regardless of the degree of competition in the earlier phases, acquisition realities are such that a large number of major systems find their way into the full scale development phase (and even the full production phase) with a considerable amount of unresolved technical risk. Pursuit of the twin objectives of 1) procuring more simple systems and 2) not performing development and production concurrently, will reduce such risk, *to the degree that it is feasible and prudent to do this.* However, countervailing forces are present and strong. Foremost, this is an era of rapidly changing technology which serves both to maintain system complexity levels near the state of the art and to increase the risk of obsolescence for protracted (multi-phased) development programs. Additionally, either practical or financial considerations, or determined urgent need, as recognized by A-109, may cause a compressed development cycle, with the obvious inherent risk. Lastly, A-109, by mandating (properly) against the full design of subsystems in advance of initiating system-level full design, serves to further "insure" the presence of technical risk at the entry to Full Scale Engineering Development (FSED).

In summary, the beneficial application of the precepts of simplicity and non-concurrency will serve to minimize the instances of entering development or production phases with high technical risk but application of those precepts will, unfortunately, often not be feasible. A large segment of technical risk will in fact remain for a substantial number of major system full scale development acquisitions (and even for production acquisitions).

Solutions have been sought for the problem of controlling the cost of major systems for many years. The Department of Defense (DOD) as the largest buyer of major systems has tried varying and dramatically different approaches, of which recent modifications to DOD Directives 5000.1 and 5000.2 (dealing with Major Systems Acquisition) are the latest. But few, if any, believe that systemic control of the acquisition of major systems, of which FSED is a key part, has been satisfactorily obtained. A review of the major thrusts of the past twenty years helps point the way to where answers may be found and, perhaps more importantly, to the pitfalls involved.

HISTORY

In the 1960s, DOD Directive 3200.9 was a guiding document for major systems acquisition. Its genesis was a desire to assure that engineering development would start with a controlling firm Contract End Item (CEI) specifications for both subsystems and systems. These CEIs were the result of a Contract Definition phase which preceded Engineering Design and Development.

Under 3200.9, the task of Engineering Development was narrowly interpreted as restricted to the design, development and demonstration of the design integrity of the requirements prestated in each CEI specification. The belief that this could be accomplished with relatively little unforeseen difficulty led to related requirements for firm schedules, firm cost projections and the recommendation that fixed price type contracts be employed wherever possible for engineering development.

But problems arose with this approach. Mainly, these problems were reflected in numerous engineering change proposals and resultant contract changes which served to radically change the technical baseline which had been "set" at entry into the Engineering Development phase. The problems stemmed from the confidence which the process placed in the quantitative values (parameter allocations) assigned to subsystems and major components as firm specification requirements at the end of the Contract Definition phase. As the technical approaches which were "verified" in earlier phases (Advanced Development, Contract Definition) were pursued in Engineering Development, difficulties continued or arose as hardware, for the first time in some instances, was built, tested (both at a component and subsystem level) and finally integrated. Technical problems at both subsystem and system levels arose which created a cycle of requisite component change/subsystem change/system change, much of which, as the programs progressed, had to take place semi-concurrently. One answer, in some instances, was a reduction of performance requirements. However, in many instances, estimated costs escallated dramatically and continued to do so in the production phase. Two well publicized examples in the late 1960s were the F-111 and C-5A aircrafts.

The above problems caused Deputy Secretary of Defense David Packard to institute, in 1969 and 1970, some major changes. In 1969, he initiated the Defense Systems Acquisitions Review Council (DSARC) to review, at specified major milestone points, the progress of major systems acquisitions and to approve their entry to the next acquisition phase. In 1970, he issued DOD Directive 5000.1 which superceded 3200.9, instituted basic changes, and called for a Validation Phase (following Exploratory Development and Preliminary Advanced Development) to precede Engineering Development.

Engineering Development was viewed, by 5000.1, under the realization that the design was constantly emerging and that it was fluid, rather than fixed, *well into the Engineering Development phase*, in two segments: 1) the firming of component and subsystem specifications and design, and 2) system integration. This was a major pronouncement, confirming the findings of an earlier "Blue Ribbon Panel" which had said the same thing. It resulted in direction to *avoid* fixed price type contracts for initial Engineering Development (the *preferred* means under 3200.9). At the same time, recognition was given to the desirability of a fixed price type instrument for the latter stages of development wherein the elements of risk were sufficiently reduced. This approach was spelled out in a 1972 revision [3-403 (b) (111)] to the Armed Services Procurement Regulations (ASPR) which merits quoting:

> Cost reimbursement type contracts are preferred for all development efforts and particularly for major defense systems. When risk has been reduced to the extent that realistic pricing can occur, fixed price type contracts should be used, e.g., when a program has reached the final stages of development and technical risks are minimal.

OMB Circular A-109, issued by the Office of Federal Procurement Policy in April 1976, does not change the basic philosophy of DOD 5000.1

but very much affects the process. A-109's focuses are, inter alia, to improve needs determination, maximize the use of competitive concepts early in the development cycle, and stress the importance of the program management function. The four phases of the acquisition cycle delineated by A-109 are largely in consonance with the above DOD 5200.1 phases. (DOD 5200.1 and 5200.2 were initially revised in 1977 to reflect A-109 requirements. This revision process has continued.)

IDENTIFYING AND ACCOMMODATING RISKS PRESENT AT THE ENTRY TO FULL SCALE ENGINEERING DEVELOPMENT

Recent General Accounting Office (GAO) Comments on Major Systems Costs and Risks

As might be expected, the GAO, over the years, has been an important commentator on the topic of major systems costs. In a recent report, the GAO said that:

- While it is not unsympathetic to the prompting causes, that pushing the state of the art with new concepts and designs is the greatest single effect on costs.
- Concurrency -- fostered by a desire to rapidly meet threats -- can cause problems of "critical proportions"[1].

The question of concurrency is addressed as regards a specific Air Force program in another GAO report[2] which recommends reassessment of the entire procurement.

In a report[3] assessing the Army's ability to fund new major weapons systems, the GAO recommends that the Army should determine (in consultation with its prime contractors) the foreseeable production risks of eleven major systems and take corrective action and revise cost estimates accordingly.

In another report[4], the GAO says that the DOD must screen and continually prune the number of systems in development in order to have sufficient funds to adequately pursue high ranked programs. The same report lists development difficulties as one of three reasons (inflation and schedule changes are the other two) for the services being unable to procure systems in desired quantities.

Risk and Uncertainty -- Their Differences and Potential Impacts on Engineering Development

Definitions of risk and uncertainty are varied. Some concepts are:

- *Risk* is the likelihood of the event occurring; *uncertainty* is the impact or consequence.[5]
- *Risk* is characterized by incomplete information as to probability of outcome; *uncertainty* represents no information as to outcome.[6]
- *Risk* involves a known possible set of outcomes, each member of the set having a known probability of occurrence; *uncertainty* involves completely unknown probabilities of outcomes.[7]

Though somewhat varied in their concepts, all of the above definitions indicate that risk and uncertainty are different and that we have more information when dealing with the former than with the latter. That proposition has important potential impact on the development cycle, specifically, in this instance, the engineering development phase.

Under the approach of DOD 5000.1 and 5000.2 Engineering Development is deliberately entered prior to the firming of subsystem and major component parameters. The implications of this condition are both historical and predictable. Requisite changes in component or subsystem specifications or design trigger a series of programmatic changes, as General Thurman relates, "all the way down the line, including replanning, renegotiation and reanalysis ... of the program strategy."[8] Engineering Development can contain identified technical risk and unidentified technical risk (uncertainty). These conditions have been referred to as the "known unknowns" and the "unknown unknowns". The propensity for variance in a cost estimate of engineering development stems from a number of variables but probably the most significant one is the degree of technical risk and uncertainty. Although the extent to which risk and uncertainty are present in a given program usually cannot be estimated with precision, it probably can be assessed within a *useful degree* of accuracy. The latter is a key concept and is addressed later in this paper.

Attempts to assess the amount of technical risk and uncertainty present must be undertaken with the caution that:

> High system cost growth appears to arise primarily from efforts to subdue difficult technology on highly compressed schedules ... (and the) acceptance of optimistic assumptions about the long-term predictability of technology and the cost of coping with it.[9]

As Rowe and Somers go on to point out,[10] the longer the time span, the greater the expected variance of actual cost. Since the span of many programs, from initial concept to first delivery of an operational unit, may be ten years or longer, budgetary estimates at the front end of such time frames are subject to wide error. But the problem, from that standpoint, for engineering development should be less for two reasons: there is greater information/data at hand and the time period for a single phase is shorter-term than for the entire process.

If, in spite of the latter factors, it were felt that a reasonably accurate estimate of risk/uncertainty present, and consequently of cost, could not be made, *then an important characterization of that specific engineering development would have been made.*

NON-TECHNICAL BARRIERS TO RISK IDENTIFICATION

Advocacy

Even in a completely technically-oriented environment, the assessment of risk present in an engineering development phase is difficult. But we do not live in a completely technically oriented environment. The attempt to identify risk is made more difficult by two non-technical impediments: advocacy and "buying-in". Much has been written about both of these conditions. They are briefly discussed here because no attempt to identify and manage the risks and uncertainties present in engineering development can succeed unless they are recognized and sufficiently overcome.

The Report of the Commission on Government Procurement said:

> Institutional arrangements and advocacy pressures tend to drive cost estimates downward and to produce overly optimistic schedule and performance appraisals. All levels in a department, in industry and even in Congress, can become parties to the 'selling' of programs founded on unrealistic and unattainable system cost goals.[11]

Further, the Defense Science Board has stated that:

> ... with strong advocates, certain programs may be continued in existence long after they should have been terminated for technical problems ...[12]

Buying-In

The bidding of a deliberately low (usually cost plus fee) figure in order to get the contract, frequently called buying-in, is another long-recognized problem. But the problem of underbidding also finds much of its roots in the inadequate treatment and identification of risk and uncertainty -- either within the contractor's own house, between the contractor and the government, or within the government itself. Two significant attempts to control buying-in are worthy of note, though both have been largely abandoned. One has already been described: the recommended use of fixed price type contracts for engineering development by DOD Instruction 3200.9. A second attempt was the "total package" concept which was designed to prevent a contractor from buying into the program through capturing the engineering development phase with a low bid and then negotiating the production contract from a clearly advantageous position. Under the Total Package Procurement Contract (TPPC) approach, the engineering development (probably cost plus fee) proposal and a fixed price type (usually Fixed Price Incentive) proposal of option prices on production units, were obtained by the government at the same time. The Lockheed C-5A contract was a TPPC. Lockheed could not produce the production units (following much discussion and attempted contract change) within the contractual ceiling price. Its obligation to do so placed the company in severe financial jeopardy. The TPPC, in light of the difficulties of projecting risk and uncertainty as time span increases, is no longer in use. But it still has its proponents, both in this country and abroad. A 1978 article describes a successful TPPC initiated ten years earlier and states that two of the principal reasons for program success were extending the Contract Definition Phase to gain adequate pre-engineering development information and

> Careful selection of known technolcgy appropriate to the real need and application in lieu of high risk technology is a major key to predictable performance, schedule, and cost.[13]

More recently, a 1982 article tells of the Swedish government's decision to develop a multirole combat aircraft using in essence, a TPPC approach. The article describes the requirement of the RFP that:

> The proposal from industry should include *firm prices for development* as well as production, the inflation index being the only price adjustment.[14] [emphasis added]

A 1981 press release relating to the program stated that:

> In the ... proposal, industry is responding to the government's request for *guarantees* regarding performance, characteristics, costs

> and time schedules. These guarantees are unique for Sweden as well as internationally.[15] [emphasis added]

Yes, the guarantees are unique. They were not, some fifteen years ago in the U.S. but as described above, have since become so. The apparent decision to design and build an aircraft *well within the state of the art* and with probably a good deal of pre-qualified hardware assumedly will make the project feasible. That Sweden *believes* it can be done is of interest independent of the eventual results and the reasons for them.

CONCEPTS AND ATTITUDES OF THE PARTICIPANTS -- BOTH CONTRACTOR AND GOVERNMENT

The author, in varied experience as a project manager, negotiator of major contracts and management systems consultant, has seen a thesis validated many times: that it is the overall contracting entities (government, contractor, subcontractor) who are in the meaningful adversary relationship, *not* the personnel representing the various disciplines within those entities. That is, program/project managers from both sides of the contract have a far more common than uncommon orientation. The same can be said for engineers and personnel representing contracts, quality assurance, and management systems, for example. Contrary perhaps to popular belief, it is often the *common* position of these buyer/seller disciplines which governs events or perhaps masks problems.

As relates to engineering development technical risk and uncertainty, several examples serve to illustrate the point:

- Program/Project Managers on both sides are under pressure to *establish* the program and to *complete* it within cost and schedule. Up front, early in contract formulation, they want to understand risk and uncertainty so that they do not personally commit to the unachievable and so that sufficient funding and time are contractually allotted. *After* the contract is initiated, delays and costs beyond those they allowed for in their risk assessments may tend (they often think) to reflect on them jointly. Consequently, problems may get masked or not highlighted and a bow wave of technical problems can start to build.

- Design Engineers on both sides (in an overview function for the buyer) see themselves (usually fairly so) as the bastions of reality. They often see their joint problem as being permitted to really "tell it like it is". When their conclusions (which could be wrong but more often aren't) will seriously stretch out schdules and costs the clear impact of their concerns may not surface in a timely manner.

- Contracts Personnel on both sides want an instrument that can't be criticized for 1) making the seller rich, 2) straight-jacketing the latter's ability to perform; 3) denying the buyer sufficient incremental overview control; 4) constantly having to be amended for avoidable reasons. The last point is of interest in the sense that contract revisions necessitated by the results of technical risk tend to be viewed as occurrences which could not have been contractually pre-accommodated. Contracts people *do* consider risk and uncertainty, *as it is presented to them* pre-contractually, in determining contract type (FP, FPI, CPIF, CPFF, etc.). Beyond that initial determination, the potential consequences of unclear risk and uncertainty are to be contractually protected against by clauses, the specific content of which are, as a counterpoint, frequently a contention between the parties.

- Management Systems People on both sides usually establish PERT-type networks and CSCS criteria baseline plans and schedules which are, by their nature, *success oriented*. Such things as negative slack and cost or schedule variances resultingly become the concerns. The concern tends to be *the rigor of design and application of the specific system*, that is, the structural legitimacy of the system and its outputs. There generally is little systemic concern -- at least emphatic concern -- as to the ability of the system to *pre-plan and display risk*, other than allowing for it in the time and cost estimates which the systems encompass.

A significant exception to the non-incorporation of risk as a specific systemic element is the Army's Venture Evaluation and Review Technique (VERT) which incorporates performance variables into a network structure including cost and schedule variables. A Monte Carlo simulation is employed to assess possible outcomes.

POTENTIAL NEW PROGRAMMATIC AND CONTRACTUAL TECHNIQUES FOR ADDRESSING TECHNICAL RISK AND UNCERTAINTY IN ENGINEERING DEVELOPMENT

Reason and experience combine to tell us that programs are presented for entry into the engineering development phase, FSED, *in varying states of technical risk and uncertainty. This reality should be given emphasis in the process and procedures for reviewing, authorizing and contracting for the FSED of major systems.* It is understood that DOD is envisioning something related to that precept -- the use of "tailored" acquisition approaches and a "maturation" phase either along with or instead of the FSED phase.

A Decision Coordination Paper (DCP) is prepared or updated as part of the DSARC review process. Among the topics covered by the DCP are program risk/uncertainty and acquisition strategy. The latter two concerns are at the heart of any attempt to predict and control engineering development costs.

This paper proposes that in conjunction with the current risk description and assessment presentation included in the DCP, that it would be beneficial to institute *forced subcategorization by risk level* of all programs presented for FSED approval by DSARC II. The concept includes: 1) having the requesting agency clearly declare its estimate of the risk and uncertainty state of the FSED candidate by classifying it within a hierarchical risk and uncertainty structure; 2) establishing a set of evaluation criteria by risk category (pre-DSARC II decision); and 3) establishing post-award program criteria by category.

For example, assume three risk and uncertainty categories for FSED: low, average, and high -- and that we briefly define these as follows:

Low Risk

- little or no pushing the state-of-the-art
- major components and subsystems anticipated as straight-forward and relatively predictable
- similar in concept and application to other reasonably successful hardware

High Risk

- agreement that program needs significant demonstration and validation type effort but operational needs force early FSED entry, or
- heavy dependence on new, unproven technology with only sketchy demonstration and validation data

Average Risk

- between low and high.

Programs submitted in the low risk category would have to be justified as suitable for:

- realistic "success" oriented scheduling and the concomitant baseline planning of the CSCS requirements
- single point cost estimates of purported high confidence level
- potential fixed-price type (probably FPI) contracting for a large segment of the FSED, if not the entire phase (this requirement is arguable)

Conversely, programs submitted in the high risk category would be *barred* from employing any of the above elements and instead would require:

- estimates of schedules and costs in ranges
- acceptance of the understanding that any baseline cost was highly suspect warranting application of an accordingly modified CSCS requirement; expenditure control would be emphasized but "earned value" tracking would not be applicable
- emphasis on the use of technical performance assessment and continuing risk assessment as the *primary* program management functions.

Average risk programs would have their own set of criteria, but the above descriptions should be sufficient to explain the concept.

The contractual implications of the low risk category were described. The high risk category should also receive special contractual treatment beyond that generally provided for FSED today. The specifics of that topic are worthy of imaginative thought. Suffice it herein to say that forced categorization, by stipulating different contractual treatment for different risk categories, would also tend to force contracts and other personnel to take a more active, as opposed to passive, role in ascertaining the relative risks and uncertainties present at FSED initiation.

CONCLUSION

All programs proposed or permitted to enter FSED must have met certain minimal demonstration/validation requirements or face clearly unacceptable FSED risks and uncertainties. But acceptable minimums can be low enough to preclude meaningful success-oriented scheduling and related cost baseline establishment and tracking. Therefore *contractual and program control techniques appropriate to each risk category* of FSED program need to be considered and instituted. Similar sets of contractual and program control techniques need to be established for the low and average risk categories. The bandwidth between the low and high risk categories, as permitted by A-109 and DOD 5000.1 and 5000.2 and as results from strategic realities, is wide. Although the risk/cost emphasis (understandably) is on programs falling in the high risk category, it should not be forgotten that a major option is to tailor certain programs so that they will be truly in the low risk or average risk category. Appropriate procurement and management planning and control techniques *are different* for the risk categories *and should be so pre-tailored*. Making risk and uncertainty analysis a focal point for categorizing FSED acquisitions would tend to force a number of beneficial things to happen:

- The procuring agency has to defend the categorizations they have chosen and -- in the process -- look into their own total planning to face the category distribution of their total programs. This facilitates (and forces) acquisition policy decisions of the highest order.
- The benefits of low risk category acquisitions are highlighted by the differing acquisition and program management techniques mandated for that category. The use of these to-be-desired techniques has to be deliberately and visibly sacrificed when higher risk programs are proposed for FSED.
- Conversely, evaluation and program management techniques appropriate to high risk programs are tailored to the circumstances of such programs rather than employing techniques which assume a degree of programmatic certainty that does not exist.

REFERENCES

[1]GAO Report PSAD-80-6, Impediments to Reducing the Costs of Weapon Systems (November 8, 1979).

[2]GAO Report MASAD-82-9, Air Force Purchase of 30mm Gun Pod System (December 16, 1981).

[3]GAO Report MASAD-82-5, Budgetary Pressures Created by the Army's Plan to Procure New Major Weapons Systems Are Just Beginning (October 20, 1981).

[4]GAO Report PLRD-82-62, Defense Budget Increases: How Well Are They Planned and Spent? (April 13, 1982).

[5]General William Thurman, "Managing Risks and Uncertainty: Looking to the Future", Proceedings, Management of Risk and Uncertainty in the Acquisition of Major Programs, USAF Academy, Colorado Springs (February 9-11, 1981), p. 17 (cited as "Proceedings" hereafter).

[6]A.J. Rowe and I.A. Somers, "Methods to Evaluate, Measure and Predict Cost Overruns", Proceedings, p. 28 (citing Harrison).

[7]Ibid., p. 35 (citing Lev).

[8]Thurman, op. cit., p. 24.

[9]Rowe and Somers, op. cit., p. 46 (citing a Rand report).

[10]Ibid., p. 44.

[11]William G. Moeller, "Affordability for Major System Acquisitions", Proceedings of the Ninth Annual DOD-FAI Acquisition Research Symposium, June 9-11, Annapolis, Maryland, p. 19-13 (citing Commission on Government Procurement).

[12]Ibid., p. 19-13 (citing Defense Science Board).

[13]J.F. Drake, "The Maverick AGM-65A, A Successful Total Package Procurement", Proceedings of the Eighth Annual DOD-FAI Acquisition Research Symposium, Newport, Rhode Island, 1979. p. 148.

[14]Lars Gissler and Harald Schroder, "Sweden's Commercial Approach to Military Aircraft Contracting", Contract Management, April 6, 1982. p. 6.

[15]Ibid.

HOW THE GOVERNMENT CAN USE COMPETITION OF THE MARKETPLACE IN BUYING COMMERCIAL PRODUCTS

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ABSTRACT

Competition is an effective way to assure reasonableness of price. But in the Department of Defense over half of procurement expenditures are reported as non-competitive. Similar statistics are not available from industry, but in our discussions with representatives of a wide range of companies, we were advised that few purchases are made without competition. So why does Government have problems implementing its own rules? We have concluded that the rules for procurement and reporting on competition obtained were developed for acquisition of special design products to satisfy a military need. They are not suited for buying privately developed products sold competitively in the commercial marketplace. Since commercial products and services directly and indirectly represent a major portion of DOD procurement, how they are bought and reported has an impact on credibility of the entire procurement process.

Our research indicates that revisions to the procurement process in buying commercial products as well as appropriate changes in the way these purchases are reported, when prices are based on catalog or market prices, will enhance competition in the Department of Defense. This paper is based on research and findings of the Commission on Government Procurement, the Don Sowle Associates study on competition in the DOD, the proposal for Federal Procurement Reform by the Office of Federal Procurement Policy, the proposed draft DOD 5000.37M, and many other sources including experiences of the author in buying commercial products for the Government. It provides a blueprint for action that can be implemented without statutory change. It is long overdue.

FORMAL ADVERTISING - The Armed Services Procurement Act of 1947 and the Federal Property and Administrative Services Act of 1949 were designed to maximize competition. They both require use of the Formal Advertised method of purchase except when negotiation is specifically authorized. Since the formal advertised method is based on a concept of "price competition," it can only be used when all bidders are offering virtually the same product under the same terms and conditions. The process for accomplishing this objective is to issue formal invitations for the lowest bid to furnish a specified product under a complex contract with detailed terms and conditions. Proposed changes in policy to use specifications or purchase descriptions that outline performance requirements of form, fit, and function have not been successful because they conflict with basic rules of formal advertising. Commercial products sold in the marketplace to a variety of users are not all in the same quality or price range, and they are not sold under the same terms and conditions. So in seeking "price competition" in buying most commercial products, the competition is limited to companies that are willing to comply with the Government process and furnish products that barely meet the specification. This poses several problems including:

- need for costly detailed specifications or purchase descriptions to avoid unsatisfactory products
- fewer competitors since those with quality products that cannot compete on a price basis with those of lessor quality will not bid
- lost opportunities to consider product value that can lead to least total cost
- reduced credibility of the procurement process by users that don't want lowest quality merchandise
- increased sole source purchases when users preselect products and justify sole source to avoid price competition

These problems are associated with those commercial products where there are significant differences in product value. It is recognized that there are many common commercial supply items such as nails, wire, lumber, etc. where industry standards and marketplace buying practices enable use of price competition. Formal advertising may be the best business approach for these items. However, the cost of formal advertising in relation to potential benefits in lower prices also needs to be recognized in order to make a good business decision. Current procedures do not include consideration for cost of the procurement process since there is a general assumption that formal advertising is the best and most economical method whenever it can be used. Since cost of the process is not a consideration there is no incentive to evaluate cost and effectiveness of alternative procedures. The OFPP Uniform Procurement System proposed to the Congress 26 February 1982 would resolve this problem by making the choice of formal advertising or competitive negotiation a business decision rather than a statutory requirement. The objective would be to achieve effective competition in a way most advantageous to the Government.

LEAST TOTAL COST - Effective competition can be obtained by soliciting offers of products with a range of values and selecting the one representing the least total cost to the Government. It is also appropriate to consider the cost of the procurement process, the method of distribution to the point of use and alternative support options as part of the least total cost decision. This is necessary since alternative techniques of buying and the commercial distribution/support alternatives vary considerably in cost and effectiveness.

Current reporting rules provide for only two classifications of competition: price and technical. There is no classification for a combination of the two where least total cost is the criteria for award. Under current procedures, if value is to be considered, it has to be reported as technical competition which infers that price or cost is not considered. In buying commercial products with significant differences in product value it is good business practice to solicit offers on a wide range of products, evaluate the offer, including products and terms of sale, and select the offer that is considered to be best value for the Government. But the DAR does not provide guidelines on how and when to buy value, and there is no way to report least total cost based on competition of the marketplace. So the reporting system has a direct impact on the procurement process. This problem has been recognized by OFPP in its proposal for a Uniform Federal Procurement System. The OFPP proposes that in addition to price competition a category of lowest total cost be provided. The third proposed category is multiple factors which is equivalent to the current category of technical competition.

Findings and Conclusions - There is a need for a reporting category of competition using least total cost as an evaluation criteria. This additional reporting element would:

- expand competition where factors other than price are to be considered because it would encourage suppliers with a better product to compete;
- reduce sole source purchases by increasing credibility of the procurement process with users;
- reduce total costs to the Government by purchase of the "best buy," not just the lowest price item.

Action Required - Add a category of least total cost competition between the currently required reporting categories of price and technical competition. This new category would be used to report competition where evaluation criteria include both price and technical considerations on a least total cost basis.

NEGOTIATION AUTHORITY: Legislation may be required to fully implement the OFPP Proposal but the objective of least total cost can be achieved under current statutes. A primary requirement is authority to use the competitive negotiation method as opposed to formal advertising. The exceptions to formal advertising outlined in the Armed Services Procurement Act address various conditions that need to be met before they can be used. Exception 2304(a)(10) in both statutes is "for property or services for which it is impracticable to obtain competition" by formal advertising. The DAR cites several examples of when it can be used. One of the examples is "when it is impossible to draft, for a solicitation of bids, adequate specifications or any other adequately detailed description of the required supplies or services." Since there are few cases where it is impossible to develop a specification, that could be used in formal advertising, the DAR inhibits use of this exception when buying commercial products. It should be noted that the General Services Administration uses exception (10) for authority to negotiate multiple award Federal Supply Schedules. The product description used in solicitations calls for a company's commercial products within a Federal stock class. The pricing for these schedules is based on catalog or market prices rather than on price competition, but when the lowest price item on contract is ordered by the using activity from among several alternatives the order meets the criteria of price competition. And when the selection is justified on the basis of product value rather than lowest price, it meets the criteria of technical competition. However, DOD reports all calls against Federal Supply Schedules as inter-departmental procurement, so no competition credit is obtained by use of these contracts.

Findings and Conclusions - The DAR has unduly restricted the use of exception 2304(a)(10) by example xiii which incorporates the word "impossible" rather than "impracticable," thereby restricting its use.

Action Required - Revise example xiii to exception 2304(a)(10) by changing the word "impossible" to read "impracticable."

MARKETPLACE COMPETITION - Before strategies are formulated for the purchase, distribution and support of required items and purchase specifications are selected or developed, the

Government should find out what the marketplace has to offer. The marketplace is dynamic, with new products and new technologies continuously introduced to commercial users. Even though DOD requirements for commercial products are large, only a small portion - 10% or less - of the output of US industry is sold to the Government. Government acquisition should be structured around those products made and sold in the private sector as a first consideration to preclude the cost of modification of standard commercial items or the cost of special design to a Government specification. Normally, only when large quantities of an item are purchased at one time can industry affort to redesign these products or produce a special design product for the Government and, even then, costs may be too prohibitive to be competitive. Therefore, competition is enhanced when standard commercial products are purchased.

Commercial business practices, including distribution and customer support channels developed for commercial users, should be considered during the marketplace analysis. The cost and effectiveness of commercial distribution and support alternatives can then be compared with that of Government distribution and support systems and an appropriate strategy formulated. Acquisition strategy includes consideration of various contracting techniques including multiple award contracting. The DOD uses the GSA/FSS multiple award contracts but does not provide for this technique in the Defense Acquisition Regulations. Provision has been made for marketplace analysis in the draft 5000.37M, including use of various contracting techniques, but this directive has not yet been released.

Findings and Conclusions - Marketplace analysis is essential for structuring a most cost effective acquisition strategy including consideration of alternative contracting techniques.

Action Required - Expedite release of 5000.37M, Acquisition and Distribution of Commercial Products.

ACQUISITION MANAGEMENT - The results of marketplace analysis will provide the basis for design of a cost effective strategy. Such a strategy cannot be accomplished, however, until all elements of purchasing, distribution and support are considered in an overall strategy and a single individual is assigned the responsibility for decision-making. Under the present organizational structure, except for major system program managers, there is no single point of responsibility for acquisition programs. User needs are determined and specifications are developed by various offices. Marketplace analyses, if performed at all, are fragmentized between several offices, contracting is a separate function after many crucial acquisition decisions have already been made, and distribtion and support decisions are made by yet different organizations. Many individuals participate on the acquisition team, but unless there is a "quarterback," each team member makes decisions benefiting limited areas of interest rather than for the good of the acquisition program as a whole.

Findings and Conclusions - The Department of Defense organizational structure needs to be reviewed and measures taken to assure that a single individual is responsible for acquisition stratgegy for every commodity line.

Action Required - Change the single item manager concept to a product line manager concept.

COST OF THE ACQUISITION PROCESS - The most significant cost factors for consideration in the acquisition process are time that the process takes from identification of need at the user level to the time the need is filled, and the cost of paperwork in requesting, purchasing and delivering the product.

In acquisition and distribution of commercial products the Commission on Government Procurement found that the least costly and most effective techniques were procurement systems such as Functional Support Contracts and Multiple Award Contracts. Functional Support Contracts are arrangements where a single supplier is selected competitively to provide all supplies or parts needed to support an operational function such as a motor pool. Effectiveness and economy of functional support is achieved by drastic reduction of paperwork by enabling suppliers to deal directly with operators of an operational activity on a prepriced contract basis. Multiple award Federal Supply Schedules also reduce individual purchase negotiations by centralizing contracting on a regional or Government-wide basis and providing for selection of the least costly product at the point of use.

One of the problems with current logistics policy is that the controlling factor is the unit price of the item rather than the total cost of providing the item to the point of use, including the cost of ownership and the cost of the acquisition process. For example, the unit price of automotive maintenance parts provided directly to the mechanic by a functional support contractor may be 20% higher than the price of the parts delivered to a Government depot. But the total cost to the Government is likely to be much less than if the mechanic had to wait for a part purchased for him by a Government buyer hundreds of miles away. This problem is even more acute when procurement processes are automated. This is especially true of small purchase automated procedures where the cost of the process may exceed the value of property purchased.

Findings and Conclusions - The cost of the acquisition process from identification of need to delivery at the point of use as a percentage of the unit price of the item must be taken into account in the formulation of acquisition strategy and contracting approach.

Action Required - Revise cost models and other method of support decision systems to reflect cost of the procurement process and distribution alternatives as a percentage of the product value rather than the cost of processing a requisition or contract.

CATALOG OR MARKET PRICES - Public Law 87-653, the Truth in Negotiation Act, establishes a requirement for cost and pricing data on all purchases of $100,000 or more. Exceptions are made where (1) there is adequate price competition, (2) the prices are based on catalog or market prices, or (3) prices are established by law. This statute, which amends the Armed Services Procurement Act of 1947, establishes catalog or market prices as a valid means of determining reasonableness of price. But the DOD has not developed procedures for use of catalog or market prices except in evaluating sole source purchases and making small purchases where price analysis is used in lieu of cost analysis. However, purchases of brand name foods for commissary resale made through Centrally Issued Supply Bulletins, and the Allied Sources Acquisition Program (ASAP) for a variety of commercial products purchased overseas are priced on the basis of catalog or market prices. These are multiple source programs similar to the GSA/FSS Schedules. All are for commercial products where marketplace competition assures reasonableness of price in establishing contract prices. A second level of competition occurs at point of use where the lowest price product meeting the need is ordered. Multiple source contracting by the DOD for all commercial products where product value needs to be considered was recommended in the Don Sowle Associates report to enhance competition. However, no action has been taken on this recommendation. Multiple source contracting would increase competition even if the recommendation to establish least total cost as a competition category is not implemented. This would occur because selection of the lowest priced item will satisfy the requirement for price competition and the least total cost item, when justified, can still be reported as technical competition.

The General Accounting Office recently issued a report (B-205720) indicating that "DOD officials concurred with our conclusion that follow-on and catalog or market price contracts are non-competitive." The report did not show how this conclusion was arrived at but in discussing the issue with DOD officials it was indicated that the GAO Report was based on sole source purchases where catalog or market prices were used to determine reasonableness. Only in this situation is the Procurement of a Commercial Product non-competitive. If the marketplace was analyzed, alterative proposals for comparable products solicited and proposed prices were based on catalog or market prices, the procurement would be competitive. If the lowest priced item was selected it would be price competition and if other than the lowest priced item was justified on a technical basis it would be technical competition.

Findings and Conclusions - The DOD could expand competition in buying commercial products by use of multiple source contracting based on catalog or market prices.

Action Required - Provide guidance in the Defense Acquisition Regulation (DAR) on the circumstances where catalog or market prices can be used, including multiple source contracting.

CRITERIA FOR SELECTION OF R & D PROJECTS

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PURPOSE

The objective of this paper is a proposed set of operational criteria that can be used to rank research projects. With this ranking approach, a decision maker can determine which projects to select or continue, in order to meet the requirement of achieving specific goals and objectives. The use of criteria ranking helps to facilitate measuring whether the progress of research projects meets performance objectives.

BACKGROUND

The process frequently used to meet the broad objectives of research, exploratory development, and advanced development requires further refinement in order to meet the objectives of affordability, timeliness, and effectiveness. The approach recommended here includes criteria which assure focusing on projects with the highest likelihood of meeting objectives and achieving desired results.

The development of criteria for use in ranking goals and objectives and selecting projects, however, should be consistent with DOD 5000.2, RDT&E Management, the POM (Program Objective Memorandum) process, and other relevant documents. A research study based on information obtained from interviews and published material was used in this paper as the basis to establish an approach for operational criteria that can be used in program evaluation.

As shown in Figure 1, research is the precursor of exploratory development and advanced development. Research efforts tend to be more basic than those for development efforts and are aimed at scientific study and experimentation which increases knowledge and understanding. These efforts are applied to engineering, environmental, biological-medical, and behavioral sciences as they relate to national security needs. They also expand the fundamental knowledge needed for advancing the state-of-the-art.

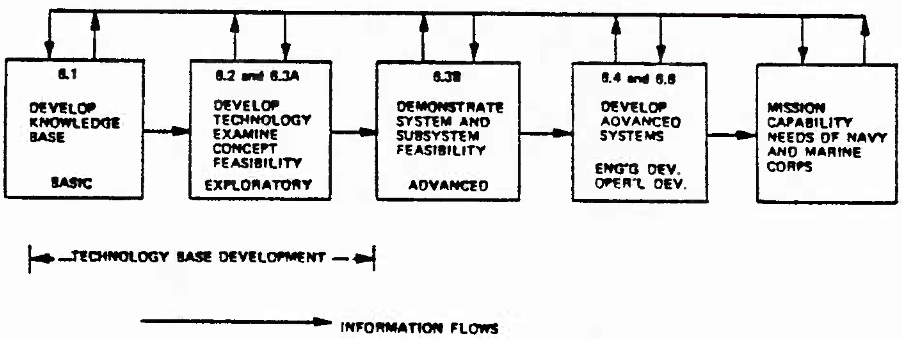

FIGURE 1 FUNCTIONAL VIEW OF THE DEFENSE RDT&E PROCESS

(SOURCE: DEPT OF NAVY RDT&E MANAGEMENT GUIDE, 15 DEC. 1979 NAVSO P-457 (REV. 12-29)) P. 2-9

FACTOR	ANALYSIS METHODOLOGY	FUNCTION PERFORMED	DOD 5000.2 IPS (INTEG. PROG. SUMMARY)
1. ENVIRONMENT	STRATEGIC PLANNING & MISSION ANALYSIS	IDENTIFY THREATS & OPERATIONAL REQUIREMENTS	THREAT ASSESSMENT, SYSTEM VULNERABILITY
2. ORGANIZATION	ORGANIZATION ANALYSIS	ORGANIZATIONAL DYNAMICS, RELATIONS, STRUCTURE, & PERFORMANCE	ORGANIZATIONAL & OPERATIONAL CONCEPT
3. RESOURCES	ECONOMIC ANALYSIS	ALLOCATIONS, RETURN ON INVESTMENT, BUDGET CONTROL	ACQUISITION STRATEGY, COST
4. TECHNOLOGY	TECHNOLOGICAL FORECASTING & ASSESSMENT	SELECTION CRITERIA, PRIORITIES, ADVANCES IN TECHNOLOGY	TECHNOLOGY ASSESSMENT, RISKS, PROGRAM ALTERNATIVES

FIGURE 3 — ANALYSIS METHODOLOGY & OUTPUT FOR FOUR FACTORS

Determining the Overall Mission

Given the above perspective, a Research and Development group responsible for developing a technology base can also effectively explore opportunities for integration of technology into existing weapons systems. Integration of technology into a currently used weapon system can be as significant as a new technological breakthrough because overall weapon effectiveness includes balancing the risks of developing technology with the costs and performance resulting from integrating advanced weapons systems concepts.

For example, a military command, in determining its overall mission, could use as its primary focus the following goals:

1. Maintenance of a technology base superior to that of any potential adversary.
2. Minimize the likelihood of technological surprise.
3. Advance the technology applicable to present and future weapon systems.
4. Develop innovative and superior weapon systems.
5. Enhance combat readiness and force modernization.
6. Improve the image of the Research & Development team.
7. Assist in building industry research components.
8. Improve deficient capabilities in weapon systems.
9. Meet general military requirements.
10. Develop new weapon systems concepts.

The primary mission of research is inexorably linked with technology development. In the long run, it requires developing an advanced technological base in order to have superior weapons systems. Both short and long run requirements entail support for the 6.4 and 6.5 programs shown in Figure 1.

Thus, technology is the driver of system improvement, and development of new technology is concerned with advancing the state-of-the-art.

Developing Specific Target Areas

With its mission defined, a military organization can determine the critical products, services, and advanced systems integration that are required. Several key requirements which help define the target areas for meeting broad mission statements are:

1. Research projects should be considered a portfolio which contains both high-priority, urgent projects and longer-term high-payoff technological advances and new-concept development.
2. Technology demonstrations that show the feasibility of new developments or integration of new technologies into existing weapons systems.

FACTOR	BASIC CATEGORY	MILITARY CATEGORY
1. ENVIRONMENT	THREAT URGENCY	MILITARY UTILITY
2. ORGANIZATION	RESEARCH PROCESS	PROGRESS EVALUATION
3. RESOURCES	ALLOCATION PROCESS	ECONOMIC ANALYSIS
4. TECHNOLOGY	SELECTION JUSTIFICATION	TECHNOLOGY UNIQUENESS

FIGURE 4 — BASIC CATEGORIES

Exploratory development strategies include: identification and solution of problems in the development process; identification of technological opportunities for new or improved capabilities; and demonstration of potential usefulness of new discoveries. Exploratory development does not include engineering development, refinements, or broad-based studies.

Exploratory development strategies contain specific technical thrusts and priorities to meet anticipated future mission needs based on application of new high-leverage technical opportunities. The intent is that the "major" portion of these strategies be demonstrably related to the technical strategies that meet mission needs.

A BASIC MODEL FOR RESEARCH CRITERIA

The conceptual approach used for establishing the ranking criteria is a four factor model that identifies the key elements which affect the potential outcome for a given organization. The four factors which are shown in Figure 2 include:

1. The "environment" in which the organization operates.
2. The "organizational" relationships and dynamics that influence the ability to perform the functions or tasks assigned.
3. The "resources" needed to accomplish the basic function and tasks of the organization.
4. The "technological" advances which form the basic function carried out by the organization.

Each of the factors relate to categories used in research and development. The factors utilized depend on a number of different analysis methodologies in order to fully cover specific requirements. These are summarized in Figure 3.

The analysis shown in Figure 3 is indicative of the applicability of the proposed approach. The four factors also provide the basis for categorizing the criteria to be employed. The basic categories that will be used are shown in Figure 4.

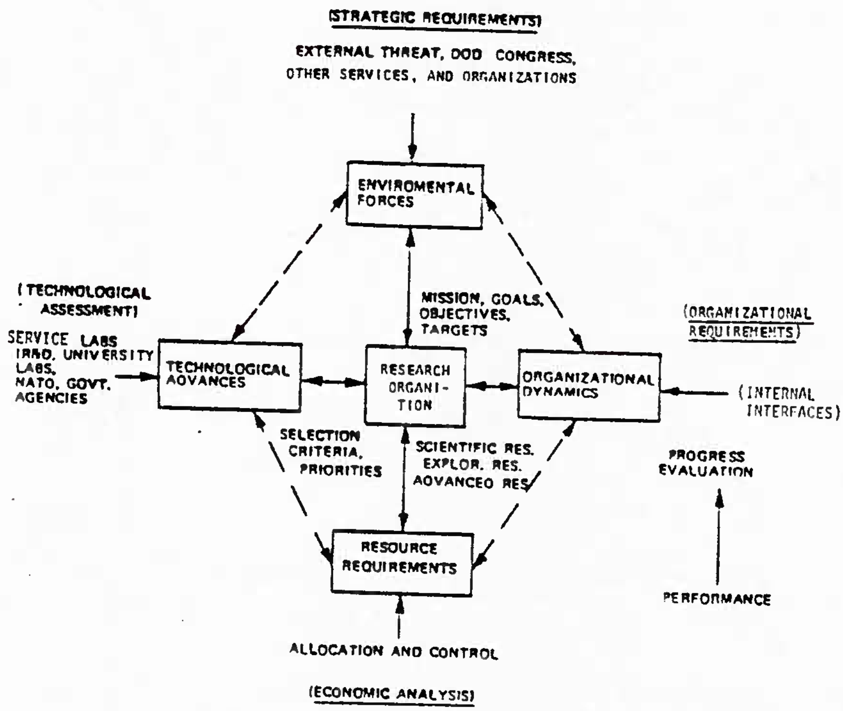

FIGURE 2. FOUR FACTOR MODEL

3. A body of technical knowledge which builds on basic physics and the chemistry of materials, generic new-technology developments, software development, biomedical advances, human-factors approaches, and total-system concepts.
4. Enhance existing capability to achieve greater effectiveness.
5. Advance developments which utilize new technical breakthroughs to significantly enhance weapon capability.
6. Assessment and prioritization of research to achieve greater effectiveness of mission performance and identify and minimize cost-driver elements.

With target areas designated, the application of evaluation criteria to assist in the assessment and prioritization of projects can be readily undertaken. The criteria and measures developed in this paper cover a comprehensive systems perspective of this process. The four factor approach assures that all relevant aspects of the problem are considered.

ASSESSMENT CRITERIA AND MEASURES

Using the four categories described in Figure 4, specific criteria were developed and measures determined which would permit ranking of projects and performance. It should be recognized that criteria are not equally applicable to each project; rather, the level of detail which should be used is commensurate with the importance of the project. Both assessment criteria and the measures are illustrated in Figure 5. The values assigned to the measures would be based on the judgment of qualified individuals who can assess the relative importance of each of the criteria.

Other Considerations in Assessing Projects

The criteria presented above are primarily guides to judgment and should be supplemented by a number of additional considerations to assure appropriate evaluation of alternative projects. These considerations are:

1. Each organization should have a research portfolio containing a mix of projects that are designed to achieve multiple objectives.
2. The mix of projects typically follows a Pareto distribution which identifies the relative importance of projects.
3. The role of qualified individuals to conduct the research needs to be recognized. Past performance is an excellent indicator of future expectation.
4. Organizational slack should be considered in terms of the relationship between an organization's capability and the demands placed on that capability. The likelihood of project disruption and delay increases sharply as the ratio of demand to capability approaches unity.
5. External constraints may limit performance and should be examined to determine whether a project can meet the schedule and output desired.
6. Technological forecasting methods can be applied in order to anticipate technological advances.
7. Based on the life-cycle approach, the half-life of a given technology can be used to determine potential obsolescence.
8. Normal cost estimating may not be applicable in experimental work due to the uncertain nature of research and lack of prior knowledge.
9. Sub-optimization results from attempting to maximize only one variable, whereas joint optimization achieves an overall optimum by trading off two or more variables.

The above list is indicative of considerations which should be applied in addition to the use of the criteria described in Figure 5.

SCORING

Measures for each of the criteria can be specified in terms of ordinal ranking, numeric values, or utility functions. The TORQUE approach was used for scoring the attributes of projects. The narrative descriptions and scoring method are shown in Figure 6. The scoring used is illustrative and can be more comprehensive if required.

Pareto Subset

The basic criteria developed utilized the four factor approach which provides a balanced perspective on project selection and evaluation. However, recognizing the time required to produce a POM, a subset of criteria utilizing the Pareto Law was also applied.

The Pareto Law is an approach used to identify the critical subset of any group of items in terms of their relative importance or impact. As shown in Figure 7, research projects can be ranked so that approximately 20% contribute 80% of the potential payoff to the research organization.

Given the complexity of the POM process, it is recommended that the criteria and measures developed be applied initially to screening high-priority projects, using a subset of criteria based on the Pareto Law of distribution of importance.

Figure 5
ASSESSMENT CRITERIA & MEASURES

CRITERIA	MEASURES
I. Environment (Strategic Requirements)	
1. Mission	
a. Operational Requirement (OR)	a. meets needs
b. Science and technology objective (STO)	b. meet objectives
c. Mission Area Summaries (MAS, TAD)	c. meets mission
2. Vulnerability/Survivability	
a. Enemy capability	a. strength
b. System reliability/response	b. survivability
c. CBR susceptibility	c. vulnerability/survivability
3. Urgency	
a. Criticality/Urgency	a. urgency
b. Mandated/Required	b. required
c. Priority/Utility	c. desired
4. Threat	
a. Operational capability	a. meets threat
b. Deterence ability	b. readiness
c. Weapons/strength/quantity available	c. inferiority
II. Organization (Organizational Requirements)	
1. Goals & Objectives	
a. Evaluation of user needs	a. consequences
b. Mission analysis/(MENS)	b. importance
c. Rank targets	c. justification
2. Performance	
a. Evaluate progress	a. status
b. Establish controls	b. flexibility
c. Quality of researchers	c. availability
3. Interaction	
a. Technology transfer	a. multi-mission
b. Research labs	b. meets requirements
c. Expert reviews	c. support
4. Communication	
a. Publication	a. number
b. Funding directed research	b. level
c. Conference	c. number
III. Resources (Allocation, Economic Analysis)	
1. Justification	
a. Project success	a. probability
b. Deficiency need	b. meet need
c. Likelihood of acceptance by user	c. probability
2. Funding	
a. Level of resources available	a. amount available
b. Time frame of need	b. current/future
c. Cost	c. affordability
3. Return	
a. Cost/benefit	a. ratio
b. Advance in state-of-the-art	b. amount advance
c. Return on investment comparison	c. return
4. Support	
a. Special equipment or facilities required	a. availability
b. Are other organizations performing research	b. dependency
c. IR&D funding	c. level of support

IV. <u>Technology</u> (Technological Assessment)

1.	<u>State-of-the-Art</u>	
	a. Degree of complexity of technology	a. complexity
	b. Knowledge available in the field	b. prior research
	c. Level of interrelatedness	c. interrelatedness
	d. Interdependency with other projects	d. interdependency
	e. Degree of support required/special manpower	e. support required
2.	<u>Type of Risk</u>	
	a. Degree of uncertainty	a. amount
	b. Level of concurrency	b. amount of overlap
	c. Likelihood of disruption/delay	c. probability
3.	<u>Importance of Technology</u>	
	a. Electronics	a. degree of fit
	b. Avionics	b. degree of fit
	c. Weapons	c. degree of fit
	d. Chemicals	d. degree of fit
	e. Medical/Behavioral/platforms	e. degree of fit
4.	<u>Evaluating Technology</u>	
	a. Extensiveness of literature search	a. amount
	b. Reaction of research labs/experts	b. support
	c. Prior research available	c. availability
	d. Likelihood of success of technology	d. probability

Figure 6
SCORING CRITICALITY OF A TECHNOLOGY OBJECTIVE*

	Score
<u>Absolutely Essential or Mandated</u> Failure to have this technology will absolutely prevent the attainment of the cability desired...	10
<u>Major Contribution</u> Failure to acquire this technology will result in a significant decrease in one or more of the major performance parameters needed to attain the capability desired..	7
<u>Substantial Contribution</u> Failure to achieve this technology will result in the loss of a highly desirable but not essential capability desired.......................	5
<u>Cost Reduction</u> Success in achieving this technology will provide a major reduction in the cost of achieving the capability desired.........................	4
<u>Refinement of Capability</u> Achievement of this technology will result in some refinement of the present capability..	3
<u>Indirect Contributions</u> Achievement of this technology will only be an indrect contribution to the capability desired..	2
<u>Remote Association</u> This effort has only a remote association with the capability desired.	1
<u>No Contribution</u>..	0

*Trozzo, C.L. <u>Description and Critique of Quantitative Methods for the Allocation of Exploratory Development Resources</u>, Paper P-731, Institute for Defense Analyses, May 1972.
[this is essentially the same scoring Methodology.]

Figure 8
PARETO SUBSET FOR POM-APPLICATION

CRITERIA	QUESTIONS	MEASURES
I. Environment (Strategic Requirements)		
1. Mission		
a. Operational Requirement (OR)	a. What degradation in readiness, survivability, manpower, energy, or safety would occur if not implemented?	a. meets need
b. Science and technology objective. (STO)	b. How significant an improvement over existing performance can be expected?	b. meets objectives
c. Mission Area Summaries (MAS, TAD)	c. How is the project related to the Master Urgency List (MUL)?	c. meets mission
2. Vulnerability/Survivability		
a. Enemy capability	a. How critical is the deficiency? Is this an area of significant enemy threat?	a. strength
b. System reliability/response	b. none	b. survivability
c. CBR susceptability	c. none	c. vulnerability
3. Urgency		
a. Criticality/Urgency	a. How does deficiency relate to overall organization objectives?	a. urgency
b. Mandated/Required	b. Who identified deficiency (Congress, DOD)	b. required
4. Threat		
a. Operational capability	a. Will this project affect weapon strength operational capability?	a. meets threat
b. Deference ability	b. Does the project change enemy capability, eg. force them to come closer or fire over longer distance?	b. readiness
c. Weapons/strength/quantity available	c. Does the project enhance fire power significantly, e.g. range, velocity, quantity of weapons?	c. inferiority
II. Organization (Organizational Requirements)		
1. Goals & Objectives		
a. Evaluation of user needs	a. What need would this technical breakthrough serve?	a. consequences
b. Mission analysis/MENS	b. to which mission would the project contribute?	b. importance
2. Performance (none)		

III. Resources (Allocation, Economic Analysis)		
1. Justification		
a. Project Success	a. What is the likelihood of project success?	a. Probability
b. Deficiency need	b. What deficiency does project address?	b. meet need
c. Likelihood of acceptance by user	c. What is the likelihood of project acceptance by the user?	c. probability
2. Funding		
a. Level of resources available	a. Can the system be implemented with proposed budget levels?	a. amount available
3. Return		
a. Advance in state-of-the-art	a. Is this a technical breakthrough	a. amount advance
4. Support (none)		
IV. Technology (Technological Assessment)		
1. State-of-the-Art		
a. Degree of complexity of technology	a. What level of technology is involved in this project?	a. complexity
b. Knowledge available in the field	b. Does success of this project depend on other R&D programs?	b. prior research
2. Type of Risk (none)		
3. Type of Technology		
a. Chemical	a. Does the project increase surveillance, e.g., detect, identify, target enemy?	a. degree of fit
b. Medical/Behavioral	b. What missions wil the project support?	b. degree of fit

Figure 9
PROJECT NARRATIVE

1. Claimant: Defense organization
2. Project Title: Structural and High Temperature Alloys
3. Project Number: XXXX
4. Objective: To perform research on new structural and high temperature alloys and their properties, to generate the scientific data, ideas and approaches needed for the production of new airframe, propulsion and functional materials; to meet the performance requirement of aircraft and missiles for the 80s and 90s.
5. Approach: Evaluate and exploit the mechanical, physical and chemical properties of steels and aluminum, titanium, and nickel base alloys for application in the airframe and energies of future naval aircraft and missiles. It is anticipated that these alloys will be produced by new techniques such as solidification in the form of single crystals and rapid solidification powder technology as well as new compositions produced by traditional processes. Fracture, crack growth, and fatigue mechanisms are particularly studied along with tensile, creep stress rupture, and environmental embrittlement over the range of operating temperatures and environmental conditions of naval aircraft. Advanced techniques as well as the traditional and most advanced microstructural characterization approaches are explored in these programs.

6. Impact: New materials and a better understanding of the properties of already developed alloys will provide the basis for materials developments required for future naval aircraft and missiles with lighter weight/higher temperature tolerance airframes, higher thrust, more efficient propulsion systems and the ability to withstand the natural and threat environments unique to naval aviation. It is noted that progress in realizing advanced designs for airframes and propulsion systems is MATERIALS LIMITED. Add to this the aggressive albeit unique military environment, the successful realization of new aviation weapon systems rests on progress in materials science and engineering.

7. Recent Accomplishments: The advanced acoustic emission facility has become operational. The signal processing software has been written and debugged and a unique calibration scheme has been developed. Experiments have shown unquestionable differences between frequency spectra of acoustic emissions from different cracking mechanisms in different materials. In a study of trace element effects on fracture, it was found that temper embrittlement of 4340 steel was mitigated or eliminated by removal of Mn and Si. A Ni base single crystal superalloy has been indentified over a 100 degree F improvement in creep strength compared to DS Mar-M200+Hf but more alloying modifications are needed to improve oxidation and hot corrosion resistance to comparable levels. Hydrogen detection device (barnacle electrode) transitioned, to 6.2 then to use. Environmental crack arrestment compounds for stress corrosion and corrosion fatigue have been developed. The role of metallurgical structure in influencing low cycle fatigue life of turbine hot section components is being established and should result in longer hot section life. New understanding of the role of microstructure on the fatigue and fracture growth of titanium should lead to improved structural integrity of titanium components.

8. Fy84 and 85 Plans: Extensive mechanical physical property evaluation, oxidation/ corrosion resistance testing, castability testing and ultimately engine testing of cast blades will be done on an optimized single crystal alloy. Also single crystals of alloys derived from composition of strong RST alloys will be prepared by directional solidification and tested. Advance corrosion control efforts will be pursued including: effects of magnetic fields on hydrogen absorption in steels; ion deposited polymeric coatings for corrosion prevention; hydrogen diffusion studies through Al and Ti; inhibitors for hydrogen absorption in steels including crevice corrosion phenomena. Emphasis will be maintained on the investigation of fatigue and fracture of aircraft high strength structural alloys and high temperature alloys including their resistance to the environment and nondestructive testing for quality control and in-service inspection. Efforts will also continue on parameters that control nucleation of separate grain in single crystal turbine blade alloys. New initiatives will be extended into the understanding of the metallurgical characteristics of new processing techniques. Rapidly Solidifed Power (RSP) and their subsequent processing into shapes, laser processing and Ion Implantation are examples of new processes that require additional scientific investigation. Alloy design for layer deposition technology will continue. The following new starts are planned:

a. Effects of a Magnetic Field on H Absorption in Steels.
b. Ion Deposited Polymeric Coating for Corrosion Prevention.
c. Inhibitors of Hydrogen Absorption in Iron.
d. Study of Hydrogen Pick-up During Crevice Corrosion.

Transition accomplishments are as follows:

Item	Funding Category	Sponsor
Advanced by Acoustic Emission from simulated structures	6.2	military organization
Electomechanical Hydrogen Detection System	6.2	military organization
Single Crystal Blade Alloy	6.2	military organization
Corrosion Monitor for measuring corrosion		

e. Electro-deposition of Metals from Organometallic Synthesis (Elimination of H-Embrittlement Effects).

9. Transition Objectives:

Item	Year	Funding Category	Fund Req.	Sponsor
Corrosion Prevention Tech.	84	6.2	XXXX	military organization
Accoustic Emission Technology	84	6.2	XXXX	military organization
Single Crystal Superalloys	85	6.2	XXXX	military organization
Layer Deposition Technology	84	6.2	XXXX	military organization

10. Funding Profile ($ in thousands):

FY83	FY84
XXXX	XXXX

11. Other Considerations: Several programs in the structural and high temperature alloys area alloys are based on Rapid Solidification Technology (RST) including "High Modulus Aluminum Alloys," "High Modulus Corrosion Resistant Aluminum," and "Layer Deposition Superalloys." These have significant potential.

Figure 10
SAMPLE PROJECT EVALUATION

- Military Organization
- Structural and High Temperature Alloys
- Project Number XXXX

Criteria	Measures	Scores
I. Environment (Strategic Requirement)		
1. Mission		
a. Operational Requirement (OR)	a. meets needs	7
b. Science and technology objective (STO)	b. meets objectives	7
c. Mission Area Summaries (MAS, TAD)	c. meets mission	7
2. Vulnerability/Survivability		
a. Enemy capability	a. strength	-
b. System reliability/response	b. survivability	10
c. CBR susceptibility	c. vulnerability	-
3. Urgency		
a. Criticality/Urgency	a. urgency	7
b. Mandated/Required	b. required	7
c. Priority/Utility	c. desired	-
4. Threat		
a. Operational capability	a. meets threat	7
b. Deterence ability	b. readiness	-
c. Weapons/strength/quantity available	c. inferiority	-
II. Organization (Organization Requirements)		
1. Goals & Objectives		
a. Evaluation of user needs	a. consequences	7
b. Mission analysis/(MENS)	b. importance	-
c. Rank targets	c. justification	7
2. Performance		
a. Evaluate progress	a. status	10
b. Establish controls	b. flexibility	-
c. Quality of researchers	c. availability	7
3. Interaction		
a. Technology transfer	a. multi-mission	7
b. Research lab	b. meets reqts.	7
c. Expert reviews	c. support	10
4. Communication		
a. Publication of research	a. number	1
b. Funding directed research	b. level	-
c. Conference	c. number	-
III. Resources (Allocation, Economic Analysis)		
1. Justification		
a. Project Success	a. probability	7
b. Deficiency need	b. meet need	7
c. Likelihood of acceptance by user	c. probability	10
2. Funding		
a. Level of resources available	a. amount available	5
b. Time frame of need	b. current/future	5
c. Cost	c. affordability	5
3. Return		
a. Cost/benefit	a. ratio	7
b. Advance in state-of-the-art	b. amount advance	7
c. Return on investment comparison	c. return	-

4. Support		
a. Special equipment or facilities required	a. availability	7
b. Are other organizations performing research	b. dependency	7
c. IR&D funding	c. level of support	-
IV. Technology (Technological Assessment)		
1. State of the Art		
a. Degree of complexity of technology	a. complexity	7
b. Knowledge available in the field	b. prior research	7
c. Level of interrelatedness	c. interrelatedness	-
d. Interdependency with other projects	d. interdependency	5
e. Degree of support required/special special manpower	e. support required	5
2. Type of Risk		
a. Degree of uncertainty	a. amount	-
b. Level of concurrency	b. amount of overlap	-
c. Likelihood of disruption/delay	c. probability	-
3. Type of Technology		
a. Electronics	a. degree of fit	-
b. Avionics	b. degree of fit	-
c. Weapons	c. degree of fit	-
d. Chemical	d. degree of fit	-
e. Medical/Behavioral	e. degree of fit	-
4. Evaluating Technology		
a. Extensiveness of literature search	a. amount	3
b. Reaction of research labs/experts	b. support	5
c. Prior research available	c. availability	7
d. Likelihood of success of technology	d. probability	7

SELECTED BIBLIOGRAPHY

Augustine, Norman R. "Augustine's Laws and Major System Development Programs." Aeronautics and Astronautics, April 1980, January 1981, February 1981, March 1981, April 1981.

Baker, N. A. and Sweeney, D. J. "Toward a Conceptual Framework of the Process of Organized Technological Innovation Within the Firm." Research Policy, Vol. 7, 1978, pp. 1150-74.

Baker, N. R. "Toward an Analytical Framework for Service Organizations," presented at the SIV International Meeting of TIMS, Mexico City, August 1967.

Genson, George and Chansen, Joseph. The Structure of New Product Organization. New York: AMACOM, a Division of American Management Associations, 1976.

Bobis, Arthur H. and Atkinson, Anthony. "Analyzing Potential Research Projects." Chemical Engineering, part I, 23 February 1970, pp. 95-101, part 2, 9 March 1970, pp. 133-42.

Cetron, Marvin J. "Technological Forecasting: A Prescription for the Military R&D Manager." The Journal of the Armed Forces Management Association, Vol. 2, No. 9, 1969, p. 49.

Christakis, A. N., Globe, S. and Kawamura, K. "Choosing Topics for Technology Assessment." IEEE Transactions on Systems, Man, and Cybernetics, Vol. SMC-10, No. 1, January 1980, pp. 1-7.

Crawford, C. Merle. "Defining the Charter for Product Innovation." Sloan Management Review, Fall 1980, pp. 3-11.

Davies, C., Demb, A. and Espejo, R. Organization for Program Management. New York: John Wiley & Sons, 1979.

Fahey, Liam; King, William R. and Narayanan, Vadake K. "Forecasting in Strategic Planning--The State of the Art." Long Range Planning, Vol. 14, February 1981, pp. 32-39.

Fiscal and Life Cycles of Defense Systems. Pomona, California: Pomona Division, General Dynamics, 1980.

Gambino, Anthony J. and Gartenberg, Morris. Industrial R&D Management. New York: National Association of Accountants, 1979.

Hannan, E. L. "The Use of Goal Programming as a Descriptive Model for Organizational Decision Making." 1977 N.E. AIDS Proceedings. Albany, New York, April 28-30, 1977.

Howard, Niles and Antill, Susan. "Putting Innovation to Work." Dun's Review, October 1980, pp. 72-81.

Kantrow, Alan M. "The Strategy-Technology Connection." Harvard Business Review, July-August 1980, pp. 6-21.

Kruzas, Anthony and Gil, Kay. Government Research Centers. Detroit, Michigan: Gale Research Company, 1980.

Larson, Ralph H. "Making R&D Relevant." Research Development, June 1976, pp. 36-40.

Latham, Gary P.; Cummings, Larry L. and Mitchell, Terence R. "Behavioral Strategies to Improve Productivity." Organizational Dynamics, Winter 1981, pp. 5-23.

Martino, Joseph P. "Technological Forecasting--An Overview." Management Science, Vol. 26, No. 1, January 1980, pp. 28-33.

McConkey, D. D. MBO for Nonprofit Organizations. New York: American Management Associations, 1975.

Merrifield, D. Bruce. Strategic Analysis Selection, and Management of R&D Projects. New York: AMACOM, a Division of American Management Associations, 1977.

Michael, S. R. "Tailor-Made Planning: Making Planning Fit the Firm." Long Range Planning, Vol. 13, No. 6, December 1980, pp. 74-79.

Nelson, Bryce. "U.S. Position in Aviation Threatened, Panel Warns." The Los Angeles Times, 7 February 1981, part III, p. 15.

Padgett, John F. "Managing Garbage Can Hierarchies." Administrative Science Quarterly, Fall 1980, pp. 583-603.

Patz, Alan L. and Rowe, Alan J. Management Control & Decision Systems. New York: John Wiley & Sons, 1977.

Porter, A. L. and Rossina, R. A. "Technology Assessment/Environmental Impact Assessment: Toward Integrated Impact Assessment." IEEE Transactions on Systems, Man, and Cybernetics, Vol. SMC-10, No. 8, August 1980, pp. 417-24.

Porter, Alan L.; Rossini, F. A.; Carpenter, S. R.; Roper, A. T., et al. A Guidebook for Technology Assessment and Impact Analysis. New York: Elsevier North Holland, Inc., 1980.

Quinn, J. B. "Managing Strategic Change." Sloan Management Review, Vol. 21, No. 4, Summer 1980, pp. 3-20.

Ralph, Christine. "Resource Allocation Logic." Chemical Engineering Process, Vol. 66, No. 5, May 1970, pp. 31-34.

Ramo, Simon. The Management of Innovative Technological Corporations. New York: Wiley-Interscience, 1980.

Rechtin, Eberhardt. "Slackening R&D Is No Way to Maintain National Power." Aeronautics and Astronautics, December 1971, pp. 22-35.

Roberts, Edward B. and Frohman, Alan L. "Strategies for Improvement Research Utilization." Technology Review, March-April 1978, pp. 32-40.

Roman, Daniel E. Science, Technology & Innovation: A Systems Approach. Columbus, Ohio: Grid Publishing Co., 1980.

Rosenbloom, R. S. "Technological Innovation in Firms and Industries." Kelly, P. et al. (eds.). Technological Innovation: A Critical Review of Current Knowledge. San Francisco, Ca.: San Francisco Press, 1978.

Rowe, Alan J.; Mason, Richard O.; Dickel, Karl. Strategic Management and Business Policy, Addison-Wesley, Reading, Mass., 1982.

Rubenstein, A. H. Studies and Analysis of the Management of Scientific Research and Development, Including Implementation and Application at NASA Centers. Evanston, Illinois: Northwestern University, Department of Industrial Engineering and Management Sciences, August 1975.

Sage, A. P. and White, E. B. "Methodologies for Risk and Hazard Assessment: A Survey and Status Report." IEEE Transactions on Systems, Man and Cybernetics, Vol. SMC-10, No. 8, August 1980, pp. 425-446.

Salomon, J. "Technology and Economic Policy in a Changing World." Research Management, Vol. 24, No. 1, January 1981, pp. 36-41.

Schorr, Alan E. "Expertise and Technological Innovation: 1960-1970." Exchange Bibliography, Monticello, Illinois: Council of Planning Librarians, May 1974.

Seurat, Silvere. Technology Transfer: A Realistic Approach. Houston, Texas: Gulf Publishing Co., 1979.

Susman, G. I. "Planned Change: Prospects for the 1980s." Management Science, Vol. 27, No. 2, February 1981, pp. 139-54.

Thompson, Paul H. and Dalton, Gene W. "Are R&D Organizations Obsolete?" Harvard Business Review, November-December 1976, pp. 105-16.

U.S. Air Force Systems Command. Torque: Discussion of Procedure on Experimental Test, Vol. 1, Washington, D.C.: Government Printing Office, 1967.

U. S. Department of Defense. Description and Critique of Quantitative Methods for the Allocation of Exploratory Development Resources, by C. L. Trozzo, ARPA/IDA, Washington, D.C.: Government Printing Office, 1972.

U.S. Department of Defense. Functions of the Department of Defense and its Major Components. (DOD Director 5100.1, publication UNCLASSIFIED.) Washington, D.C.: Government Printing Office, September 1969.

U.S. Department of Defense, USDRE. Major System Acquisition Procedures. (DOD Instruction 5000.2, publication UNCLASSIFIED.) Washington, D.C.: Government Printing Office, 19 March 1980.

U.S. Department of Defense, USDRE. Major System Acquisitions. (DOD Directive 5000.1, publication UNCLASSIFIED). Washington, D.C.: Government Printing Office, 19 March 1980.

U.S. Navy. Advanced Planning and Appraisal of NAVORD Research and Technology. (Naval Ordinance System Research and Technology Directorate.) Washington, D.C.: Government Printing Office, 1974.

White, P.A.F. Effective Management of Research and Development. New York: John Wiley & Sons, Inc., 1975.

Winkofsky, E. B.; Baker, N. R. and Sweeney, D. J. " A Decision Process Model of R&D Resource Allocation in Hierarchical Organizations." Management Science, Vol. 27, No. 3, March 1981, pp. 268-83.

Wirt, John G.; Lieberman, Arnold J. and Levien, Roger E. R&D Management: Methods Used by Federal Agencies (R-1156-HEW). Santa Monica, California: Rand Corporation, January 1974.

Wright, Norman H. Jr. "Matrix Managment: A Primer for the Administrative Manager." Management Review, April 1979, pp. 58-61; May 1979; June 1979, pp. 57-58.

THE ROLE OF TOP-LEVEL CM/CCM MANAGEMENT
in
NEED ASSESSMENT & ACQUISITION PLANNING

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ABSTRACT

For over a decade various attempts have been made to improve top-level CM/CCM management in DOD — but with marginal results. This paper addresses the baseline aspects of CM/CCM management. First we examine the general role of CM/CCM in DOD weapon systems acquisition management by addressing the following fundamental questions: Is CM/CCM significant enough —e.g., does it consume a major portion of the DOD acquisition resources or does it play a high-leverage role on the battlefield -- to warrant management as a separate entity? And if so, what are the salient features of CM/CCM that make it so difficult to manage, particularly at higher echelons? Then we focus on the Army, and examine the existing machinery for top-level CM/CCM management, identify the Army's objectives in this area, and assess the extent to which these objectives are realized.

INTRODUCTION

Some weapons systems are fielded without adequate hardening to potential countermeasures. In such cases, if the other side somehow surmises one or more of the system's soft spots, it is in a position to significantly degrade the system's effectiveness, thus virtually neutralizing a battlefield asset with relative ease, or, what may at times even be worse, turning it into a liability.

A considerable fraction of the DOD acquisition budget goes for hardening our weapons systems against potential exploitation by the enemy. This hardening activity has been known as vulnerability/survivability, etc. But in recent years it has been most often referred to as countermeasures/ counter-countermeasures (CM/CCM). This is probably the most appropriate term because it conveys the thought of assessing potential enemy countermeasures (CM) and deciding on the need for an appropriate suit of counter-countermeasures (CCM).

For over a decade various attempts have been made—as reflected in memoranda by the Deputy Secretary of Defense and in Defense Science Board (DSB) and Army Science Board (ASB) reports, for example -- to improve the top-level management of CM/CCM. The fundamental CM/CCM management issues are captured in a short piece of advice an Army general recently gave to a group of executives of the DOD acquisition community. He asked them to consider the following questions during each phase of the system's development: Will you be fielding an asset? Or will you be fielding a vulnerability? And, more importantly, do you know the difference?

This paper addresses the baseline aspects of CM/CCM management by examining the existing management machinery and identifying the issues. Specifically, we first examine the general role of CM/CCM in DOD weapon systems acquisition and then we focus on top-level CCM management in one of the Services, viz, the Army, identifying its objectives and assessing the extent to which they are realized.

ROLE OF CM/CCM

The CM/CCM community functions in an advisory capacity, interacting directly with the Program Manager (PM). The PM, however, does not always appreciate its advice for several reasons. First, he does not always agree with it; he frequently does not have the technical expertise on hand to refute it; and he does not have the resources to implement it, even if he wanted to. At times the PM even resents the advice because it somehow finds its way to various places in the Pentagon. We therefore examine such questions as: Why does the CM/CCM community insist on interacting directly with the PMs? Unlike the intelligence community, the CCM community has no direct leverage on the PMs. Why then doesn't the CCM community leave the PMs alone, channel its advice to the intelligence community and get them to modify the "blessed" threat—to which the PM must respond. In other words, how is implementing CCM different from working against the threat? Why isn't it sufficient for the PM to work against the threat?

Working Against The Threat

When working against the threat we are basically oriented to what the other side is doing or planning to do. For example, suppose the threat changes as follows: the enemy decides to improve his air defense by, say, increasing the number of radar sites, fielding a better low-altitude detection capability, increasing the number of interceptors and improving their quality (e.g. increased maneuverability, speed and firepower) and by fielding an improved airborne look-down capability. Such an improved air defense system constitutes a countermeasure (CM) to our strategic bombers because now our bombers are detected earlier and at lower altitudes, and are confronted with more formidable interceptors. Fewer bombers get through. And the net result is that the effectiveness of our strategic bomber force is reduced.

Working against this changed threat may consist of one or more of the following: (1) Simply buying more bombers so the required number would get through (2) building an improved bomber, or (3) building a new missile system to be carried on our existing bombers, enabling them to deliver their missiles from a greater standoff distance.

Implementing CCM

CM/CCM is basically oriented toward specific aspects of our own systems that may frequently still be under development or even in the design and planning stages. In a sense, the origin of the problem is on our own side, not on the enemy's side. The problem stems from the number of potential soft spots we are likely to have in the system — intentionally or unintentionally. When we leave a soft spot intentionally, we are usually doing it as a result of a judgment that the other side is unlikely to find it profitable to exploit it and that consequently it is not worth our effort, time and money to patch it up.

The first step in CM/CCM is to identify the soft spots of our own system, by means of analysis and/or testing. The second step is to estimate or judge to what extent the enemy will be able to surmise these soft spots — how many, which ones, and how he will perceive/envision them. The third step is to decide which subset of the soft spots that the enemy surmised he is likely to try to exploit, how he might go about achieving his goal, and what price he is likely to be willing pay for it. The fourth step is to decide what solutions — tactical and/or technical — are or could be made available against such exploitation. If a tactical solution is selected then it usually does not significantly affect the development of the system, but it may nevertheless have some price associated with it. If, on the other hand, we decide on technical solutions, the next, or fifth, step is to estimate the impact of each solution on the system in terms of cost, schedule, technical performance, complexity, and supportability. The final step is to decide — in light of the price associated with each solution — which soft spots we want to patch up.

CM/CCM MANAGEMENT

The DOD acquisition community is not always convinced that there is a CCM management problem. As a matter of fact, because of the occasional friction between elements of the acquisition community and the CCM lead laboratories, the acquisition community sometimes believes that CCM is the problem. We therefore examine the following two questions: Is there really a CM/CCM management problem? And if so, is the problem significant enough to merit special attention?

To answer the first question, for over a decade, DOD guidance — as reflected in memoranda by the Deputy Secretary of Defense and in DSB and ADB reports, for example — has emphasized the need to improve the top-level management of CM/CCM. This guidance stems in part from the fact that a significant fraction of the systems experiencing delays as a result of the outcome of OT II have serious CCM problems which had not been detected in the earlier phases. Such problems could have been corrected with relative ease, if addressed in time. The later in the systems development cycle that a soft spot is identified, the more the CCM "correction" is likely to impact the cost, schedule and technical complexity of the system. And therefore the higher the pressure and temptation not to implement the necessary CCM.

To answer the second question, the CCM management problem is significant enough to merit special attention for the following reasons: (1) CM/CCM consumes a significant fraction of the DOD acquisition resources, (2) CCM is a very critical feature of weapon systems and has very high leverage on the battlefield, and (3) CCM frequently lacks "visibility" at the systems level. Furthermore, since CCM is highly judgmental, it must be carefully balanced. These CCM features are briefly discussed below.

Judgment and Balance

The system is initially designed against an existing and/or projected threat—or, more accurately, due to the uncertainties associated with our knowledge and projections, the system is designed against a threat band. The initial design usually includes adequate CCM. But, since it typically takes about twelve years to field a major weapons system, as the system is developed and tested two things happen: (1) the threat, or our knowledge of the threat, changes and (2) certain new soft spots, that were not initially apparent during the design of the system, come to the surface. CM/CCM is therefore highly judgmental. It involves assessing our own system for potential soft spots, making predictions regarding the enemy's knowledge and intentions, and making tradeoffs.

In each Service there are quite a few specialized organizations, or lead laboratories, each chartered to address a different aspect of CM/CCM. The PM is saturated with excellent inputs. Because CCM frequently has very high leverage on the battlefield, there is a temptation to recommend more and more CCM. But it is impractical for the PM to implement all these "good" CCM recommendations, no matter how well justified each is from its own narrow perspective. If he tried, the system would probably be too costly, the schedule would be delayed to the point where the system would be technologically obsolete by the time it was fielded, the reliability of the system would be severly degraded, and it would be too complex, too bulky and too heavy to be operated effectively on the battlefield. Furthermore, CCM is usually an iterative process: while each blanket of CCM eliminates a set of potential vulnerabilities, it frequently brings into play a new set of its own.

Also when we consider the fact that the enemy also has limited assets (even when they are quantitatively significantly greater than our own) we tend to invest much less in CCM. We sometimes change our thinking from that of providing as much immunization as possible to a line of thought which says that if the enemy really wants to invest an unusually large amount of his limited assets to neutralize one of our systems, it may indeed pay to let him do that, and not protect our system but rather to sacrifice it, because in terms of the total picture on the battlefield it may be an exchange greatly favorable to our side.

But how much CCM is enough? Where do we draw the line? Who decides what CCM is included and which system soft spots are left uncovered? How are the decisions made? And what are they based on? The CCM line is essentially drawn on an intuitive basis. The PM usually makes the decisions, in light of sporadic guidance from higher echelons and very intense pressures from a number of functional CM/CCM organizations, or lead laboratories.

Magnitude of CM/CCM

There are many ways of judging the importance of a element in DOD systems acquisition. Each method has its strengths and weaknesses and none commands unanimous agreement. One relatively objective way is by the magnitude of the resources it consumes. Therefore, to put CM/CCM in a better perspective, we examine the fraction of the DOD acquisition resources that go for CCM.

An attempt to gain a handle on the size of the DOD CCM resources by interviewing key members in the DOD acquisition community yielded estimates that were orders of magnitude apart, and are therefore deemed too unreliable to be worth reporting here. An examination of the open literature yield much more consistent figures. The unclassified portion of the FY 1982 DOD budget and other unclassified sources indicate that DOD is spending about $2.8 billion in a research, development, test and evaluation (RDT&E), and about $3.4 billion in production for a total of $6.2 billion for CM/CCM in FY 1982 alone. These figures suggest that CM/CCM is highly R&D intensive.

If we were to assume, on the other hand, that CM/CCM is not significantly more R&D intensive than most of the other areas in DOD but that the apparent relatively low production-to-R&D ratio reflects the fact that CM/CCM frequently loses visibility in the systems arena (as discussed in the next section), we get an estimate of $7.4 billion for CCM in the production area, or a total CCM expenditure of $10.2 billion in FY 1982.

Lack of Visibility

In CM/CCM top level management is particularly difficult because, with few exceptions, CM/CCM funds in the systems arena (6.3B and above) lose their visibility above the PM level. This is so because CCM by its very nature is frequently not a system itself but rather a functional part of a system or subsystem. This can be easily illustrated by means of an example. Consider the case where we found that one of our air defense systems is vulnerable to enemy antiradiation missiles (ARMs) which are capable of homing on the sidelobes of its radars. One possible solution is to build decoys. A second solution is to go to a different frequency band where the air defense system can still accomplish its mission but where it is difficult to build effective ARMs. This type of solution may frequently be impracticable because it involves replacing the entire radar systems. A third possible solution is redundancy: leave the radars as they are but simply build enough systems so that even after some are knocked out by ARMs, there are still enough left to do the required job. A fourth solution is reducing the sidelobes of the antennas. The first three solutions are examples of "tangible" CCM--where CCM constitutes a clear-cut subsystem or system. The fourth solution, on the other hand, is in a sense an example of "intangible" CCM. The new, improved antenna subsystem may cost 10 times as much as the previous one. Yet, on the surface at least, we are merely paying for an antenna. Its CCM feature cannot be "touched". It does not have clear-cut visibility. Here CCM is not a system itself but rather a functional part of the new antenna subsystem. This type of CCM solution is the type most frequently encountered in weapon systems development.

To consider CM/CCM management on a more specific level, we focus on one of the Services, viz., the Army—with the assumption that the CCM management picture is probably not significantly different in the other Services and that solutions developed for improving the Army's top-level CM/CCM management can probably be adapted, with relative ease, for the other Services.

ARMY CM/CCM

Major Players

The two major CM/CCM players in the Army are the Materiel Development and Readiness Command (DARCOM) and the Training and Development Command (TRADOC). DARCOM is the developer; TRADOC represents the user. The major players in TRADOC are its specialized schools and centers (the Air Defense School Artillery School, etc.) and the Combined Arms Center, at Fort Leavenworth, which performs the integrating function. The major players in DARCOM are (a) the Directorate for Development and Engineering (at HQ DARCOM), (b) the Directorate of Technology Planning and Management (at HQ DARCOM, by viture of its control of the Army's Technology Base), (c) the Center for Systems Engineering Integration, or CENSEI (at the Communications and Electronic Command, CECOM, in Fort Monmouth, playing an indirect role by virtue of its overall systems integration responsibility), (d) the DARCOM CM/CCM Office or Center (at the Electronics Development and Research Command, or ERADCOM, in Adelphi, Maryland) serving DARCOM's focal point for CM/CCM, and (e) the following 15 CM/CCM lead laboratories or functional organizations: The Harry Diamond Laboratories (HDL), Ballistic Research Laboratory (BRL), Test and Evaluation Command (TECOM), Army Materiel Systems Analysis Agency (AMSAA) Foreign Science and Technology Center (FSTC), Missile Intelligence Agency (MIA), Missile Command (MICOM; by virtue of its Technology Laboratory and Target Management Office), Electronic Warfare Laboratory (EWL), Office of Missile Electronic Warfare (OMEW, reporting through EWL), Army Materials and Mechanics Research Center, Mobility Equipment and Research and Development Command (MERADCOM), Night Vision and Electro-Optics Laboratory (NVEOL), Office of the Test Director for Joint Services Electro-Optical Guided Weapon Countermeasures Test Program (OTD), Program Manager Aircraft Survivability Equipment (PM-ASE), and Program Manager SMOKE/OBSCURANTS. Each of these lead laboratories, or first-order umbrella organizations, is chartered to address a different aspect of CM/CCM, as described in DARCOM Regulation No. 70-4. (For example, the U.S. Army Harry Diamond Laboratory has the responsibility for addressing the CM/CCM aspects associated with the electromagnetic pulse and antiradiation missiles). In the case of a given system, an appropriate subset of these lead laboratories comes into play. Each of these organizations is usually very competent in its specialty and it ensures that the system is examined, tested, evaluated and/or analyzed from its own highly specialized CCM perspective; it uncovers the potential vulnerabilities and surfaces CCM solutions for the PM's consideration.

Procedure

Strictly speaking, the DARCOM CM/CCM community addresses only susceptibility i.e., whether the system can technically be defeated, or its effectiveness reduced when certain countermeasures are brought into play against it. It is not the DARCOM CCM community's responsibility to pass judgment as to whether the enemy will actually utilize such countermeasures on the battlefield. When a decision is made—by, say, the PM or the intelligence community— that there is a high probability of the enemy utilizing such countermeasures, the susceptibility becomes a vulnerability. At this point, TRADOC takes the first crack at a solution by looking at such tactical aspects as changes in deployment, procedural measures and concealment. If the CCM problem cannot be completely solved by tactical means, DARCOM gets into the act, addressing the problem by hard engineering. DARCOM's job is to provide a technical solution within the tactical framework established by TRADOC. In theory, at least, DARCOM provides the optimum level of CCM in light of its impact on such factors as program cost, performance, etc. In practice, however, there is no prioritization in the recommended CCM.

Top-Level CCM Management

What are the Army's/DARCOM's requirements relative to top-level CM/CCM management?

And to what extent are they currently realized?

First of all, there is the requirement to ensure balance in systems hardening—balance within each system as well as balance among systems and among mission areas—from an overall battlefield perspective in the projected threat environment. The PM finds himself in the unenviable position of being saturated with excellent inputs from highly competent flag wavers, each input well justified from its own narrow perspective. The PM knows that there is no way for him to implement all these recommendations. Nor would he want to, even if he had the resources. The other side of the CM/CCM coin is that one sure way of killing a system is by overimmunizing it to countermeasures. The PM usually ends up bowing to the demands of some flag wavers by implementing some recommendations, disregarding some, and getting waivers on others.

The major problem is that there is no management machinery for harnessing the very valuable, highly specialized talents of the flag wavers by weighing the benefits of their "raw" inputs against their associated costs from an overall battlefield perspective --in terms of their impact on the system's cost, schedule, technical complexity, supportability and, perhaps most importantly, reduced readiness—and distilling them into a manageable prioritized set of requirements.

Second, there is the requirement to focus the CM/CCM spotlight on critical Army systems by presenting, as a minimum, the Commanding General of DARCOM with an annual evaluation of the CCM posture of selected Army systems. So far this has never been done.

Third, there is the requirement to close the feedback loop. Currently, there is no management machinery in the Army's acquisition community for following up on what happened to all the CCM recommendations the PM received. Were they all addressed by the PM? On what basis did he make his selections?

And fourth, there is the requirement to help drive the Army's technology base. Sometimes when systems reach OT II, we find that they have serious CCM problems which had not been detected in the earlier phases. What's worse, at times we find that we don't even have the necessary technology to adequately address those problems. Such incidents point up the need for top-level management to help drive the Army technology base from the point of view of CCM requirements, to ensure that adequate CCM technology is available for systems now in the long-range planning stages.

For almost a decade, the DARCOM CM/CCM Center (formerly known as the DARCOM CM/CCM Office) has been trying to accomplish the Army's top-level CM/CCM management objectives but with limited success. One difficulty contributing to this lack of success stemmed from the reporting and funding procedures of the Center. Until very recently the Center has been funded by a technology-base line (6.3A) but reported to the R&D systems directorate at HQ DARCOM. The bureaucratic intent was probably to give the Center the best of both worlds: a technology base and a systems perspective. Instead, it turned out to be more of a bureaucratic nightmare -- with the Center being pulled in both directions at the same time. This has been recently corrected by having the Center report to the Directorate of Technology Planning and Management, the HQ DARCOM unit that controls the technology base. While this realligmment will simplify the administrative aspects associated with the CCM Center, it is highly unlikely to improve the Center's potential for coming to grips with DARCOM's top level CM/CCM management objectives. If anything, it will probably make it much harder for the Center to achieve these objectives because now it is lacking the continual pressure from the systems perspective. And it is in the system's arena that most of DARCOM's top-level management requirements lie.

Another difficulty is the fact that the CCM Center has been stationed at Adelphi, Maryland, and reporting through HQ ERADCOM, a major subordinate command in DARCOM. As a result, the Center has been perceived by the rest of the Army's CCM community as just another component of ERADCOM rather than as independent second-order umbrella organization. And indeed, this perception has some justification: (1) the OER of the Center's director is written by the commanding general of ERADCOM, and (2) the Center's personnel spaces are controlled by HQ ERADCOM and must compete within ERADCOM's priority system.

Still another difficulty has to do with personnel. The CCM Center was formed out of the previous SAM-D Vulnerability Office, and inherited its entire staff which was primarily oriented toward technical analysis. The Center has had almost a 100% personnel turnover since its inception, and, in spite of various difficulties, has made slow but steady progress toward attracting and retaining appropriate personnel for its management mission.

The underlying reason for the Army's failure so far to develop a top-level management structure for CM/CCM is probably that the methodology for overall management of such assets — assets that frequently lose their visibility at the systems level, and yet require a high degree of judgement plus a great deal of careful balance from a broad battlefield perspective—has as yet not been developed.

CONCLUSION

We examined the baseline aspects of CM/CCM. Specifically, by examining the difference between working against the threat and implementing CM/CCM we showed that the CCM community cannot function through the intelligence community but must interact directly with the Program Managers. We then examined some unique features of CM/CCM: We showed that it consumes about 10% of the DOD acquisition budget, is highly judgmental, exercises very high leverage on the battlefield and frequently lacks "visibility" at the systems level.

Then we focused on the Army's major requirements in top-level CM/CCM management and showed that virtually all of them are not being realized. Specifically, the Army's 15 CM/CCM lead laboratories or first-order umbrella organizations shower the Program Manager with highly competent CCM recommendations, each well justified from its own narrow perspective, knowing full well that there is no way for the PM to implement them all. The Army currently has no management machinery for harnessing the very valuable, highly specialized talents of these organizations and distilling their recommendations into a manageable prioritized set of requirements. There is also no management machinery for closing the feedback loop —for following up on what happened to all the CCM recommendations the PM received and seeing to what extent they were addressed by the PM. Also, top-level management is not helping to drive the technology base to ensure that adequate CCM technology is available for systems now in the long-range planning stages.

Furthermore, the Army lacks the management methodology for ensuring balance in CM/CCM — balance not only within each system but also among systems and among mission areas, from a total battlefield perspective.

In view of the problems discussed in this paper, it is deemed appropriate that the Army initiate a study/assessment to accomplish the following objectives: (1) take a closer look at the operation and effectiveness of all the players in the Army's CM/CCM arena, with a view toward consolidating and streamlining them, (2) examine the possibility of developing the top-level management nucleus and administrative machinery at an organization which either already has the responsibility for total systems integration in the Army or which has developed outstanding analytical tools, (3) lay the ground-work for developing the methodology for top-level management of CM/CCM assets.

REFERENCES

1. Department of Defense Directive C-4600.3
2. Department of the Army Regulations AR 105-2, AR 105-87, and AR 310-25.
3. Department of the Army Pamphlet 381-14
4. DARCOM Regulation 70-4
5. Charters of DARCOM lead laboratories for CM/CCM

MANAGERIAL TACTICS FOR UNIT PRICE CONTRACTING

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ABSTRACT

This paper deals with a central and recurrent concern of managers responsible for contracting by *Unit Price Proposals*: viz., optimal tactics for the selection, formulation, and evaluation of unit prices and item quantities of competing tenders.

UNIT PRICE CONTRACTING

Unit price proposals are common instruments of contracting for supplies, services, roads, marine and other engineered construction. The client (owner) prepares unit price proposals which indicate (anticipated) contract items and (estimated) quantities deemed necessary to accomplish the proposal objective. As an example, Table I is a unit price proposal for highway construction that was advertised several years ago.

Bidders are required to indicate *unit prices* for each item. The unit prices multiplied by the indicated quantities are summed to arrive at the *bid total*. The sealed tenders received from four bidders designated A, B, C, and D appear in Table II. Note the wide variation in unit prices for many items. The unit price for Item 1, for example, varies from \$2900 to \$8123. Inexpensive items also vary widely as, for example, \$40 to \$80 in Item 36 and 60¢ to 90¢ in Item 35. Many such public records were examined with about the same results.

For the contractor, the contract is often a greater financial than technologic challenge. Tait [1] observed:

> "The contractor must in addition consider how he intends to finance the project, for in all probability, apart from a modest initial outlay, he will be required to make it self sufficient and needs therefore to arrange to make a reasonable profit in the early stages of the contract.
>
> Quite apart from being able to estimate what each (proposal) item ... will cost him, the contractor must be able to fix appropriate rates to ensure a sufficient flow of revenue from measured work to finance subsequent stages of construction and yet collectively sum to a competitive tender price.
>
> However, there is a risk in manipulating (unit prices) independently of true cost, for the quantities scheduled in the (unit price proposal) are only estimates and significant differences may be found in the actual quantities measured in the works and on which payment would be based."

TABLE I. DELAWARE DEPARTMENT OF HIGHWAYS. 23.06 MILES, KENT COUNTY

18 ft surface treated roadway on 6 in. soil cement base. Completion date: 210 working days

Item No.	Quantity	Item
1	L.S.	Clearing and grubbing Road No. 184
2	L.S.	Clearing and grubbing Road No. 186
3	L.S.	Clearing and grubbing Road No. 187
4	L.S.	Clearing and grubbing Road No. 189
5	L.S.	Clearing and grubbing Road No. 199
6	L.S.	Clearing and grubbing Road No. 201
7	L.S.	Clearing and grubbing Road No. 218
8	L.S.	Clearing and grubbing Road No. 219
9	L.S.	Clearing and grubbing Road No. 223
10	L.S.	Clearing and grubbing Road No. 225
11	L.S.	Clearing and grubbing Road No. 226
12	L.S.	Clearing and grubbing Road No. 258
13	L.S.	Clearing and grubbing Road No. 299
14	L.S.	Clearing and grubbing Road No. 300
15	1000 C.Y.	Excavation
16	168,400 C.Y.	Borrow
17	1000 C.Y.	Select borrow
18	264,500 S.Y.	Soil cement base course
19	26,450 bbls.	Portland cement
20	178,500 gal	RC-250 asphalt
21	5100 tons	Coarse aggregate
22	4800 L.F.	12 in. R.C. pipe
23	3800 L.F.	15 in. R.C. pipe
24	900 L.F.	18 in. R.C. pipe
25	300 L.F.	24 in. R.C. pipe
26	350 L.F.	36 in. R.C. pipe
27	160 L.F.	42 in. R.C. pipe
28	160 L.F.	48 in. R.C. pipe
29	60 L.F.	54 in. R.C. pipe
30	210 L.F.	60 in. R.C. pipe
31	70 L.F.	58 in. x 36 in. C.M. pipe bit. C. and P.
32	1 each	Type "PW" catch basin
33	100 L.F.	Wire rope guard fence (wood post)
34	4 each	End post attachments
35	20,000 L.F.	Lateral ditching
36	30 tons	Calcium chloride for dust control
37	220 S.Y.	Grouted riprap
38	1 each	Standard junction box
39	L.S.	Removal of existing structures
40	121,756 L.F.	Seeding and mulching
41	23.06 miles	Grading and reshaping roadway
42†	0.0 L.F.	30 in. R.C. pipe

† The need for 30 in. R.C. pipe was not anticipated and this item did not appear in the advertisement.

TABLE II: PUBLIC RECORD OF BIDS

Item No.	Bidder			
	A ($)	B ($)	C ($)	D ($)
1	4000·00	3400·00	2900·00	8123·00
2	400·00	300·00	800·00	1832·37
3	1000·00	1000·00	500·00	901·55
4	3000·00	3400·00	2300·00	7384·00
5	1400·00	2600·00	2000·00	1560·00
6	700·00	2000·00	1000·00	2765·00
7	4400·00	3200·00	4100·00	7493·00
8	600·00	500·00	1500·00	750·00
9	400·00	2400·00	1400·00	594·10
10	1400·00	1000·00	2000·00	1930·00
11	1400·00	800·00	2400·00	2598·00
12	1900·00	1800·00	2000·00	2499·00
13	1400·00	1500·00	1300·00	591·00
14	2000·00	2200·00	1400·00	1479·00
15	0·96	1·00	1·00	0·70
16	1·02	1·10	1·18	0·99
17	2·00	1·50	1·50	1·95
18	0·24	0·25	0·26	0·27
19	4·85	4·60	4·15	4·50
20	0·125	0·14	0·14	0·1275
21	6·00	6·50	6·00	5·85
22	3·00	3·00	3·00	2·73
23	5·00	4·00	5·00	4·45
24	6·00	5·00	5·50	5·95
25	9·00	8·00	7·00	7·89
26	14·00	17·00	12·50	13·18
27	18·00	20·00	15·00	16·68
28	22·00	26·00	18·00	22·77
29	28·00	33·00	24·00	27·27
30	35·00	37·00	28·00	30·44
31	25·00	32·00	24·00	22·20
32	300·00	500·00	250·00	482·00
33	2·70	3·00	2·65	1·90
34	50·00	50·00	45·00	50·00
35	0·70	0·90	0·75	0·60
36	70·00	50·00	80·00	40·00
37	12·00	10·00	10·00	10·00
38	300·00	400·00	200·00	375·00
39	600·00	1000·00	1000·00	900·00
40	0·14	0·15	0·14	0·14
41	1800·00	1500·00	1800·00	1500·00
42				
Total bids	585,946·84	598,528·40	600,993·34	580,327·21

† Winner.

This is an uncommonly explicit characterization of the financial challenge in unit price contracting. It often accounts for the wide variability in unit prices mentioned earlier.

Contracts are usually awarded to the low bidder and provide for periodic payments as work progresses. Since the proposal quantities are usually only estimates, as noted by Tait, the actual project cost will generally differ from the bid total. In practice, the bid total tends to determine the successful contractor and becomes irrelevant once the contract is awarded. One quickly grasps the enormous implications. Manipulations involving items, quantities, unit prices, and perhaps the sequence and timing at which contract items are executed, can be made to yield advantages to the owner and/or the contractor. *Clearly, "lowest bid" need not mean "lowest price"; and often doesn't.*

The manipulations mentioned are not only common but often desirable. Indeed, competently administered they contribute to efficient utilization of resources. In a competitive and informed environment it benefits the client since it helps to ensure that the most efficient contractor contracts. However, the uncertainties of quantity, item, time, sequence, and discount make the selection of lowest cost contractor far from simple. Holtz [2] bares these nuances.

An unusually competent technology is now available to assist acquisition managers with evaluating competing unit price tenders. Of course, guarantees for all contracting situations cannot be given and, indeed, research and development with the techniques described below are continuing.

ACQUISITION MANAGEMENT TACTICS

Recall Tait's words, "... to fix appropriate (unit prices) to ensure a sufficient flow of revenue from measured work". At the outset, acquisition managers should compare present worth of contract revenues for the competing tenders seeking, in principle at least, to minimize the present worth of contract revenues. The contractor should also be cognizant of the contract present worth but he, of course, seeks to maximize the present worth.

Optimization of contract present worth is subject to constraints. One constraint is often the bid total submitted by the contractor. Three other constraint types have arisen in practice: formality, cost, and rate constraints.

Formality constraints protect the integrity of the tender. As a routine matter, contracting officers screen unit prices for obvious errors. For example, one expects the unit price for rock excavation to exceed that for earth excavation, etc.

Cost (or bounds) constraints are used to bound the unit price. Such bounds are used as:

- formality constraints, i.e. to avoid appearance of error,
- protection against quantity mis-estimates, as noted by Tait and Holtz, and, for the contractor,
- to conceal pricing policies.

Rate constraints time project revenue (perhaps for funding or other client conveniences or, for the contractor, for tax purposes).

Managers acquire an instinct for items whose quantities are frequently mis-estimated (underrun or overrun) and which can significantly affect tendering. It is important, therefore, that the model facilitates evaluation of tenders for the effect of quantity mis-estimates.

ACQUISITION DECISION MODEL

Having characterized relevant aspects of unit price contracting, translation into an effective decision model is handsome in its simplicity.

Consider an N item unit price proposal for a project to be completed in T months. Let X_m denote the unit price (decision variable) and a_{tm} the quantity of the m^{th} item required in the t^{th} month, $t = 1, 2, \ldots, T$ and $m = 1, 2, \ldots, N$. For the moment assume that the quantities in the unit price proposal are accurate.

The present worth of contract revenue, Z, is

$$Z = \sum_{m=1}^{N} \sum_{t=1}^{T} a_{tm} \rho^t X_m \qquad \text{OBJECTIVE} \qquad (1)$$

where ρ is the discount factor, $(1+i)^{-1}$, and i the monthly money rate.

The minimization of Z is subject to the constraints cited earlier. The contractor's total bid, B, requires

$$\sum_{m=1}^{N} \sum_{t=1}^{T} a_{tm} X_m = B \; . \qquad \text{BID CONSTRAINT} \qquad (2)$$

Formality constraints are of the form

$$X_r - X_e \geq 0 \qquad \text{FORMALITY CONSTRAINTS} \qquad (3)$$

where X_r and X_e are unit prices for rock and earth excavation in the example cited earlier.

Cost (bounds) constraints, useful for several contract purposes, can be expressed as

$$c'_m \leq X_m \leq c''_m \qquad \text{COST CONSTRAINTS} \qquad (4)$$

where c'_m and c''_m are respective cost limits. For example, for the acquisition manager c'_m represents the lower limit that precludes possible contractor or quantity estimate error while c''_m represents the maximum justifiable cost exposure.

Experience indicates that rate constraints are not often used. However, they can be expressed as

$$\sum_{m=1}^{N} \sum_{t=1}^{\tau} a_{tm} X_m = \alpha B(\tau/T) \; . \qquad \text{RATE CONSTRAINT} \qquad (5)$$

The left side represents the total revenue that accrues in the first τ contract months while the right side is the completed time fraction of the total bid. The proportionality constant, α, is unity in the simplest case, i.e. project revenue is directly proportional to project work rate.

With an uncommon adequacy, the linear programming decision model of equations (1)-(5) describes a managerial problem of central importance. The managerial problem is fitted "by", not "for", the linear program. The model linearity arises from the requirements of the contracting process and not the more common limitation of available analytic technique.

The acquisition manager can now analyze the contractor responses to unit price proposals armed with a number of routine linear programming computations for various "bench marks" and "exposure limits". It provides a substantial first step to evaluate cash flows inherent to unit price contracting and to selecting contractors whose tenders provide a balance of the risks in the inevitable contract uncertainties.

IMPLEMENTATION EXPERIENCE AND SUMMARY

Several concluding remarks about implementation and model usage are appropriate.

*Linear programming problems are prized for their simplicity and the ease with which the effects of parameter uncertainties can be evaluated. The acquisition manager uses these sensitivity analyses to assess the cost implications of item, quantity, and time estimates. In addition, simplex multipliers can guide choices among competing contractors. Stark and Nicholls [3] and Stark [4] provide additional information and numerical examples.

*Using the decision model, the acquisition manager can also evaluate the impact of alternative work schedules upon the present worth of the contract. For example, if the original work schedule calls for a_{tm} units of the m^{th} item in the t^{th} month while the alternative requires a_{im} and a_{jm} units of the same item in the i^{th} and j^{th} month, simply replace the coefficient of X_m

in the objective by $(\rho^i a_{im} + \rho^j a_{jm})$ and make any necessary constraint changes.

*In a similar manner, the effect of alternative quantity estimates can be evaluated by replacing the original estimate a_{tm}, say, by an alternative, a'_{tm}. The linearity of the decision model is unaltered. Note again that *lowest total bid need not mean lowest project cost.* Sizeable savings are likely from sensitivity analyses that expose proneness to serious overruns and underruns.

*Moderately priced hand held computers such as the Casio FX720, Radio Shack models, and the Sharp PC1500 are now widely available programmed in BASIC for linear programming. They may well be adequate for all but larger contracts thereby enabling the acquisition manager to compare alternatives in minutes and in hand.

*Since *linear programming optima are global, and provide minima and maxima,* these acquisition management models have a remarkable feature. *For given project (contract) conditions it is not possible to choose unit prices by another means to yield a greater present worth of contract revenues. Similarly, the acquisition manager can obtain the irreducible minimum for the contract present worth.* Having an insight and even knowledge of optimal policies for both contractor and client, the acquisition manager has a powerful standard against which to evaluate prospective contractors.

REFERENCES

[1] W. B. TAIT (1971) "The Role of the Civil Engineer in the Planning, Design, and Construction of a Modern Highway". *Proc. Inst. Civil Engrs. (U.K.)* 49, 211.

[2] H. HOLTZ (1979) Chapter 5 in *The $100 Billion Market: How to do Business with the U.S. Government.* American Management Associations, New York.

[3] R. M. STARK and R. L. NICHOLLS (1972) *Mathematical Foundations for Design: Civil Engineering Systems.* McGraw Hill Book Company, N.Y.

[4] R. M. STARK (1974) "Unbalanced Highway Contract Tendering". *Operational Research* 25, 373.

QUALITY GOALS THAT REDUCE "RISK AND UNCERTAINTY"

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ABSTRACT

The amount of risk and uncertainty in any major program depends directly on the quality of each of the parts manufactured to produce the assembly or the system. Each part has characteristics that have to be considered for their impact on the critical parts of the system. The experience of the writer indicates that practically none of the negotiated contracts in the military procurement system has quality as a goal in the initial negotiating processes. The procurement contract will list a part number, some overall requirements, a delivery schedule and cost factors. One of the requirements in a contract could be MIL-Q-9858, which outlines quality system definitions. There are generally money incentives in the contract for shortening of schedule times, Equal Opportunity Employment, and also value engineering for design changes. There are generally no quality goals in the contract for quality improvement. Quality goals would be related to elimination of repetitive defects. When defects appear in any part the identification of any problem must be made immediately. The elimination of repetitive defects would also be a subject for money incentives. This paper will examine experiences needing better management control of quality, which will lead to reducing the impact of risk and uncertainty by improving quality.

Extensive statistical information analyzing all defects discovered and their relation to the problem resolution have not been accomplished. They are too diverse on the various products. The one factor consistent in all analyses was the discovery that there is a basic cause for each problem. All of the causes have also been in some process in the manufacturing sequence if the engineering is adequate.

SOME SYSTEMS CAUSING DELAY IN PROBLEM IDENTIFICATION

Material Review Boards (Defective Material)

A critical rotating aircraft spar had special requirements for shot peening, copper and chrome plating on a bearing surface. Some mishandling at the machining vendor and plating source caused irregular plating and chips. Ten or more MRB actions with corrective action being "vendor notified", "operator cautioned", an analysis determining the source of the defects to be uncontrollable and a drawing change was issued relaxing the requirements. Many MRB actions would have been avoided with immediate determination of cause of the defect. Numerous contractor and vendor department lines had to be crossed to determine the exact cause.

A contractor had seven critical forgings manufactured. On receipt of the forgings, material substitution was requested. It was necessary to section a portion of the forging lots to provide hundreds of hardness readings to determine that the subsequent heat treating had provided the minimum hardness at .380 inch below the surface. The engineering, test and quality time plus the accounting and purchasing time, in addition to the destroyed forgings, amounted to $3,000. The incentive to assure quality was not present at the time when the contractor knew that the vendor was substituting material. This was known when the Purchase Order was placed. A decision to speed production by biasing the decision with all forgings in house was costly.

Standard Repairs

On a critical aircraft rotating device an incorrect length bolt was used on the folding arm causing damaging interference on flight line procedures. It was determined that the correct length bolt was not available and the shop management substituted a different bolt without using procedures established for changing work instructions. Planning would not have authorized the change. There were many hundreds of dollars spent removing the rotating device and replacing bolts on the folding arm. Units in the field also had to be changed. The incentive to follow the work instructions was not strong enough.

On composite material aircraft structures, a diameter or square inch area designated as one and one half inches was permitted on a multiple layer structure for an unbond condition. Larger areas were put on standard repair for resin injection. The dozens of standard repair forms and the quality control, engineering, and foreman time to process them were in the thousands of dollars. Engineering finally agreed to make the part of the manufacturing process up to much larger areas and allow the work instructions to guide the operator (who is the quality developer anyway). Money to study the cause or identify the problem is much better spent at the start.

Contractor Field Service Operations

Some aircraft fuel pumps were continually causing problems in field service operations. The field service teams were proving "on the spot" assistance and replacement of parts (O-rings, etc.) to avoid large numbers of unsatisfactory reports. Review at the factory indicated the assembler had not seen the work instructions for O-ring installation in several gears and was omitting two of the five important steps in O-ring installation. At final test, pumps were set up and had to be reset sometimes two or four times before they would operate properly when controls were activated. Had passing final test been an incentive goal on the first attempt, the standard exercising of the bellows would have been part of the manufacturing process rather than a test option. Those that started by chance, on the first try had bellows that were not exercised and therefore might not operate on the aircraft after installation. This happened and resulted in high service costs. The incentive to have pumps pass test the first time by identifying the cause of the non-start, cost much money.

A critical aircraft structure holding a rotating aerodynamic control was continually failing. Two years had produced more than fifteen aircraft failures, including one aircraft lost. Consideration was given to "beefing up" the gear box casting which was bolted to the frame through four independently located forgings. Investigation revealed the forgings were not being manufactured in a single plane with faces meeting the casting not parallel. Once this manufacturing technique was revised, no further failures occurred. Field personnel had not notified factory quality assurance personnel of the failures. Cracked units were replaced. Factory quality assurance was not able to cross department lines for corrective action.

Standard Parts or Off-the-Shelf Items

Some tendency to use industry standard parts to enhance cost effective systems results in allowing statistical programs to predict the accurate number of defects in a given lot of parts. In the critical systems that need careful risk and uncertainty studies, the defective parts, without screening, would be installed causing failures. The standard answer is that we must live with some defects because of the lower cost permitting defective units to be accepted and stocked.

Each service and contractor has sufficient repair and replacement cost records and history to determine that the inspection of these items to provide no defects in a stockroom would be far more cost effective for the user. The incentive should be in the front of a product manufacture as the important characteristics are generated rather than after the fact defect processing.

Summary

The few of hundreds of experiences in the previous paragraphs were each considered as "Monday morning quarter backing" or after-the-fact analysis. Considering the many characteristics that were produced without defects, management will look at percentages and consider "cost effectiveness" in the problem identity process. This must cease and although the immediate solution of problems will not readily lead to indicating how much risk was avoided, history that each manufacturer can assemble as to his costs to MRB, repair, replacement of defective parts, can lead to prediction as to how much money should go to the incentive program to solve the problem at the front end. This is just as much an identifiable cost as manufacturing, planning, finance and production time estimates on proposals. This would result in a significant reduction of the cost of risk and uncertainty for both the contractor and the military procurement agency. Quality assurance (characteristics on soft ware and hard ware) must be elevated to a point in organization where quality decisions can override production considerations. Incentives for identifying problems rather than penalties for non-delivery both in the field activities and manufacturing facilities.

Incentives for better quality must be negotiated with a base line plus a goal for fewer MRB, field actions and standard repairs. These fewer actions are the result of problem identification. A quality group that crosses department lines to identify the problem would be an important input to the "risk and uncertainty" program.

WHY NOT PERSONAL (DESK TOP) MINI - COMPUTERS FOR PROCUREMENT PERSONNEL? INCREASING PROCUREMENT PRODUCTIVITY BY 72.2 MILLION TO 180.5 MILLION PER YEAR!

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ABSTRACT

This discussion will present reasons why personal (mini-computers) should be made available to procurement personnel i.e., Contracting Officers, Negotiators, Procurement Analysts, Pricing Analysts and other professionals and/or support personnel in the profession. The ultimate goal of this paper is to provide procurement managers with a picture of the practical applications and cost effectiveness of this proposal.

During the past year, I have researched the market of mini-computers that are currently available and affordable for individuals and small businesses in particular and their potential advantages for large organizations and procurement professionals in general.

Problem: The current Reductions in Force (RIFs) and furloughs in Civil Agencies and the increased workload placed on Department of Defense Procurement Personnel, with relatively little increase in staffing, causes an ever mounting pressure on these civil servants to improve productivity. **Do more with less and do it right the first time!**

Solution: One solution to this dilemma is to provide mini-computers to the Federal procurement workforce as quickly as possible.

TIME SAVINGS AND COST EFFECTIVENESS

The American Management Associations' studies indicate that:

- Almost everybody wastes at least two hours a day.
- The average office worker could take a five month vacation each year and still get the same work done.
- Most managers could learn to speak a foreign language in the work time wasted each year.
- The ineffective use of time actually decreases production and efficiency -- yet increases the amount of time consumed.

All of these time wasting factors and required working space for employees can be drastically reduced by using personal computers.

Most procurement functions can be accomodated by straightforward state-of-the-art word processing and data processing techniques. This paper will describe:

- An example of a user oriented system already operating in place at a Chicago, Illinois bank which by combining mini-computers and picture phones has:

  -- By providing personal mini-computers to professional and support personnel for use both at home and in the office has reduced or eliminated the need for:

  -- Office space ($18 a square foot in Washington, D. C.)

  -- Commuting

  -- Day care centers or baby sitters

  -- Filing and paper costs

  -- Local travel

  -- Time consumed in meetings

These are just a few of the results.

The system has also improved morale, increased productivity, communications and accountability.

This article was written by David A. Webb in his private capacity. No official support or endorsement by the U.S. Department of Education is intended or should be inferred.

- o How a personal computer is currently being used in the Department of Education to implement Federal Property Management Regulations in that agency.

- o A listing of current Japanese and American Manufactures of personal mini-computers.

- o What a buyer should look for in mini-computers:

  - -- A cost comparison of hardware and software which combine both ADP and Word-processing capabilities and why the computer and soft-ware should not exceed a retail price of $2,000.

  - -- Compatability with other equipment and systems.

  - -- Types of printers and modems and their costs.

  - -- Why wordprocessing units purchased separately from mini-computers are not cost effective.

  - -- Size (physical and data capacity) and portability.

- o How personal computers can be used effectively in the home for official business and why the Federal Government should seriously consider and implement this option.

- o Security problems.

NOTE: The opinions and conclusions expressed in this paper are those of the author and not necessarily those of the U. S. Department of Education.

COST EFFECTIVENESS

Automation can raise clerical and secretarial productivity by as much as 35%. For managers and executives, it can improve productivity 10 to 25 percent. (1)

According to statistics from the Federal Acquisition Institute there are approximately 19,000 people in the Federal government who are actively involved as procurement personnel in the GS-1102 Civil Service Procurement Series. If one assumes that the average grade level is a GS-1102-13 Step Five contract specialist with an annual salary of $38,000 per year this indicates by simple multiplication (the number of people times the the average annual salary) that the Federal Government is spending $722 Million per year, on average, for the Federal procurement workforce(excluding Commissioned Officers and Enlisted Personnel of the Military).

Therefore, if the American Management Associations' figures are correct and procurement managers and exectutives productivity could be improved between ten and twenty-five percent, this would mean a savings (based on annual salaries) of betweeen $72.2 million and $180.5 million per year by supplying these people with mini- computers.

The cost of providing these people with these mini-computers i.e., $2,100 for the computer and a printer; if multiplied by 19,000 would be $39.9 Million. Assuming a minimum 10% increase in productivity of the $72.2 Million figure this would result in net savings of $32.3 Million in time lost in the first year.

PREPOSTEROUS? Why not? In the United States for example, there are probably 300,000 micro computers in the home, schools and businesses -- 100,000 in schools alone! (2)

LOCAL SCHOOL SYSTEMS ARE WAY AHEAD OF THE FEDERAL PROCUREMENT WORKFORCE!

In my own county of Prince William, Virginia $217,000 or almost one quarter of a million dollars has been approved for the purchase of mini-computers for the school system to ensure "COMPUTER LITERACY".

In Irvine, California a two-way cable television links 24 schools, the public library, City Hall, the University of California, the community Science Experience Center, the Community College and the art museum.

EFFECTIVENESS OF COMPUTERS IN THE SCHOOLS (SEE TABLE I)

TABLE I (8)

THIRTY-TWO STUDIES OF COMPUTERIZED SIMULATIONS AND TESTING

	Source	Time saved	Cost saved	Greater efficiency	Improved skills	Provision of training not previously available
S	Abernathy and McBride, 1978	+	+	+	+	+
S	Allen, 1976...	+	+	+	+	+
T	Bejar et al., 1977..........	+	0	+	+	+
S	Bentz, 1975...	+	−	+	+	+
S	Brown et al., 1977..........	+	0	+	+	+
S	Brown, 1977...	+	0	+	+	+
T	Brown and Weiss, 1977..........	+	+	+	+	+
S	Buchanan, 1978	+	+	+	+	+
S	Ellis, 1978...	+	−	+	−	+
S	Gregory 1975..	+	−	+	+	+
T	Guerra et al., 1977..........	+	0	+	+	+
T	Hansen et al., 1974..........	+	+	+	+	+
S	Johnson, 1976.	0	0	0	+	+
T	Lippey and Partos, 1976..	+	0	+	0	+
T	McLain and Wessels, 1975.	+	0	+	+	+
S	Misselt and Call-Himwich, 1978..........	−	−	−	−	−
S	Mockovak et al., 1974..........	+	−	+	+	(Conventional − superior)
S	Orlansky and String, 1977...	+	+	+	+	+
S	Puig, 1976					
	Tanks.......	0	+	0	0	−
	Aircraft carrier...	+	0	+	+	+
	Weapons trainer...	+	+	+	+	−
	Air traffic controller	+	0	+	+	−
	Automobile..	0	+	+	+	−
	Airborne ECN system....	+	+	−	+	−
S	Robert, 1977...	+	+	+	+	+
T	Sealy, 1975....	+	0	+	0	+
T	Vale, 1977.....	+	+	+	+	+
S	Willey, 1975					
	Dartmouth...	+	0	+	+	+
	Ohio State..	+	−	+	−	+
	University of Wisconsin....	0	−	+	+	+
	University of Illinois.....	+	0	+	+	+
	University of Michigan.....	+	+	+	+	+

Michigan.....	+	+	+	+	+
Totals..........	+ = 27	13	28	26	25
	− = 1	7	2	3	7
	0 = 4	12	2	3	0

Key: S = Simulation
T = Testing
+ = Positive results
− = No significant difference
0 = No results

*Note: Studies in this review cut accross all levels of education and include trainin as well.

SOURCE: Human Resources Research Organization 1979

This recent review of 32 studies in simulation and adaptive testing provides further support for the notion that computer-based education can be an improvement over the conventional educational methods. This study performed by HumRRO for the Office of Technology Assessment is summarized in Table I. above. The majority of these studies shows savings in learner time to complete a course of study (as much as 50% savings), greater efficiency in terms of achievment per unit of time, improved skills and provision of instruction not available conventionally.

Note: While increased efficiency in the business office is not quite as dramatic it is signifigant. Once people get used to using mini-computers a learning improvement in work habits does take place.

A COMPUTER FOR EVERY CHILD

Seymour Papert of MIT proposes that each child be given a microcomputer on her/his first day of school. His rationale is that, since computers can support a person's creativity and since creativity cannot be turned on or off at will, children should have access to a computer at any time they wish, rather than the scheduled 20 minutes per day that is typically available to students in schools with computers. The concept clearly makes sense intellectually. With computers costing less than $1,000, excluding software (only three percent of the cost of educating a child through twelfth grade), it makes sense on economic grounds, when we consider the potential impact of computers on learning.

NOTE: Currently, I seriously doubt if there is even one mini-computer available for the exclusive use of a Federal Contract Specialist.

COMMERCIAL APPLICATION OF A USER ORIENTED SYSTEM

On Tuesday August 11, 1981, Walter Cronkite's Universe Volume II, Number 9, broadcast over the CBS Television Network a program titled "Home Work" which was produced by Igor Oganesoff.

In this program a married female employee works for the Continental Bank of Chicago--but not at the bank's headquarters. She works at home, in a quiet suburb about an hour's drive from the bank. She works as a typist, using equipment the bank installed for her. When an indicator light comes on, that means she has dictation waiting for her on a tape transmitted from the bank. When she's done, she dials a number on the phone and feeds the computerized work back to the bank, where it is printed automatically.

The work-at-home works eight hours a day and earns the same as a regular office worker. She saves on commuting costs, lunches, a baby sitter (she has five children) and even business clothes.

But, the female employee's office at home would not be possible if Continental Bank had not installed a computer system in its own offices. There's hardly any paper around at all. Bank employees check at computer terminals for messages, memos, and instructions, and they answer back on the same machines.

The bank's vice president for cash management is capable of sending a memo to six people concurrently. One of them is going to an employee the bank's Los Angeles regional office. Another copy is going to a man in San Francisco. The third to a man in Seattle. A copy to a guy about three--three desks down. Copies to his boss, his boss's boss, and the party working with, the vice president on the project.

Note: Hard copies may be reproduced on a printer but. essentially all of these copies may simply be stored on a floppy disk by the computer.

The vice president isn't exactly used to working on a keyboard: that used to be a secretarial function.
He says: "I'm getting there. As you notice, I"m still one finger. I don't--I don't know if I'll ever evolve out of that. But it's harder. I had to learn how to spell. Do my own paragraphing and punctuation. A secretary could pick up the punctuation from the tone of your voice. Here you have to put it in."

However, if there is a mistake or something has to be changed all that is required is punching a few keys. No erasing. No retyping. No wasted paper. In other words any mistakes or corrections can be made on the computer screen without retyping the entire text of the data or material which is to be recorded or transmitted quickly and simply.

All of this allowed Continental Bank to experiment with people working at home -- people who might otherwise be unable to take jobs because of home responsibilities.

The man who is primarily responsible for all this is the manager of the bank systems division.

He says: "Well, today I receive about 80 percent of all information I'm required to read electronically. Some managers don't like keying. An interesting notion a pencil is professional; a keyboard is clerical. But slowly but surely, we're moving along the adaptation curve and people are getting more and more comfortable with the product, because they find it has value."

The systems division manager also uses a picture phone for tele-conferencing. Using ten of these instruments within the management group the bank is gradually replacing face-to-face meetings with picture phone sessions. Where it normally would take an hour round-trip for the management group to travel to the central office for an hour's meeting. this local travel time is eliminated

Note: In Washington, D. C. if this method were used for 10 GS-13s at $18 per hour there would be a savings of $180 in time spent coming and going to the meeting. Plus $20 in taxi/subway fares, for a total savings of $200. for every meeting held during a year's time for this hypothetical group of civil servants.

This program also went on to show on a much bigger scale, Arthur Anderson, a large accounting firm, which is the first major business to use video tele-conferencing on a regular basis. These executives in Chicago are talking to some people in Washington. The TV cameras automatically switch to whoever talks, or even coughs. Technically, there's no reason why this couldn't be part of the future office at home.

Note: Mr. Cronkite's office in-formed me that a video tape of the program is available for $350. The text material provided above was free of charge.

TECHNICAL DESIGN FOR EIGHT YEAR OLDS (4)

In fact Irvine, California, which I mentioned earlier, is already in effect doing what Mr. Cronkite talked about today rather than in the future and has been doing so since 1974.

The 2-way cable television system in this community is decentralized. There is no central switching, and each of the 24 schools is capable of transmitting its own video signal over one of two channels provided by the local cable company. Thus, each school can share its resources with any other school or any combination of schools in the District. By using a third public access channel, anyone in the community can watch school programs and, if desired, respond to the programming via conventional telephone lines.

Clearly, connecting an entire city with 2-way cable television has offered new opportunities for bringing people together via electronics to share personal expertise, interests and philosophies. The system operates smoothly, with users themselves switching from one school to the next by simple oral commands. Each site can originate programs; there is no central studio, and no site has the technical capability to eavesdrop on another without prior acknowledgement. Administrators conduct District-level meetings without leaving their own schools; they bring in local experts to share skills with learners throughout the school system. They also hold weekly meetings to coordinate continuing programs which operate at multiple sites within the District.

Students use the 2-way system to share ideas, projects, special research, hobbies, and learning games. During these dialogues, students are in entire control of the system, from filling out program request, organizing and planning each program, to setting up and operating cameras, microphones, videotapes, channel selectors, and signal modulators. Eight-year-olds use the system daily

The equipment is extremely durable and maintenance problems are kept to a minimum. With the exception of the television modulator, the equipment is off-the-shelf, consumer quality. Two standard television receivers monitor both channels, two CATV channel selectors pick up the mid-band channels, a microphone mixer, microphone and either a standard black and white or a consumer quality color camera comprise the basic components of the system.

The equipment for 2-way transmission at each site is placed on a portable cart capable of being moved to any location within the school. Today, a portable CATV unit costs approximately $3,500, almost 50 percent more than in 1974 when the project began.

Again, in my own community of Prince William, County, Va., a man living in Woodbridge, Va. who works for a firm in Baltimore, Md., which is about 65 miles away, works at home every day using his computer and transmitting his work by telephone without ever leaving his house. His one complaint: He gets lonely and doesn't get to see his co-workers.(5)A system similar to that which is now being used in Irvine, California would probably eliminate that feeling of isolation. In Washington, D. C., this means, the Office of Federal Procurement Policy (OFPP), the Federal Acquistion Institute (FAI) or any other government office could hold meetings and transmit information throughout the metropolitan Washington, D. C./Baltimore, Md. area.

USING A PERSONAL COMPUTER TO WRITE FEDERAL REGUALTIONS (SAVING DOLLARS)

I am one of those people who believes in practicing what he preaches. This paper, as well as the writing of the Department of Education's Property Management Regulations, are being written on an Osborne Computer. The cost of this computer is $1795., including six different types of software plus an Epson MX100 printer with a 2K buffer which cost $749. Smaller printers cost as little as $300. In otherwords, for an investment of as little as $2100. a Government manager can have 100% access to wordprocessing, programing, and financial statistical analyses. For a small additional investment one can have time sharing with larger nation-wide systems including electronic mailing services for about 26 cents a letter.

The advantages of using a computer with wordprocessing capabilities are too numerous to list in their entirety.

However, it is in fact similar to using a flight similator where you can make all of the mistakes and correct them in the computer before any harm is done.

- Paragragraphs can be restructured.
- Margins are automatic.
- Sentences can be restructured.
- Word searches for specific words or phrases and instantaneous correction can be effected.
- Highlighting of words, sentences or paragraphs is possible.
- Complete elimination of the time spent waiting for a secretary or clerk typist to provide you with rough drafts, final drafts,

and final copy.

o Misspellings are easly corrected.*

* As a matter of fact, there is software available including a 50,000 word dictionary which will edit your entire text for spelling errors in minutes rather than hours. (Cost $295.)

MINIMAL SOFTWARE REQUIRED FOR USE WITH A MINI-COMPUTER FOR PROCUREMENT PERSONNEL:

NOTE: Software is provided on diskettes which are placed into the computers to make them work. Without this software computers are simply dumb expensive boxes which won't do a thing.

o SYSTEM DISKETTE - The system diskette contains the programs which directs the transfer of data between the computer's memory and the other diskettes or software programs which are used by the computer.

o LANGUAGE DISKETTE - If you are not a programmer a "high level" language program is required for the individual to use the computer. The most commonly used program or software in this area is called BASIC. This program was designed to help students and first time users of a computer to learn to write programs. Many programs have already been written in BASIC which can be used even if you are not interested in programming.

Even more important, are those programs which provide wordprocessing allowing you to format, record and print text and Mail-Merge from which you can create form letters, print multiple files, mailing list and format text to fit your application.

Equally important is a financial planning program which provides a video worksheet where figures can be arranged in columns and rows while arithmatic operations are automatically performed on them.

Thus, we add:

o WORDPROCESSING DISKETTE - This program is a must for anyone who writes and can be used by procurement professionals for advanced procurement plans, boiler plate contract clauses, changes, modifications, supplemental agreements, regulations, ad infinitum.

o FINANCIAL MANAGEMENT DISKETTE - Cost proposals can be analyzed and figures changed in minutes. Direct labor and overhead numbers can be changed for example, and all other numbers such as material costs and profit will automatically be recalculated in seconds without redoing the entire worksheet. This information can then be stored on a diskette, for futur use comparison or immediately reprinted if desired.

A recent ad, in the March 18, 1982 Washington Post, offers software to businessmen with mini-computers. It reads as follows:

"WIN GOVERNMENT CONTRACTS WITH WINNING BID (TM)

WINNING BID is a VISICALC (R) package that helps you pare cost proposals on DD 633 or Form 60 in minutes, not hours. Make fast accurate changes. Load WINNING BID in your copy of VISICALC and write cost proposals with 3 subcontracts, 10 labor categories, different overhead and G & A rates for the prime and each sub, and much more. WINNING BID lets you have 12 tasks for each labor category; then automaticallly generates full cost proposals. WINNING BID runs in seconds so you can make changes easily. Perfect for negotiations. Can you afford to be without WINNING BID when your competition uses it?

WINNING BID available on data diskettes for TRS-80 Models I, II, and III; Apple II plus in preparation; IBM ready soon. Full documentation included. Send $50.00 (VA) residents add 4% sales tax) + $2.50 postage... or rush right over and pick up a copy.

WINNING BID is a trademark of DBS Corporation 1982."

WHAT A BUYER SHOULD LOOK FOR IN MINI-COMPUTERS

In their book "WITHOUT ME YOU'RE NOTHING" Frank Herbert and Max Barnard give the best advice in the world.

1. Don't take a course in computers. Most of them are using obsolete equipment and the $150 or so that you may spend at the local night school would be better spent in buying your own computer.

2. Learn some of the basic jargon.

3. Spend as little money as possible for a computer that will do what you want.

4. Make sure the computer not only does what you want now but can be expanded or modified to match your growing skills and your increased demands.

PROFESSIONAL PERSONAL COMPUTERS

MANUFACTURER AND MODEL	BASE PRICE	TYPICAL SYSTEMS PRICE
APPLE II PLUS	$1530	$3130
APPLE III	4690	5760
ATARI 800	899	2652
COMMODORE CBM 8032	1495	4285
HEWLETT-PACKARD HP-85	2750	7000
IBM PERSONAL COMPUTER	1595	4445
LOGICAL BUSINESS MACHINES DAVID	8500	10,000 12,000
NEC HOME ELECTRONICS	995	3645
NORTH STAR	3999	5500
OSBORNE I*	1795	2095
RADIO SHACK TRS-80 MODEL II	3899	5098
ZEROX 820	2595	5895
ZENITH DATA SYSTEMS	3195	4790

*This price includes $1500 worth of software.

For the procurement professional, I believe the following specifications for mini-computers meet the four basic rules:

A ROLLS ROYCE OF MINI-COMPUTERS WITH VW (1960 PRICES) LESS THAN $2,000.

Hardware or Equipment (the computer itself):

- o Z80(R)CPU
- o 64 K of RAM memory
- o Two floppy diskette drives with 102K bytes of storage each
- o Full business keyboard with 10-key numeric pad.
- o Built in CTR with automatic scroll
- o IEEE-488 interface
- o RS232C interface
- o Modem interface
- o External battery pack connector
- o Pockets for diskette storage

Standard Software (Programs to run the computer):

- o CP/M(R) disk operating system
- o WORDSTAR (R) word processing with mailmerge (R)
- o SUPERCALC (R) electronic worksheet;
- o CBASIC (R) and MBASIC

Compatibility and easy use:

- o Capability to:

-- use a variety of printers either dot matrix or daisy wheel letter type including graphics;

-- expand to double density capacity;

-- Battery Pack with up to five hours of capacity

Trademarks:
OSBORNE 1: Osborne Computer Corporation
CP/M: Digital Research
WORDSTAR,MAILMERGE: Micro Pro
SUPERCALC: Sorcim Inc.

Z80A: Zilog Corporation
MBASIC: Microsoft
CBASIC: Compiler Systems
VISICALC: Personal Software
APPLE II,III: Apple Comouter Corporation

MINI-COMPUTER COST COMPARISON

FEATURES	COMMODORE 4016	APPLE II	IBM
Base Price	$995	$1,330	$1,565
12" Green Screen	Standard	299	345
IEEE Interface	Standard	300	NO
TOTAL	$995	$1,929	$1,910
Upper & Lower Case Letters	Standard	NO	Standard
Separate Numeric Key Pad	Standard	NO	Standard
Intellegent Peripherals	Standard	NO	NO
Real Time Clock	Standard	NO	NO
Maximum 5 1/2 Capacity per Drive	500K	143K	160K

NOTE: All of the above is somewhat deceptive to the first time buyer and even some of the experts. While it is all true, there are some very big costs left out. For example, in very small print you will find out that: The cost of disk drives which will permit you to use diskettes and programs are not included. Also not included are the costs of programs on the diskettes which you would need to make the computer work.

For example:

The Commodore 4016 for $995. It only has a 16 K RAM capacity. To get the dual disk capacity and 64K RAM plus the software you need another $3,000 to $4,000 investment if you want financial analaysis, wordprocessing and higher language program software capabilities.

The IBM personal computer, if you want wordprocessing capabilities, will cost at least $3,600. Other software which the procurement professional requires will escalate the cost to the $4,000 or $5,000 range.

Both of these examples exclude the cost of the printers, which is what you need if you want hard copy or pieces of paper reproducing the information stored on the floppy disks.

The only mini-computer on the market today which includes BASIC, VISICAL and WORDSTAR costing less than $2,000 is the OSBORNE 1.

CURRENT MICRO WORLD

8 bit — Mostek 6502, Motorola 6800, 6809 Intel, Zilog 8080, 8085,Z80

Major Users: Apple, Atari,Commodore, Radio Shack Color, Radio Shack Model I & II, Osborne, IBM. Hitachi, Toshiba, NEC. The latter three being Japanese firms.

16 bit — Intel 8086, 8088, Zilog Z8000, Motorola 68000

Major Users: Exidy, ISC, CP/M Systems.

CURRENT STANDARDS: CP/M, Z80, MICROSOFT BASIC

SECURITY

HOW CAN THE AUTOMATED OFFICE BE MADE MORE SECURE?

A. Full software controls, logs- Take the five key protection principles and answer the following:

1. Identification-Who is to use the system? How can we identify that it is the correct person utilizing the hardware?

2. Isolation -Can we make sure that a person has their own "view" of the system and that is all?

3. Controlled access-Who is allowed what type of access to the data? Who should amend or who should just observe the data?

4. Integrity-Of what value is the data if it is not correct? How can we ensure that the data is correct?

5. Surveillance-How can we tell what the users actually did in their application run?

B. Strict classification and protection of data-define the quality of the information, Private and sensitive.

C. Communications controls - Future technology will provide the necessary security requirements e.g. key encryption.

D. Make personnel aware - Office automation is just another DP application.

WHAT MUST THE MANAGER DO AND THINK ABOUT?

A. Think of security first and foremost - Do not think of the system in terms of the "ostrich", or "titanic" approach.

B. Phase into automation - Pilot systems.

C. Plan for the information society- Distribution, Interconnection.

D. Educate.

E. Growth of the electronic office is an opportunity, not a threat to DP managment.

SUMMARY:

A. Security of the office must involve plans and policy that:

1. Identify the resources.

2. Determine the risks involved.

3. Identify the countermeasures available.

4. Perform a cost benefit analysis.

5. Implement the approved measures.

6. Monitor what has been done.

B. Will we ever be totally secure? - No, but we can attain a level of acceptable risk with top managment awareness of the problem.

Source: Richard Condon, Deputy Director, Information Systems Security, U. S. State Department.

COST OF PRINTERS

LETTER QUALITY:
Most of the letter quality daisy wheelprinters range from $2,000 to $7,000.

DOT MATRIX:

Dot Matrix printers range from $300 to $1,000.

NOTE: TRADITIONALLY THE GOVERNMENT AND LARGE BUSINESSES SEEM TO PREFER "LETTER QUALITY PRINTERS" EVEN THOUGH THEY ARE IN FACT FOR THE MOST PART SLOWER! Small businesses, who do not have a thousand dollars or so to throw away do not worry about "LETTER QUALITY" and "DAISY WHEEL" capability. (NEITHER SHOULD THE FEDERAL GOVERNMENT!)

COST OF MODEMS (HOOKING THE COMPUTER UP TO A TELEPHONE):

Modems and couplers cost between $239 and $749.

SUMMARY

PROBLEM: The Federal Government has a serious shortage of qualified people and office space in the functional management area of procurement.

WHY WE PROBABLY WON'T DO ANYTHING ABOUT THE PROBLEM:

o Providing mini-computers in the office:

-- Many managers would not even consider using mini-computers because they require one to type instead of using a pencil or a pen or dictating to a secratary, or they think that one has to be a computer specialist to use them.

NOTE: By 1985 if the current trend continues, we will be lacking 250,000 secretaries. (6)

-- Many small systems such as the Osborne are not even on GSA schedule: even though they are off the shelf items because GSA experts, who control schedules have probably never even used a mini-computer. Also, small companies are afraid of the red tape involved in getting on a GSA schedule.

-- Very few Federal managers are aware of the fact that mini-computers have wordprocessing capabilities and video financial worksheets.

-- Most Federal managers think that mini-computers must cost at least five to ten thousand dollars.

o Providing mini-computers at home:

-- Relatively few Federal managers believe that an employee does not have to be at the office to be able to produce and be accounted for. In fact there is more accountability. One can see exactly how much is produced every day using a mini-computer.

-- Lobbyists representing those industries which sell cars, word-processers, run buses, cafeterias, rent office space etc. would seriously oppose this effort because in the long run the Government may have no major need for these services.

WHERE WILL THE MONEY COME FROM?

In my own agency of Education and I'm sure we're not alone. We were leasing wordprocessing equipment at the unit cost of $400 a month without mathematical capabilities for $4,800 a year which could be accomplished by a mini-computer for $1795, with no additional cost. We were leasing letter quality printers for $300 a month or $3600. per year when dot matrix printers could be purchased for as little as $750.

TOTAL ANNUAL SAVINGS FOR COMPUTERS:

o In the office:

-- Total cost for a mini-computer including printer $2500. Increased productivity for a GS-13 @ 10% = $3800. Net savings = Increased productivity for 19,000 employees $72.2 Million minus cost of the equipment $47.5 Million = $24.7 Million for the 1st yr. Thereafter, $72.2 Million.

o In the home:

Elimination of 135 sq. ft. of office space @ $18. a sq. ft. = $2430 x 19000 = $42.2 Million plus the $72.2 Million cited above = $118.4 Million per year.

A NASA study where 26,000 employees commute an average of 20 miles a day to work shows the cost of commuting is $6 million a year. (6)

WHERE AUTOMATION WORKED IN THE FEDERAL GOVERNMENT! (6)

The Department of Transportation Automated Office System (TAOS) has approximately 200 work stations, some of them in employee's homes.

CONCLUSION

Obviously, we cannot expect management to permit everyone to work at home (WHAT ABOUT TRADITION, THE AUTO INDUSTRY AND THE OIL INDUSTRY?) Nor, would everyone want to work at home. People get lonely or forgotten by management when promotions come around. (Out of sight out of mind!) But, if even half of the procurement work force could use the mini-computers at home and not commute and the other half had them in the office the savings would be significant.

THE MAJOR QUESTION SHOULD THEN BE NOT WHETHER WE CAN AFFORD TO PROVIDE MINI-PERSONAL COMPUTERS TO PROCUREMENT PERSONNEL BUT, RATHER HOW CAN WE AFFORD NOT TO???

References:

1. Plotzke, George T., "New Technology Creates the Office of the Future" Management Review, February 1982, pp 8-15

2. Braun, Ludwig, "Computer Aided Learning and the Microcomputer Revolution", PLET, Vol. 18, No. 4 - November 1981, pp 223-229.

3. Braun, Ludwig, "Computers in Learning -- An Imperative for the 1980s", April 1980.

4. Ritter, M. Craig, "2-Way Cable Television in the Schools and Community of Irvine, California, March, 1982.

5. Markowitz, Eve, "Working in Baltimore Without Leaving Home", The Potomac News, March 19, 1982.

6. Shandler, Philip, "Electronic Age Making Inroads in Bureaucracy", The Washington Star, December 26, 1980.

"IMPROVING DEFENSE ACQUISITION"

BANQUET ADDRESS

TO

THE 1982 FEDERAL ACQUISITION RESEARCH SYMPOSIUM

BY

HONORABLE JAMES P. WADE, JR.

PRINCIPAL DEPUTY UNDER SECRETARY OF DEFENSE

FOR RESEARCH AND ENGINEERING

MAY 6, 1982

Good evening, ladies and gentlemen. It is an honor for me to be with you this evening to describe for you some of the acquisition management efforts we have undertaken with the Department of Defense: some of our problems and some of our successes. Sixteen months ago a new management team, led by Secretary Weinberger and Frank Carlucci, took charge of the Pentagon. The new senior leadership arrived and immediately recognized a number of important tasks. They wanted to increase the military budget to rectify the neglect of the past. You have seen the results in the 1982 and 1983 budgets. They wanted to reconsider the entire question of our strategic forces and how they could be modernized in an integrated, comprehensive way. You saw the results of that in the President's strategic modernization program, announced last October. But even as they set these two important efforts in motion, Secretary Weinberger and Deputy Secretary Carlucci turned to improving the management of the Department of Defense in two areas--planning and acquisition. Three weeks after the inauguration, Secretary Weinberger began a review of the planning, programming and budgeting process, a review which led to a number of changes and to the reintroduction of planning into what had become a purely budgeting and programming process. Shortly thereafter, on the second of March, we undertook a review of the entire subject of defense acquisition. This intensive review, involving the participation of all the various organizations in the Department of Defense--and probably involving some of you personally--took place over the next month and resulted in the series of initiatives which have come to be called the 32 Carlucci Initiatives or, more formally, the Department of Defense Acquisition Improvement Program. We believe that this program goes to the heart of the procurement problems facing us. The initiatives we are undertaking to improve program stability, to improve readiness and support, to reduce administrative costs, to reduce procurement times, and to improve the effectiveness of competition will tremendously enhance our procurement efficiency.

But they will only do this if we, collectively, are successful in fully implementing them. There are several factors to keep in mind:

o Other acquisition reform attempts in the past have not been completely successful. Either they have not been implemented at all or they have been implemented only partially.

o The acquisition improvement program is one year old and we have much more to accomplish if we are to meet our objectives. Clearly, difficult problems require time in order to solve them fully.

o More than just time is involved. More than just OSD is involved. Interaction with industry, OMB, and Congress is required--and the fully active support and participation by the services and layers within the services are required.

Now let me turn to some of the specifics of our initiatives.

Program Stability. The reverse of this, program instability, has been one of our greatest problems. Program starts and stops, stretchouts, and reduced buys have been all too characteristic of the acquisition process over the years. If we can bring some stability to the process, we will have made a tremendous contribution to our national security.

Within the acquisition improvement program, we have identified some specific ways to meet the problem. Our basic objective is to identify and fully fund high priority programs which the services and OSD are committed to support. We have a preliminary list of stable program candidates from the services and are working with them toward establishing a final list. This is a difficult but essential first step toward achieving more stable programs which will result in greater quantities of systems, sooner, at lower cost.

For programs which are more mature, stability is enhanced through application of multiyear contracting. We estimate that multiyear can achieve program efficiencies of up to 10 to 20 percent which means considerable savings. Last year, in FY 1982, we sought and received authorization to use multiyear procurement for three of our major programs: the F-16, the C-2A Aircraft, and the Troposcatter Radio (C-2 multiyear funding appears in the FY 1983 budget). Estimated savings for these programs are $325 million. This year's budget includes 15 programs with estimated savings of $815 million. We will identify additional multiyear candidates in the FY 1984 budget request.

At the same time, we are reviewing all of our programs to see where we can achieve more economical production rates. The FY 83 budget included production rate increases for 14 programs which will result in savings of about $2 billion over the next five years.

I do not want to convey the impression that we have not faced problems, incurred set backs, or that we can succeed in the stabilization part of the program without continued extraordinary management effort. Unforeseen reductions during development of the FY 1983 budget contributed to destabilization of a number of acquisition programs. Some programs which had been restored to more economical production rates through the FY 1981-82 budget amendment subsequently were proposed for cancellation, reduction, or stretch-out in order to meet the new fiscal constraints. The balance between across-the-board responses to threats and program stability is difficult to strike, but, unless we reduce the number of programs and at the same time preserve the required funding for our "stable" programs, our acquisition improvement program will not succeed.

Difficulties with the multiyear effort include Congressional concerns over a loss of control over this portion of DOD's budget and the unstable nature of offsetting changing threats to our security. This inherent tension between the desire for savings and the need for flexibility presents a formidable barrier to wider implementation of the multiyear concept.

It is clear that effective implementation of the initiatives connected to stabilization requires their immediate incorporation into the planning process. We must reflect the thrust of the acquisition improvement program in all applicable guidance/planning documents.

Controlling Costs. We fully recognize the need to control costs as a key area in our efforts to achieve program stability and otherwise improve the acquisition process. We have taken some important steps which we hope will begin to bring this problem under control.

Inflation has been a major factor behind cost growth. This year's budget utilizes inflation indicies based on specific commodity price experience where inflation rates have significantly differed from those in the general economy. Program managers have been encouraged to budget to most likely cost and to budget for technological uncertainty.

We now require that the services explicitly choose between the program manager's estimate of costs and an independent one, and defend the choice.

Not all reported cost growth is real. Some of it results from establishing a cost baseline too early. To eliminate this "pseudo growth" and allow us to focus on controlling actual growth we have modified the milestones used by the Defense System Acquisition Review Council--or DSARC-- to delay the point where we establish a baseline to later in the development cycle. We anticipate that this will result in more realistic baselines being reported to Congress in the future.

Despite these initial steps, controlling cost growth, both real and perceived, remains a major problem. The solution requires the utmost effort of all involved and must include more realistic estimates, accurately reflecting future costs and difficult choices, to reduce requirements when costs grow.

Improved Readiness and Support. Improved readiness and support are primary objectives of the acquisition process of comparable importance to reduced unit cost or reduced acquisition time. By providing the necessary incentives to industry, we are seeking to design in reliability, maintainability, and support from the inception of weapons systems programs. If the incentives are there--and we are taking action to ensure that they will be--I see no reason why industry will not reorient and focus design talents toward improving the reliability and maintainability of our conventional military systems. However, the December 1981 report of the Acquisition Improvement Task Force indicated that programs continue to be structured to give precedence to acquisition cost, schedule, or performance objectives, while support and readiness are left to be accommodated within these program constraints. Early in the program reviews, we must examine acquisition strategy, including front-end funding, contractor incentives, design and supportability tradeoffs and alternative schedule and funding approaches, in the light of this effect on readiness. We also recognize, at the same time, the need, in some cases, for a more evolutionary approach to systems development. Our pre-planned product improvement program is a new design approach which plans a series of upgrades to lower technological risk and accelerate deployment while allowing continued development of high technology alternatives. In a sense, this will allow us to have our cake, with low risk to support and readiness, and eat it too. Many systems, such as the joint tactical information distribution system and the M-1, have already adopted this approach. We are seeking many more candidates.

Reduce Administrative Cost and Time to Procure Items. Simply stated, we're trying to reduce the hassle of doing business. This hassle impacts both the contractors seeking to do business with DOD and our acquisition personnel. We must remember what we are trying to do, to assure that industry is provided the maximum opportunity for innovation, and an opportunity to compete. We in Defense must eliminate complicated specifications and let industry know in the simplest possible terms what we need. We must emphasize reliance on commercial off-the-shelf components and equipment to the extent possible.

We in OSD have and continue to seek relief from various legislative and regulatory requirements that impede the acquisition process. To date we have been successful in obtaining legislation to:

o Raise the ceiling for small purchases from $10,000 to $25,000;

o Raise the threshold for contractor submission of cost or pricing data from $100,000 to $500,000; and

o Raise the threshold for secretarial D&F's for research and development from $100,000 to $5 million.

Additional efforts that are in process include those to: standardize the threshold for significant socio-economic programs at $25,000, and permit 4-day, 40-hour work week without premium overtime compensation.

Relief is being sought from regulatory requirements under the cognizance of other departments and agencies. For example, the Department of Labor is in the process of revising the Davis-Bacon Act and Service Contract Act implementation. It is anticipated that these changes will remove substantial administrative and direct cost in the acquisition process.

Our efforts to reduce the burden on the acquisition process have included a large degree of self examination. For example:

o OSD and service working groups are reviewing all directives to identify areas where changes (consolidations or eliminations) can be made without affecting essential elements of the acquisition process;

o The number of program review milestones has been reduced from four to two;

o Documentation for the review process has been reduced in length and scope; and

o We have eliminated micro management by raising the review thresholds from $75 million to $200 million for R&D and $200 million to $1 billion for procurement.

These efforts to reduce the burden on the acquisition process essentially have been aimed at directives and reviews required at the OSD level. Certainly, this effort should not end there. I suspect that similar reviews at the service and devense agency level will disclose areas where similar changes can be made to the benefit of the acquisition process. To the extent that such reviews have not been undertaken, I would like to encourage such efforts.

Simplification of Contractual Documents. There has been a growing concern in both the Government and industry that the complexity of solicitations and contractual documents severely inhibits the economy and efficiency of our procurement process. Long and bulky solicitations frequently do not fulfill any beneficial requirement. Instead they often aggravate and confuse contractors, inhibit competition, and add to the administrative time and cost of the process. As I mentioned earlier, we were successful in our effort to have the small purchase threshold raised to $25,000 thereby significantly reducing the complexity of purchases below that level. We are presently involved in an effort to simplify the contract format and content for the acquisition of supplies valued between $25,000 and $500,000. This dollar range encompasses contractual actions involving a vast majority of transactions for other than small purchases. Further, it is this area where industry complaints on the complexity of the procurement system are the most pronounced.

Although this effort has just gotten under way, we fully expect the results to be important in terms of improved competition and reduced administrative costs, particularly for activities such as DLA that do a significant part of their business with small business firms and acquire essentially commercial items.

Competition. It is firm DOD policy to purchase required materials and services including major weapons systems on a competitive basis whenever this makes good sense. Achieving cost effective competition is recognized as a major challenge and is one of our key acquisition improvement initiatives. In FY 81, 41% of our procurements were the result of price or technical/design competition--about four points better than FY 80. Another 23.5% were follow-on awards for items from sources that had been initially established as a result of competition--up two points over FY 80. We recently took a fresh look at competition in those major weapons systems reported to Congress in the selected acquisition reports. Out of a total of 48 systems examined, we found that 42 had initial competition in the program where the contractor was picked through a competitive source selection process. Our efforts to pursue the benefits of competition did not and must not stop there. In 24 of the systems examined we actually contracted with two or more competitors for some or all aspects of the development program. In some of these systems like the F-16, A-10, AAH, and M-1 we had competitive hardware for evaluation before entering full scale development. In others, such as the Multiple Launch Rocket System, Divad Gun, and Cruise Missile, we carried the competition through the entire development program. Even when we eventually get to a single development prime contractor, significant competition still takes place at the subsystem and vendor levels for the majority of the effort. We are pursuing several systems with production competition at the prime and subcontractor level and plan to add more in the near future. In many cases we break out production subsystems for direct purchase by the Government. For instance, the Tomahawk Cruise Missile has, or will have, competition, for virtually every major subsystem managed by the program office. We now examine the acquisition strategies of all major programs for the benefits of competition in production. We firmly believe competition provides cost benefits in most cases. We have intensified our scrutiny of the broader economies from competition in the production phase and plan to continue this emphasis in the future.

Additionally, last November the services and defense agencies were tasked to:

- o Designate advocates for competition at each procurement activity; and
- o Establish goals for increasing competition.

We will be monitoring their efforts.

The Logistics Management Institute has been tasked to assess commodities/programs with best potential for competition. Their report is due in June.

Essentially, we are turning over every stone we can find in our efforts to increase the level of competition.

But despite our efforts, it is absolutely certain that real success in increasing the extent of competition in the DOD acquisition process cannot be achieved without your strong support. The exceptionally high level of competition experienced in the Tomahawk Cruise Missile Program was the result of a firm commitment to this by those in leadership positions. If this success is to be repeated, similar commitments are essential.

Let me conclude by summarizing where we stand and what we expect and need from you. I think it is important to keep in mind that acquisition reform attempts in the past have not been implemented or implemented only partially. We intend to meet our goals.

So far we at OSD have been successful in:

o Lessening the legislative burden on the acquisition process by raising the thresholds for small purchases and the requirement for cost or pricing data. More changes are being pursued.

o Reducing internal OSD Administrative burdens such as those associated with the DSARC process, reductions in DOD directives, and secretarial D&F's. Here too, more changes/reductions in directives, etc. are in process.

o Stabilizing the acquisition of some major programs. More has to be done.

o Getting the word out on our initiatives to the public, industry, and Congress through articles, speeches, and testimony.

To insure implementation, responsibility for the program has been focused in the Under Secretary of Defense for Research and Engineering with primary action responsibility assigned to Bill Long, Deputy Under Secretary for Acquisition Management. Bill chairs an acquisition improvement steering group composed of senior Department of Defense and service officials charged collectively with monitoring progress and taking action to assure rapid implementation of the 32 initiatives.

The program and the progress that I have described this evening are important. We have made a good start. We have recognized and defined and identified the problem. But many of you in this room have been involved in the acquisition business for much of your adult life. I am not the first senior OSD official you have heard stand up and describe initiatives to reduce cost and bring discipline to the acquisition process. You may well be wondering what is different about this effort. Will this effort--like many other well intentioned efforts in the past--fade into obscurity? It is a fair question. I think there are important differences this time. The first, and perhaps the most important, is the exceptionally high degree of commitment which we have at the top. Secretary Weinberger and Frank Carlucci strongly support this effort and are anxious for it to succeed. I started my remarks by noting that undertaking the study which led to the acquisition improvement program was one of their earliest acts when they took over the responsibility for the Department of Defense. They are fortunate in having the strong support of the Office of Management and Budget, the Office of Federal Procurement Policy and the General Accounting Office. They have made considerable efforts to ensure proper implementation and under their leadership we are trying very hard to make implementation of this program a team effort. It would be foolish to assume that these initiatives will take root and grow simply because of their own merit. The basic policy changes have been made. But we must now shift our emphasis to action and implementation at the working level. In large measure the success of the acquisition improvement program will be a function of the efforts of those of you in the acquisition community. Your support, and the support of those with whom you come in contact--both in and out of Government--are essential. Continued public support for this administration's effort to rearm America depends on our convincing the American people that we are using their tax dollars wisely, prudently, and efficiently. If we are to do this, your active and continuing involvement in the acquisition improvement program is vital. We have the support from the top but we must all work together to implement this. We cannot afford to fail.

Thank you very much.

AWARDS

NATIONAL CONTRACT MANAGEMENT ASSOCIATION

First Place

LCDR James S. Anderson, SC, USN, and
LCDR Ronald A. Marchetti, SC, USN
"Multiyear Contracting As A Ship Repair Capital Investment Incentive"
(Page O-3)

Second Place

Raymond S. Lieber
"New Approaches for Quantifying Risk and Determining Sharing Arrangements"
(Page A-11)

Third Place

CPT Donald L. Brechtel, USAF
"Simulation Modeling: Bridging the Gap
Between Acquisition Research and Experience"
(Page J-19)

Honorable Mention Certificates

Carol Hawks
"Cost Variation Study of Reparable Items"
(Page I-11)

MAJ Peter J. Perkowski, USAFR
"DOD Contracting and Acquisition: Unprepared for A National Emergency"
(Page H-19)

INSTITUTE FOR COST ANALYSIS

Raymond S. Lieber
"The Underlying Learning Curve Technique"
(Page I-25)

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