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A COMPARISON OF AIRCRAFT MAINTENANCE ORGANIZATIONAL STRUCTURES

THESIS

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Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology
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In Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Logistics Management

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Preface

This study would not have been possible without the contribution of many people and organizations. We would specifically like to thank the personnel at HQ TAC/LGMP and the Naval Sea Logistics Center for providing the data used in this research. Two persons deserve special thanks, Squadron Leader McIntyre, RAF, and Maj Dempster, Canadian Forces. These two individuals spent their valuable time discussing their service's organization with us. In addition, we would like to thank members of the United States Coast Guard Auxiliary and K&G for their help.

We reserve special thanks to our thesis advisors, Lt Col Miller and Dr. Brandt for their patience and guidance through a trying and difficult process.

Wesley C. Davis
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Abstract

This study compares the aircraft maintenance structure being implemented by General Merrill A. McPeak with that of the previous structure typified by TACR 66-5. Historical aircraft data is used to compare organizational structures. Data from the USAF and USN is used to build regression models to determine if organizational structure contributes to combat capability. Statistical tests are used to determine if a significant difference exists between the two organizational structures.

Regression analysis and comparison of the results lead the researchers to conclude that a significant difference exists in the performance measures of COMO and Objective Wing organizations. While many reasons may account for this difference, the structure of the organization is a key determinant of performance.

A COMPARISON OF AIRCRAFT MAINTENANCE ORGANIZATIONAL STRUCTURES

I. Introduction

Background

The United States Department of Defense is reducing the size of its forces in response to the dissolution of the Soviet Union and to Congressional concerns over economic conditions. Despite this reduction, the mission of the United States Air Force (USAF) will continue to be to maintain combat ready forces prepared to support national policy objectives through military action (7).

The Chief of Staff of the Air Force, General Merrill A. McPeak, has outlined broad changes for the USAF and the aircraft and munitions maintenance (hereafter called maintenance) organizational structure (35:12, 28). The maintenance structure is changing drastically. Organizational and intermediate levels of maintenance are being split between the Operations and Logistics Groups respectively. Generically known as flightline and backshop maintenance, they have existed under a single chain of command for the last 35 years (18:126). Instituting this dual channel of authority is intended to provide, among other things, equal or greater levels of effectiveness with reduced manpower (35:12, 28).

Before the recent reorganization of the USAF, tactical aircraft maintenance units were organized under the provisions of Multiple Command Regulation (MCR) 66-5. This directive placed all unit level maintenance under the functional authority of a single manager, the Deputy Commander for Maintenance (DCM). Organizational maintenance was performed by personnel assigned to Aircraft Maintenance Units (AMUs) that were attached to the fighter squadrons. These AMUs were not under the command of the fighter squadron commander (8).

Intermediate level maintenance fell under the responsibility of two maintenance squadrons. The Component Repair Squadron (CRS) was responsible for maintenance of individual parts removed from the aircraft such as avionics boxes, engines, and hydraulic actuators. The Equipment Maintenance Squadron (EMS) provided the capability to perform heavy maintenance such as phase inspections and was responsible for maintenance of the Aerospace Ground Equipment (AGE) and all activities in the Munitions Storage Area (MSA) (8:111-172).

The reorganization of the USAF will change this structure. No longer is there a single functional manager for the maintenance complex. All organizational level, and some intermediate level, maintenance personnel are now assigned directly to the individual fighter squadrons. The remnants of the intermediate level capabilities will transfer to the new Equipment Maintenance Squadron under the command and control of the new Logistics Group Commander. This new structure is referred to in this study as the Objective Wing.

This revamped system is very similar to the organization of the United States Navy's (USN) Naval Aviation maintenance units deployed at sea. Gen Merrill A. McPeak compared his proposed Composite Wing, using the Objective Wing structure, to the Navy's carrier wing.

> The best example of a composite wing is provided by the modern aircraft carrier, where the typical deck loading creates a true composite with a range of capabilities tailored to the mission. (25:9)

Krisinger also compares the Navy's air wing to the new composite wings. The composite wings will share the organizational structure of the new Objective Wing (21:32-40). In the carrier air wing, all organizational level maintenance is performed by specialists assigned directly to the fighter squadron under the command and control of the fighter squadron commander. The remaining intermediate level maintenance is consolidated under one functional manager, the Aircraft Intermediate Maintenance Officer (AIMO). The intermediate functions are split among the General Maintenance, Avionics/Armament and the Support Equipment Maintenance Divisions.

The combined aircraft and munitions maintenance career fields make up 28% of the Air Force (30:38-57). Because this group is the single largest group of personnel in the Air Force, reorganizing to reduce its size can provide significant benefits.

General Issues

The USAF maintenance structure is changing. However, there are no published studies which predict or analyze the effects of this change as measured by a performance value such as mission capability (MC) rate. Previous changes in maintenance organizational structure were either the direct result of studies undertaken to improve a specific measure such as the number of sorties flown per day, or arose from the requirements of combat.

Problem Statement

There has been no comparison made to determine if organizational structure contributes to, or detracts from, an aircraft maintenance unit's performance measures.

Research Questions

1. Can a model (either mathematical or analytical) be developed which can accurately predict an organization's performance as reflected in the MC rate?
2. What variables contribute to the prediction of this maintenance performance?

3. Are the variables in models of the USAF and USN organization's performance the same?

4. Do statistically significant differences exist between the levels of performance achieved by USAF and USN aircraft maintenance organizations as predicted by mathematical or analytical models?

Scope

This study will compare the performance of the old USAF maintenance structure with an organization similar to the new structure. The organization which best represents the new structure is the USN, specifically USN fighter squadrons deployed at sea. The researchers will determine if a statistically significant difference exists between the performance of maintenance organizations of the USAF and USN. One measure of this performance is in the MC rate of assigned aircraft.

The aircraft studied will be limited to USAF F-15 and F-16 and to USN F-14 and F/A-18.

Overview

This thesis is organized with five chapters. Chapter I is the general introduction to the situation being examined by the researchers. It contains the background, problem statement, research questions and scope of the research. Chapter II contains a review of literature found on subjects related to the problem and summarizes some techniques relevant to the analysis. Chapter III describes the methodology used in performing the comparison of the target organizations. Chapter IV begins the examination of the results from the treatments outlined in the methodology. Chapter V will present conclusions reached from the comparison and recommendations for future studies.

II. Literature Review

Introduction

Congress has recently passed a military budget bill which sets the tone for Air Force operations for the next five years. This bill takes the manpower levels now in force and mandates a 25% reduction (35:12,28).

Aircraft maintenance is one of the primary areas of concern with the impending drawdown. The Air Force Specialty Codes (AFSC) which make up aircraft and munitions maintenance represent the largest career groups in the Air Force at 28% of the total enlisted force (29:51). If that pool of manpower is reduced by a fourth, it will have a noticeable effect upon the ability of the Air Force to defend the nation.

Scope

This chapter will examine the history of maintenance in the USAF and the way in which the USAF and the USN organize their aircraft maintenance structure. Other countries organizations are included for comparison. The two countries examined are the United Kingdom and Canada. In addition, the new organizational structure of the USAF will be examined. Three previous master's theses using modelling techniques to predict aircraft availability will be examined. The researchers will include a general discussion on mathematical modelling techniques used to determine the effects of independent variables on predictors and the techniques used to validate these models. Standard techniques used to determine the level of significance between the results of two models will be discussed. In addition, current literature on comparing different organizations in similar industries will be reviewed.

History of Aircraft Maintenance in the USAF

In the USAF, changes to the aircraft maintenance organizational structure have traditionally been undertaken in response to problems as they arose. As a result, overall revision of the entire system has been a long term, piecemeal process. (20:39)

1909 - 1945. Prior to the first world war aircraft were technologically unsophisticated. Enlisted personnel, who were experts on the entire aircraft, performed all repairs. This was the beginning of the crew chief, an individual who was responsible for all servicing and repair of the aircraft. During the first world war rapid growth of the Aviation Section forced a structure onto the maintenance organization. A brief outline of the structure is listed below.

> First echelon - Maintenance was performed by the aircrew; e.g., servicing the aircraft, performing pre-flights and daily inspections, making minor adjustments and repairs.

> Second echelon - Maintenance was usually performed by the ground crew of operating units, air base squadrons, and aircraft detachments; e.g., servicing aircraft and equipment, performing periodic preventive maintenance inspections, making minor adjustments and repairs.
>
> Third echelon - Maintenance was performed by specialized mechanics from base shops and sub-depots; e.g., removal and replacement of major unit assemblies and all minor repairs to aircraft structures and equipment.
>
> Fourth echelon - Maintenance was performed by highly specialized mechanics in air depots; e.g., major repairs, modifications, and overhauls. These depots were located at Dallas, Texas; Montgomery Alabama; and Indianapolis, Indiana. (18:30)

This structure was required because of the rapid build up of Army Aviation and the resulting need for more maintenance personnel. It was easier and faster to train personnel to perform one specific duty, or group of related duties, than to train personnel to perform all repairs.

In the years between the two world wars, Army aviation began to swing from specialized mechanics back to the generalization of the pre-World War I era. "The mechanic was again being trained to maintain his entire aircraft" (18:41). This was a return to the crew chief system first instituted in 1913 and was brought about by reductions in the size of the Army Air Corps and its manning.

With the entry of the United States into the Second World War, aircraft maintenance once again underwent change. In the continental United States (CONUS), Headquarters Army Air Forces Instructions outlining the maintenance organizational structure were mandatory. Overseas theater commanders were allowed to modify or even ignore these instructions. The organizational structure of overseas units was varied and adapted to the local situation. In contrast, CONUS units were structured and uniform. During this time the use of specialties began to become prevalent within CONUS. The organization of base maintenance units consisted of Flying Line Maintenance and Production Line Maintenance. In 1945 the Army formalized this structure in its United States Army Strategic Air Force Regulation 65-1.

1945 - 1957. The period from 1945 to 1957 was a period of demobilization and change. The U.S. Air Force became a separate service in 1947, the Berlin Airlift was the new Air Force's first challenge in 1948 and Korea exploded in 1950. The main points of interest to this study occurred between 1947 and 1949.

The end of World War Two created many problems for the new Air Force. For example, rapid demobilization led to manpower shortages with many of the highly skilled mechanics leaving the military for more lucrative jobs in industry. The shortage of skilled technicians along with the lower manning in general, left personnel who were unable to maintain the complex aircraft in use at that time. To counter this loss of skilled personnel and to improve the quality of maintenance, the Air Force instituted the Hobson Plan in 1947 (18:74).

> This plan made the wing headquarters the highest echelon on a base. Subordinate to the wing headquarters were four groups: the combat group, the maintenance and supply group, the airdrome group, and the medical group. Combat squadrons within the combat

> group had the responsibility for the first and second echelon maintenance on assigned aircraft. This included engine changes. The maintenance squadron within the maintenance and supply group was responsible for third echelon maintenance and all maintenance on base flight and transient aircraft. (3:26)

Following the Hobson Plan, the Air Force conducted a survey in 1948 to gather information from the field on maintenance practices. As a result of this survey, a report by Maintenance Division outlined a plan to

> increase the effectiveness of the peacetime maintenance organization; reduce maintenance costs; and finally, provide a sound basic organization for mobilization expansion. (37:141)

The underlying concept of this plan used concepts taken from industry, primarily the production line. Personnel were trained to high skill levels on one specific task. The main advantage of this system was the technicians were trained to the necessary skill level in a short time. Strategic Air Command (SAC) took the lead with this concept and established technician specialization as their maintenance concept. This concept was published as SAC Regulation 66-12 in 1949. The purpose of this regulation was:

> to establish a functional aircraft maintenance organization within the wing-base organization which would insure full utilization of personnel and facilities to produce maximum availability of aircraft. (36:141)

Tactical Air Command (TAC) did not adopt a mandatory regulation for maintenance organization, as did SAC. TAC left the organization of maintenance up to the unit commander, much like overseas practice in the Second World

War. The next major event in aircraft maintenance took place in 1957 with TAC's adoption of a new maintenance concept.

1957 - 1972. The Air Force underwent many changes in the period from 1957 to 1972. The year 1957 saw a fundamental shift in TAC's aircraft maintenance organization. In this year control of the maintenance personnel and the aircraft changed from the operational squadron commander to a Chief of Maintenance (34:1). The next important event for aircraft maintenance took place in 1972 with project RIVET RALLY.

All major commands began to use AFM 66-1 in 1957, first pioneered by SAC as SACR 66-12. This change was driven by the complexity of tne new jet aircraft coming into the inventory. These new aircraft were more complex than older aircraft and were not designed for ease of maintenance. AFM 66-1 continued the move towards more and more centralization of the maintenance complex. Crew chiefs were the only personnel assigned to work on the flightline. All other maintenance personnel were assigned to backshop functions. These personnel were located off the flightline and had to be dispatched to assist the crew chief as required. Dispatching specialists required communication and coordination. Communication and coordination required staff personnel. Staff personnel required paperwork and documentation. The result was high numbers of overhead personnel who were not directly involved in sortie production on the flightline (18:127).

Another problem with centralized maintenance as outlined in AFM 66-1 was the unit did not train as it would fight. Tactical wings in the early sixties were very large, some with hundreds of fighter aircraft. In addition, these wings were tasked to provide small numbers of fighters for routine deployments to overseas locations. When a group of fighters deployed, the maintenance personnel and aircraft were assembled as a unit for the first time. Unit integrity and unit pride were lacking (24). The Air Force went to war in Vietnam with this structure but began to realize it was not capable of producing a high number of sorties.

1972 - Present. The Air Force carried centralization of the maintenance complex through Vietnam. In 1972, feeling the pressure of budget cutbacks, the Air Force created project RIVET RALLY. RIVET RALLY "was designed to centralize base level maintenance organizations, standardize functions within those organizations, and develop a common maintenance management directive for use by all commands" (34:17-29). This process standardized all maintenance throughout all commands in the Air Force.

The end of fighting in Vietnam led to a large scale reduction of the United States' military forces. The focus of military attention shifted to the defense of Western Europe and peace in the Middle East. The Air Force attempted to meet its commitments by maintaining high readiness. However, high readiness required many training sorties, and many training sorties required maintenance to perform more work. Once again, a shrinking military was asked to perform more with less (18:142-143). There was a rising concern in the Air Force that maintenance could not produce the number of sorties required.

> In the past, there had been a shortfall in aircraft sortie production to meet the needs of operational and aircrew training requirements. An identified cause for the inability to meet those requirements was maintenance capability and training. (3:76)

In an attempt to find a solution to generating more sorties, the Chief of Staff, USAF, created the Maintenance Posture Improvement Program (MPIP). MPIP's charter directed it to "develop new ways to perform required maintenance with diminishing numbers of personnel without compromising safety standards" (3:76). MPIP created a board that was tasked to consider manpower utilization, training of maintenance personnel, modernization of Aerospace Ground Equipment, and the organizational structure of maintenance (3:77). One of the board's findings was the belief that a war in Central Europe would require very high sortie rates for the first 10-15 days. The board asked the question "can maintenance generate a sufficient number of sorties and sustain it over a period of time?" (3:77). Their answer was no.

The 1973 Arab-Israeli War (Yom Kippur) occurred at approximately the same time as the MPIP board concluded the Air Force would need to produce very high sortie rates each day in the next war. The Israelis flew extremely high sortie rates, as the MPIP board had predicted. To find out how the Israelis accomplished this high sortie production, TAC sent a team to Israel to study their maintenance organizations. The team found the Israelis assigned the personnel who were directly responsible for repairing, servicing, and launching aircraft to the flightline. Personnel who did not directly contribute to generating aircraft were assigned to shops off the flightline. The team felt the Israelis' system of maintenance "appeared to have great possibilities in the fighter environment" where "rapid aircraft turnaround, sortie generation and surge capability were essential" (3:78). HQ USAF urged TAC to adopt this organizational model in 1974.

The findings of the MPIP board and the study of Israeli maintenance practices lead to the introduction of the Production Oriented Maintenance Organization (POMO). POMO took advantage of the natural on- and off-equipment split in maintenance (3:80). Flightline personnel directly supported the sortie generation of aircraft. Specialist dispatching was abolished. Personnel who were not involved in sortie generation were assigned to backshops to repair the black boxes removed on the flightline. The maintenance personnel on the flightline were assigned to Aircraft Maintenance Units (AMUs) and cross trained to perform many general types of simple tasks.

POMO did not produce the numbers of sorties expected. When General W. L. Creech took command of TAC in 1978 he instituted a study to determine what TAC's capability was. The study found sortie production fell 7.8% from 1969 to 1978. The major reason for the decline in sortie production was not due to external factors such as reduced funding. It was simply maintenance's inability to produce the required number of sorties programmed. (18:19-20). General W. L. Creech felt the organization of maintenance was the major contributing factor to this decline.

TAC created the Combat Oriented Maintenance Organization (COMO) to fix this problem. COMO was formalized as Multiple Command Regulation (MCR) 66-5, the title later changed to Tactical Air Command Regulation (TACR) 66-5. The Combat Oriented Maintenance Organization differed from POMO in the following manner:

1. Each squadron/AMU performed its own scheduling and was responsible for its own utilization rate.

2. Each squadron/AMU had its own dedicated analyst to provide statistical analysis.

3. Wing score-keeping functions such as Maintenance Supply Liaison were eliminated and supply responsibility was decentralized to the squadron/AMU.

4. Each squadron/AMU had its own supply support section.

5. Each squadron/AMU performed its own debriefing after a mission.

6. The squadron/AMU had its own pool of Aerospace Ground Equipment.

7. Dedicated crew chiefs were assigned to each aircraft.

8. Each squadron/AMU dispatched its own flightline personnel to jobs.

> 9. There was squadron/AMU integrity; red hat maintenance personnel worked on red tailed jets flown by red scarfed pilots. (18:25)

Unit pride, which was the central theme of COMO, was the result (18:149-150). However, implementation of COMO was very manpower intensive.

> The results of the transition to COMO have been dramatic. Sortie production, from the third quarter of 1978 through the third quarter 1983, rose at an annual rate of 11.2 %. In the first full year under COMO, 1979, TAC flew all of its programmed sorties for the first time in a decade. (18:150)

Maintenance Organizational Structure

Several alternative methods of organizing aircraft maintenance are commonly used in different air forces around the world. The researchers will examine several of these air forces through journal articles and reports as well as through their own regulations and directives. This literature search will serve to establish a baseline for comparison with both the TACR 66-5 structure and the new Objective Wing structure. The service of most interest to this study is that of the United States Navy because it will be used as a comparison to the new Objective Wing structure in this study.

United States Air Force, TACR 66-5. Prior to 1992, the standard CONUS based tactical USAF unit was organized under a single Deputy Commander for Maintenance (DCM) as outlined in TACR 66-5. This pre-1992 organization is the focus of the current study. Subsequent mention of the organizational structure of CONUS based USAF tactical units will refer to the pre-1992 organization. The DCM worked directly for the Wing Commander and was responsible for all base level aircraft maintenance. Underneath the DCM were three maintenance squadrons: Aircraft Generation Squadron (AGS), Component Repair Squadron (CRS), Equipment Maintenance Squadron (EMS) (8). See Figure 1.

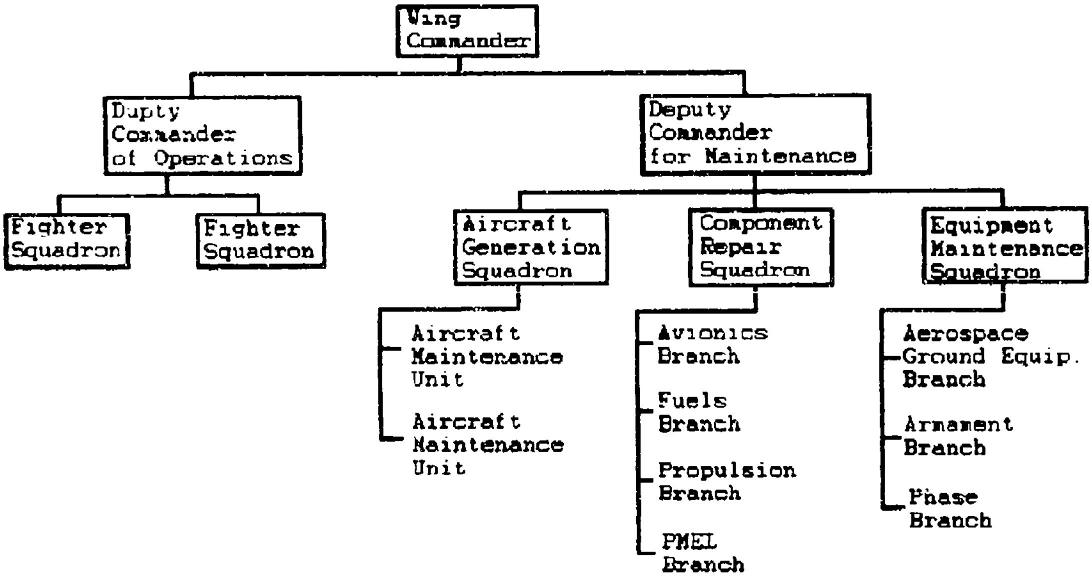


Figure 1. USAF Aircraft Maintenance Organizational Structure, TACR 66-5 (8)

Each of the three squadrons had specific areas of responsibility. AGS was responsible for launching, recovering, and servicing aircraft, and was arranged into Aircraft Maintenance Units (AMUs). The AMUs were responsible for their own scheduling, utilization rate and maintenance analysis. AMUs were partnered with a flying squadron and only performed maintenance on their own aircraft. The AMU concept allowed dedicated maintenance personnel to work closely with the flying squadron to enhance mission capabilities.

The typical AMU contained two crew chief flights (usually called APG Flights), a Specialist Flight, a Weapons Flight and a Support Section. See Figure 2.

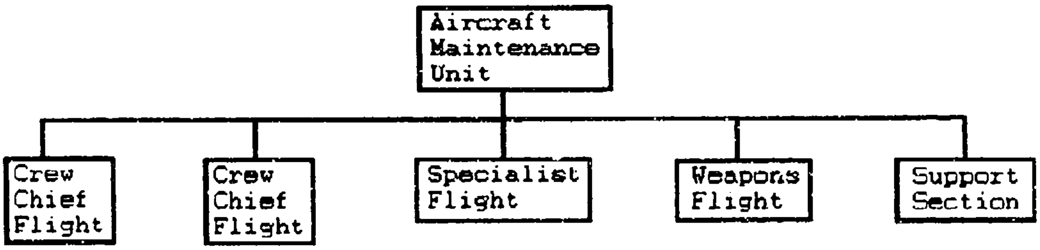


Figure 2. USAF Aircraft Maintenance Unit Organization (8)

The crew chiefs in the APG Flights performed servicing, inspection and maintenance on the aircraft they were assigned. The Specialist Flight contained the avionics technicians, hydraulic technicians, electricians, environmental specialist and power plant mechanics. The Weapons Flight personnel were responsible for loading munitions and maintenance of the aircraft weapons release systems. The Support Section maintained tools, test equipment and technical orders (TOs). A small staff assisted the AMU supervisor in managing the AMU. The staff included the functions of Plans and Scheduling, Administration, Training and Dispatch/Debrief (8:72-111)

CRS was responsible for off-equipment maintenance on avionics components and fuel systems. It was composed of four branches: Avionics Branch, Fuels Branch, Propulsion Branch, and Precision Measurement Equipment Laboratory Branch (PMEL). With the exception of Fuels Branch, personnel from CRS were not routinely dispatched to the flightline.

EMS was responsible for off-equipment maintenance on munitions, Aerospace Ground Equipment (AGE), phase inspections, and fabrication. EMS was authorized four branches: Munitions Branch, AGE Branch, Maintenance Branch, and Fabrication Branch (8).

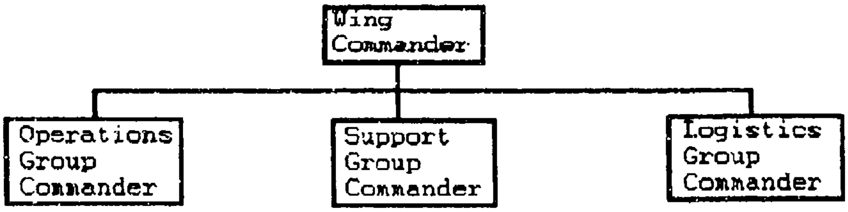


Figure 3. USAF Maintenance Organization, Objective Wing (12)

United States Air Force, Objective Wing. The Objective Wing as described by General Merrill A. McPeak, will be: "one base, one wing, one commander". It is intended that air force wings should train as they will fight. It will accomplish this by having a single wing commander at each base with flight crews and flightline maintenance personnel working for the flying squadron commander. The backshop maintenance personnel will work for a logistics group commander. This is the same basic wing structure used in Operation Desert Storm (10:99). See Figure 3.

The aircraft maintenance structure will be organized to place the on-aircraft maintenance functions under the Operations Group commander. The supply, transportation, and off-aircraft maintenance functions will be under the command of a single person in the Logistics Group.

> This structure places the sortie producers under the flying squadron commander and the support shops under the Logistics Group commander. An accountability matrix will ensure a system of checks and balances. (12)

The Operations Group Commander will report directly to the Wing Commander. Underneath the commandor there will be operations squadrons (flying squadrons) and an Operations Support Squadron. The on-equipment maintenance officer will report to the operations squadron commander.

The maintenance officer will have an APG Flight, Weapons Flight, Specialist Flight and Support Flight. The functions of these flights are the same as those under the TACR 66-5 structure. See Figure 4.

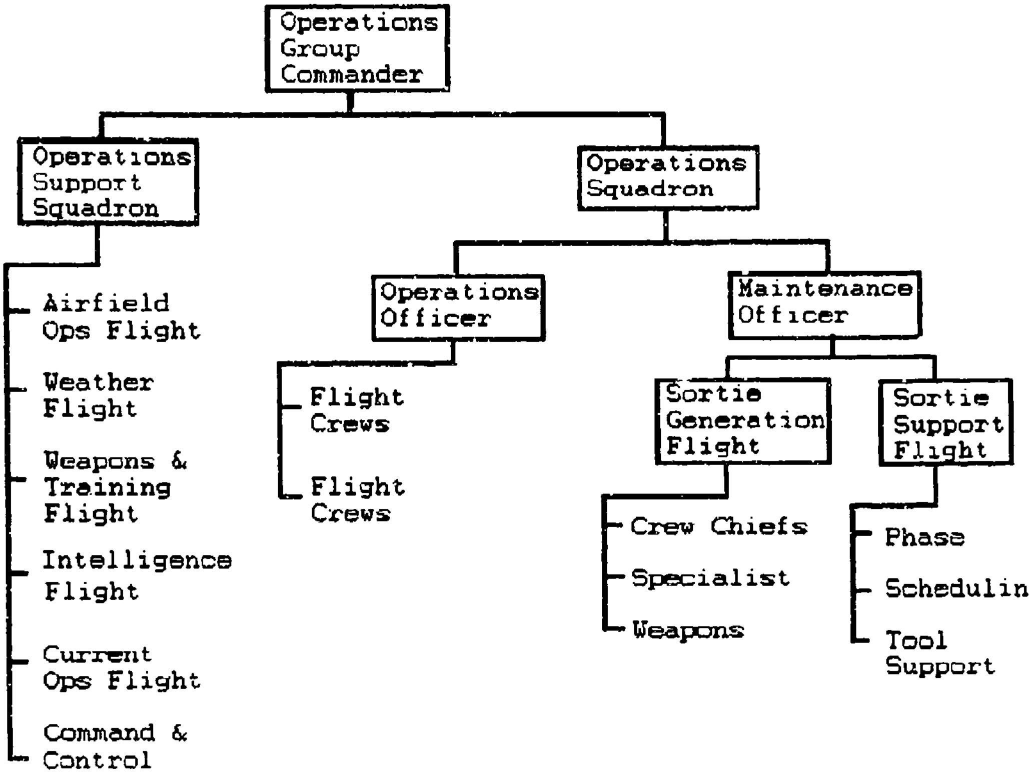


Figure 4. USAF Maintenance Organization, Operations Group (12)

The Logistics Group Commander will absorb the supply squadron, logistics plans division, the former CRS and EMS and the transportation squadron. The former CRS and EMS will be consolidated into a Maintenance Squadron responsible for off-equipment work. See Figure 5.

United States Navy. The United States Naval Aviation Maintenance Program (NAMP) delineates its organization into several types: ship-board, shore-based, large readiness and training squadrons, Marine Corps Aviation units, and detachments with four or less aircraft (5). For the purpose of this study only ship-board units will be discussed.

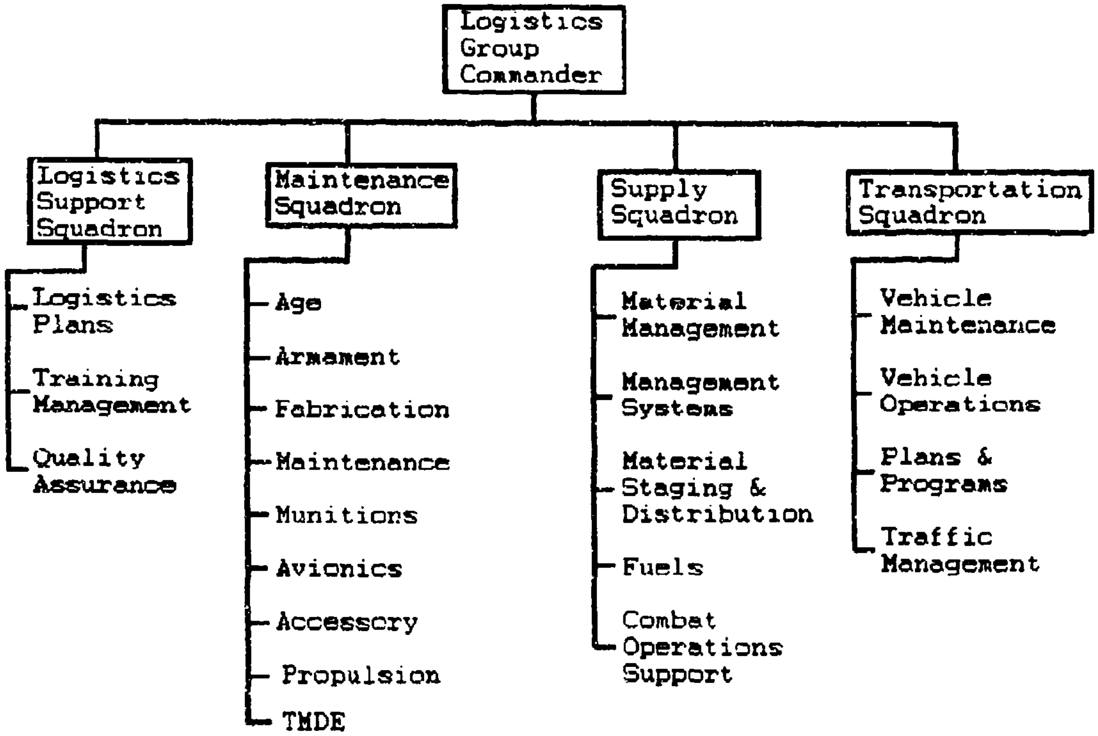


Figure 5. USAF Maintenance Organization, Logistics Group (12)

The ship-board aircraft maintenance structure of the United States Navy closely resembles the structure of the new USAF Objective wing. There is a single commander over both operations and intermediate level maintenance. The operations function owns the organizational level maintenance. The intermediate level maintenance is the responsibility of a separate commander (15). This is a loose analogy as the Navy's ship's commanding officer has some operational responsibilities in addition to his intermediate level maintenance responsibilities. For example he is responsible for the command and control functions, the responsibility of the Operations Group commander in the Air Force. The top level organization of ship-board maintenance units is shown in Figure 6.

On board ship, aircraft maintenance is separated into Organizational level and Intermediate level.

The Navy assigns all organizational level maintenance activities to a single Maintenance Officer with an assistant. The Maintenance Officer reports directly to the fighter squadron commander, who has direct command authority of all organizational level aircraft maintenance. Figure 7 shows the USN's organizational level maintenance structure.

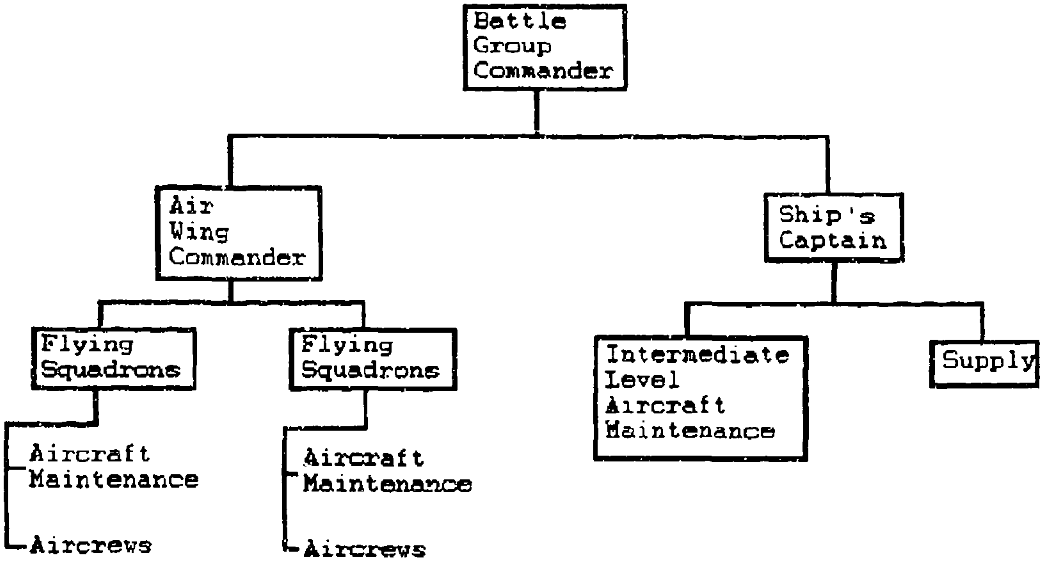


Figure 6. USN Maintenance Organization, Top Level. (15)

This officer is either a career maintenance officer or an officer on flight status. Either the Maintenance Officer or his assistant must be a career maintenance officer with specific training qualifications outlined in OPNAVINST 4790.2E, Volume II.

Underneath the maintenance officer there are three branches: Quality Assurance/Analysis, Maintenance/Material Control Officer, and Maintenance Administration. The branch of interest to this study is the Maintenance/Material Control Officer.

The Maintenance/Material Control Officer has six divisions under him: Maintenance Control, Material Control, Target Division, Aircraft Division, Avionics/Armament Division, and Line Division. The Target Division is not considered in this study as there is no direct USAF counterpart.

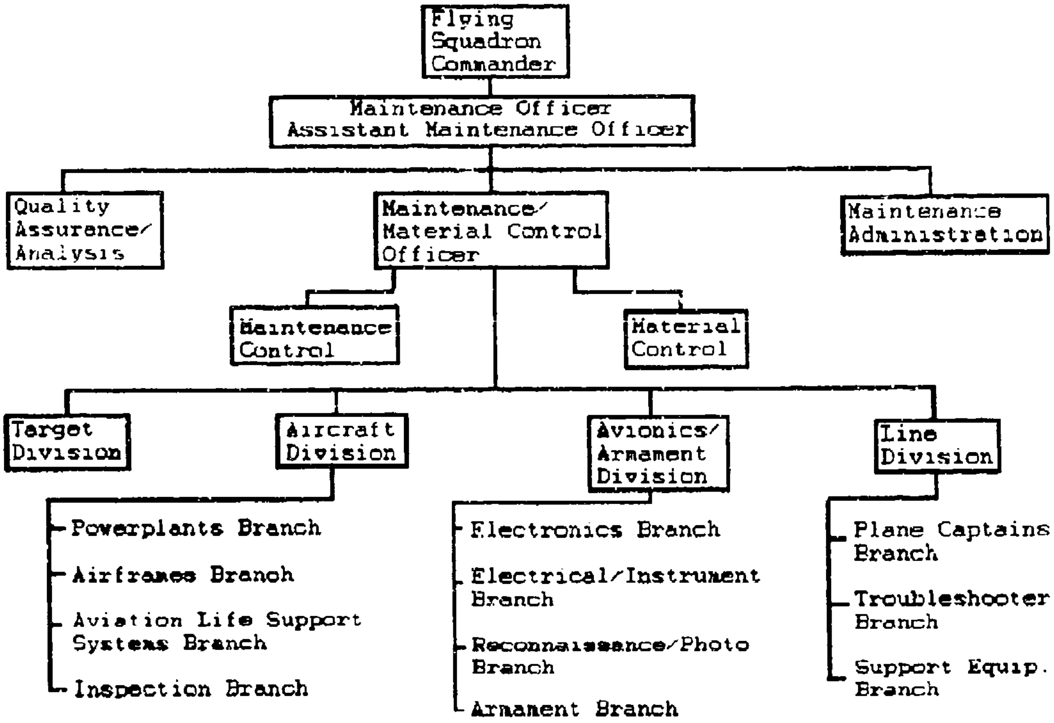


Figure 7. USN Maintenance Organization O-Level (5:3-3)

Only three divisions have personnel who work on the flightline: Aircraft Division, Avionics/Armament Division, and Line Division. The functions under the Aircraft Division are Powerplants Branch, Airframes Branch, Aviation Life Support Systems Branch, and Inspection Branch. The Avionics/Armament Division contains the Electronics Branch, Electrical/Instrument Branch, Reconnaissance/Photo Branch, and the Armament Branch. The specialists in both the Aircraft Division and the Avionics/Armament Division are dispatched to the flightline to support the Line Division. This is analogous to the Specialist Flight and Armament Flight in a USAF AMU. The third division directly supporting the flightline is the Line Division. This division contains the Plane Captains Branch, Troubleshooters Branch, and the Support Equipment Branch. This division is similar to the Aircraft Generation Squadron in the USAF with the exception of the Support Equipment Branch which would be placed in a backshop. In this structure the maintenance officer has control over all of the organizational aircraft maintenance personnel assigned to the fighter squadron.

All intermediate level maintenance at sea is organized under the functional command of the Aircraft Intermediate Maintenance Officer (AIMO). The qualifications for the AIMO and the assistant parallel those for their organizational level equivalents. All intermediate level aircraft maintenance is the responsibility of the ship's commanding officer. The AIMO heads the Aircraft Intermediate Maintenance Department (AIMD) which splits into three major production branches (6). See Figure 8.

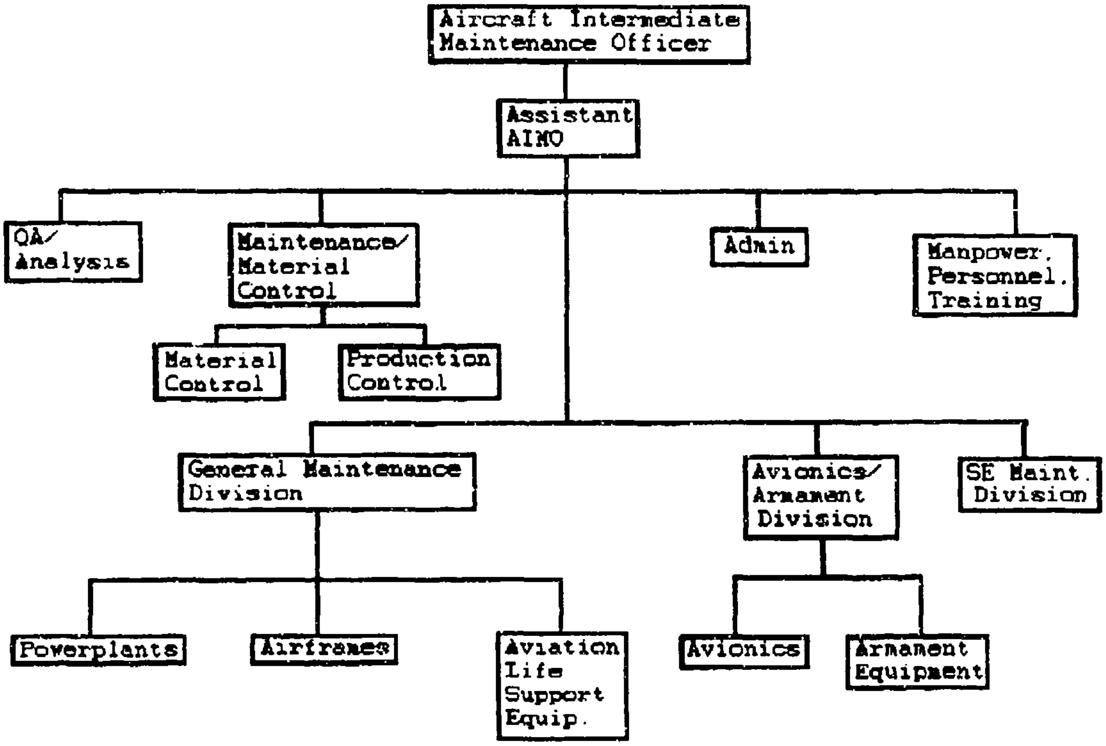


Figure 8. USN Maintenance Organization, I-Level (6)

The General Maintenance Division is split into sections responsible for off-equipment power plant maintenance, airframe maintenance and aviation life support equipment. The Avionics/Armament Division performs off-equipment work on avionic and armament components in the two separate branches. The final division is the Support Equipment Maintenance Division. This section performs all work on the Navy's equivalent of aerospace ground equipment.

The AIMO has a staff to assist in management of the AIMD. The Maintenance/Material Control section is identical in function to its counterpart in the fighter squadron.

Additional staff functions are the traditional sections of Quality Assurance/Analysis, Administration and Manpower, Personnel and Training.

Canadian Forces, Air Command. Canadian forces arrange their maintenance personnel in a different manner. The senior maintenance officer, the Base Aircraft Maintenance Engineering Officer (BAMEO), is responsible for all aircraft maintenance activities, see Figure 9 (4:3).

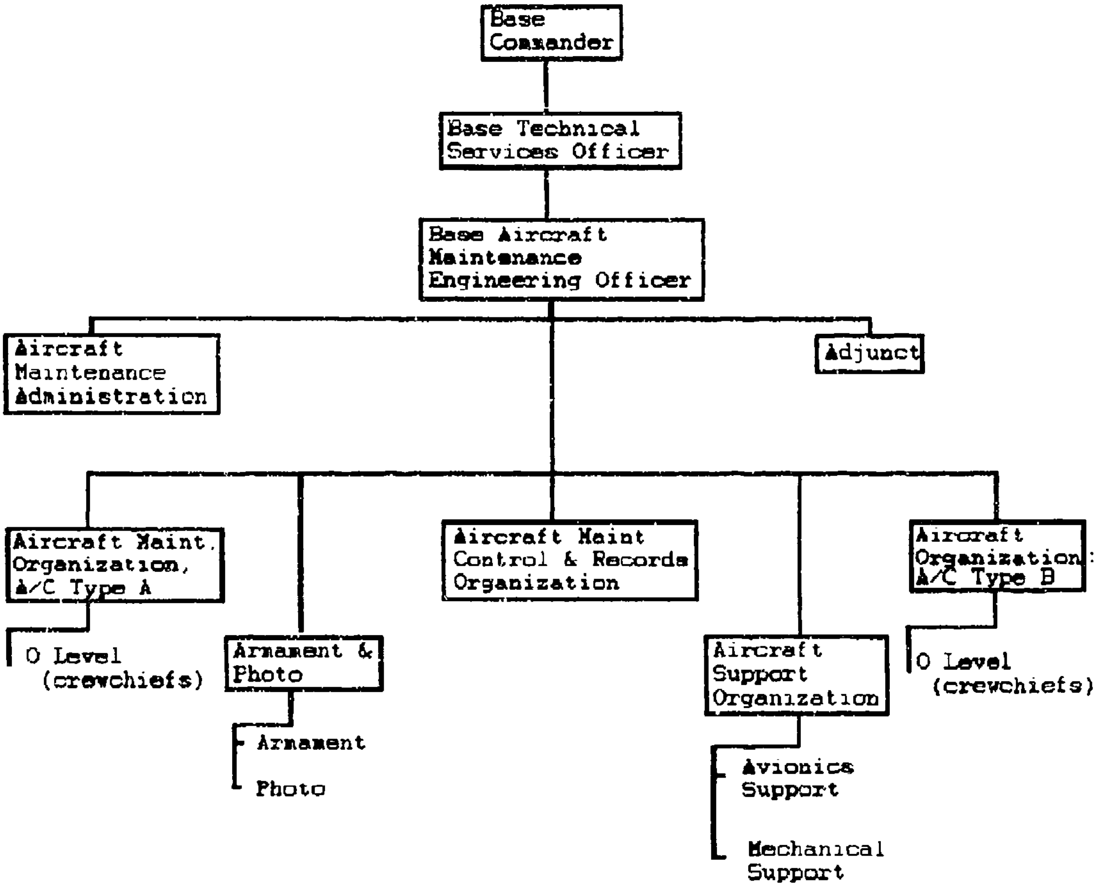


Figure 9. Canadian Forces, Air Command, Maintenance Organization (4:3)

Under the BAMEO, flightline units are established based on the type of aircraft they support. They perform all organizational level maintenance. One example is the Aircraft Maintenance Organization-Tracker, which supports Tracker maritime reconnaissance aircraft. At Canadian Forces Base-Summerside, two separate operational squadrons fly the Tracker aircraft. One maintenance organization supports both squadrons (4:3-E1). Different units are set up to maintain different aircraft at the same base. At CFB Summerside, Buffalo and Voyageur search and rescue aircraft are maintained by the Aircraft Maintenance Organization Search and Rescue (4:3-F1).

Intermediate level maintenance is accomplished by the Aircraft Maintenance Support Organization (AMSO) and the Armament and Photo Organization (4:3-G1, 3-18). These two organizations perform all off-equipment repair (regardless of aircraft type) much as the intermediate maintenance squadrons in the USAF.

The aircraft maintenance organizational structure closely resembles the structure of the USAF under TACR 66-5.

Royal Air Force. Another basic organizational structure has evolved within the Royal Air Force (RAF), United Kingdom. The Royal Air Force aircraft maintenance organizational structure resembles that of the USAF Objective Wing, see Figure 10.

Much like the USAF Objective wing and the US Navy, organizational level maintenance is performed by personnel assigned to the flying squadron they support. These maintenance personnel are under the command of the flying squadron commander.

The intermediate level of maintenance belongs to a separate functional commander. Overall intermediate level maintenance is the responsibility of the BAMEO, the commander of the Engineering Wing. The Engineering Wing performs the common intermediate functions of propulsion, structural repair and avionics, all off-equipment work (23). A copy of the RAF's maintenance directive, AP100A-01, was requested from the RAF but was not supplied.

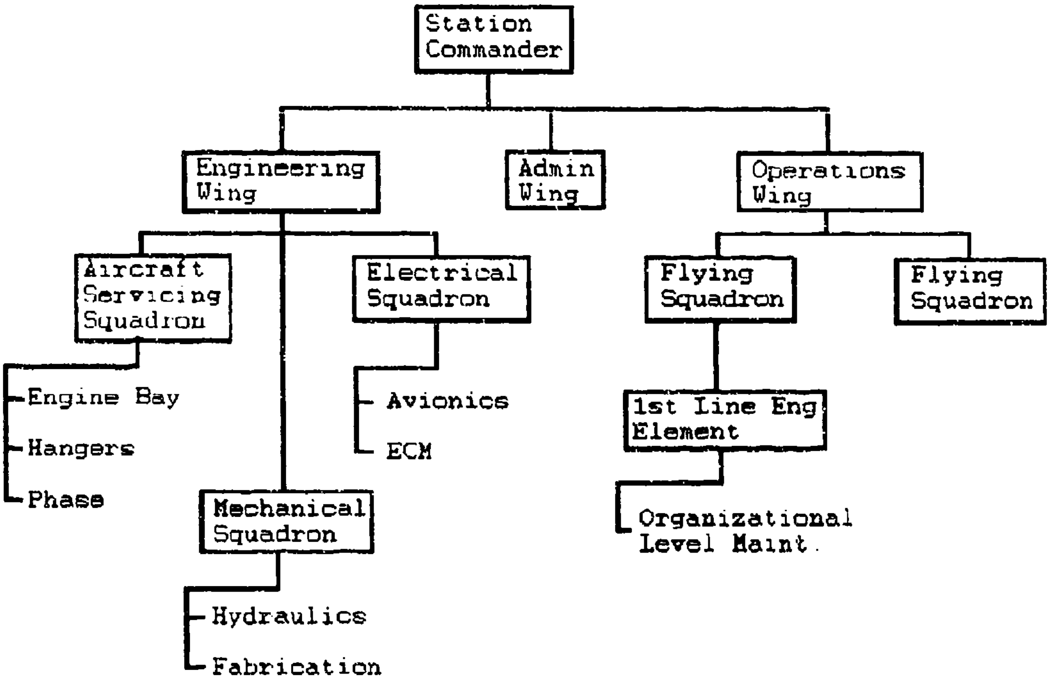


Figure 10. Royal Air Force Maintenance Organization (23)

The RAF aircraft maintenance structure is parallel to the USAF Objective Wing. The flying squadron commander has command authority over all organizational level maintenance personnel. A separate commander has command authority over all intermediate level maintenance activities.

Previous Research

Previous research into the effect of maintenance variables on mission capability was examined, both for completeness and for applicability to the problem stated by the researchers. Each of these theses examined the relationship between maintenance variables and their effect upon some dependent measure of performance or productivity.

Gililland. Gililland studied productivity in the USAF. He specifically identified the productivity measures used and attempted to "understand the relationships among the various productivity measures" (14:4). His research evaluated how [aircraft] maintenance productivity measurements affected the USAF productivity objectives.

One of Gililland's research questions directly applicable to the current study is "Of the measures implemented by aircraft maintenance organizations, which contributes most significantly to explaining maintenance productivity?" (14:5). To answer this question, Gililland used six months of aircraft maintenance performance data from the Military Airlift Command (MAC). Gililland used the software package, System for Elementary Statistical Analysis (SAS) with six months of data to build regression models to determine the variables with the most significant contribution to various dependent variables. From this analysis, the independent variables found to contribute the most to the MC rate were cannibalization rate, awaiting maintenance and awaiting parts discrepancies and average possessed aircraft (14:105).

Gililland's study is of interest because it examined the relationships of several variables on MC rate and it validated MC rate as one of the most important indicators of a unit's effectiveness. In addition, the SAS software package was used to build regression models using these variables.

Jung. Jung examined the existing performance measures of several SAC aircraft. His research attempted to find the "maintenance production constraints that limit or enhance production capability", the "relationships between the maintenance constraints and an organization's production capability" and "what maintenance constraints can be used in a predictive model of a maintenance organization's sortie production capability" (19:3).

The research aim of Jung's study is different than that of the present study. Jung attempted to use existing maintenance indicators to predict a unit's capability. His study is only of interest because of his methodology; he used regression techniques using historical data. Twenty seven months of data were obtained from SAC HQ. Twenty one months of data were used to build the models and the remaining six months of data used to validate them. The six months chosen for validation were consecutive months; no attempt was made to randomize the data withheld for validation.

Gonnerman. In her thesis, Gonnerman took a significantly different approach to analyzing performance factors. This study used a technique known as Constrained Facet Analysis and evaluated its applicability to maintenance indicators (16:1). The study took data from 5 months of activity at a specific Air Force base operating A-10 aircraft (16:2). The research target was split into two categories, the Aircraft Maintenance Unit and the aircraft itself (16:16). Using selected input and output variables and reciprocals, Gonnerman graded the efficiency of the AMUs and 28 different aircraft (16:25,28).

The Constrained Facet Analysis (CFA) performed for this thesis involved the use of special computer programs not available at AFIT (16:29). Additionally, the conclusion reached by the author did not show an clear advantage to using this type of analysis (16:56). In fact, Gonnerman listed several disadvantages to CFA, among them the complexity of the method and the need for training for those using it (16:56). For these two reasons, more traditional methods of statistic analysis were selected for this thesis.

The one important factor in this analysis lies with the selection of the input and output measures. As in other studies, the mission capable rates of an aircraft were chosen as output variables (19:22). Additionally, two important measures were established as input variables: manhours per flying hour (per time period) and the number of sorties scheduled and flown (19:19,20). While some variables were chosen for analyzing the AMU and others affected the individual aircraft analysis, both were used in evaluating performance of the maintenance organization in general. Many of these same variables will have an affect on the researchers' study using regression analysis.

Inter-Service Comparisons. There is a complete lack of written material on a comparison between the USAF and other air forces' maintenance organization. This was a surprising discovery. The researchers expected to find numerous comparisons based on the frequent examination of the organizational structure of the USAF. Some examples of these examinations are Projects RIVET RALLY and RIVET WORKFORCE and the Maintenance Posture Improvement Program.

Inter-Industry Comparisons. Literature concerning analytical comparisons between companies within a like industry were reviewed to gain insight into methods used by other researchers. The works of a well-known author in this field was searched for analytical methodologies on intra-industry comparisons.

Vogel has studied the differences between selected Japanese industries and the corresponding American industry. In the two texts reviewed, analytical methodology was not discussed. Instead of analytically comparing industries in the two countries, Vogel discusses broad cultural differences, the effects of the Second World War on both economies and the drive on the part of the Japanese to become world leaders in selected industries (32; 33).

A search of periodicals was conducted to determine if other authors have made analytical intra-industry comparisons. This search revealed numerous studies by economists evaluating several factors in intra-industry comparisons.

One article is of interest because of the method the researchers used in selecting companies within an industry to compare to each other. They chose companies based on such factors as common language, average per capita income and average trade orientation. The factors chosen are common factors used by economists to describe an industry. The same rationale was used by the authors of this study to choose the service of comparison and the aircraft to compare against. Another point of interest in the same article is their use of regression analysis to determine the amount of similarity among like industries. However, no mention is made of the method used to validate the models (1).

Another article, also by an economist, used ten years of historical data to build regression models to determine the similarities among companies within an industry. Again, this article is of interest to the present study because of its use of regression analysis and historical data to determine similarity (2).

Modelling Techniques

The underlying premise of this thesis is that several known variables contribute significantly to the measure of performance known as MC rate. After these variables are identified for both the USAF and the USN, historical data will be used to predict the MC rate of USAF and USN fighter aircraft. Following this step, the data from the USAF will be used in the model developed for the USN to determine if the USAF could produce better MC rates using the Navy's maintenance concepts. A method is required that will establish which variables contribute the most to this prediction.

Emory and Cooper provide a discussion on the selection of an appropriate multivariate technique based on whether the research question is stated in terms of dependency or interdependency. If there are criterion and predictor variables in the research question, then the research question is stated in terms of dependency. When dependency exists, three techniques may be employed to test to determine the relationship between the dependent and independent variables. These techniques are Multiple Analysis of Variance (MANOVA), discriminant analysis and multiple regression (13:628).

MANOVA is used to determine "the relationship between two or more dependent variables and classificatory variables or factors" (13:636).

Discriminate analysis is used to classify data into two or more groups. This method is not applicable for predicting results based on past data and so will not be explored further.

Multiple regression is a method used to determine relationships between variables. Many standard textbooks outline the techniques and limitations of regression analysis.

> Often there exists a functional relationship which is too complicated to grasp or to describe in simple terms. In this case we may wish to approximate to this functional relationship by some simple mathematical function, such as a polynomial, which contains the appropriate variables and which graduates or approximates to the true function over some limited ranges of the variables involved. By examining such a graduating function we may be able to learn more about the underlying true relationship and to appreciate the separate and joint effects produced by changes in certain important variables. (11:2)

Regression analysis allows the researcher to construct a mathematical model to determine which independent variables contribute the most to predicting the dependent, that is the predictor, variable. "One way to decide quantitatively how well a straight line fits a set of data is to note the extent to which the data points deviate from the line" (22:460). The method used is to determine the deviation, or errors, from the line to the actual data points. The sum of these errors equal zero but the square of the sum of errors (SSE) will be equal to something other than zero. If all possible lines with their SSE are calculated, one line will be found with a minimum SSE. This line is the line with the best fit of the data points.

The general form of the regression model is

$$\hat{y} = \hat{\beta}_0 + \hat{\beta}_1 x_1 + \hat{\beta}_2 x_2 + \ldots\ldots + \hat{\beta}_k x_k + \epsilon$$

$\hat{y}$ = predicted dependent variable

$\hat{\beta}_o$ = predicted y-intercept

$\hat{\beta}_i$ = predicted coefficients of independent variable

x_i = independent variable

ϵ = random error (22:522)

Given there are variables that can be modeled mathematically to predict a specific y, the question then becomes, how is the best regression equation selected? Draper and Smith discuss various methods for selecting the best regression equation, three of which are presented below (11:294).

1) All possible regressions. This method involves fitting every combination of equations using all possible variables. Draper and Smith caution that this method can produce a model with more variables than is necessary (11:302).

2) Backward elimination. In this method each possible variable is entered into the regression equation and tested to a predetermined level of significance. If the variable does not meet the predetermined level of significance, it is removed from the equation. This procedure is repeated until

all variables have been tested. Draper and Smith state that is method is satisfactory (11:307).

3) Stepwise regression. This method begins by adding or subtracting variables in the regression equation one at a time and testing their level of significance for predicting the y-value. Draper and Smith's opinion is that stepwise regression is one of the best methods for selecting variables and recommend its use (11:310).

Model Validation

Regression will take any values provided and attempt to fit a line to those values. The question then becomes, is the model useful for predicting the dependent variable?. One way to check the validity of a model is to leave out some of the data set, build the model using the remaining data and then attempt to predict the dependent variable using the remaining independent variables. A variation on this method is to split the data set in half and then use the remaining half to validate the model. (11:420)

Both of these validation methods require that part of the data set be withheld from the data used to build the model. This reduces the amount of data available for building the model and thus reduces its accuracy. One method available that overcomes this shortcoming was suggested by C. I. Mosier in 1951 (27:10-11). Mosier suggests splitting the data set in half, building a model with each data set then validating each model with the other half of the data set. If there is no significant difference between the results from the validation it can be assumed each model is an accurate predictor of the system being modeled. After validation, the data set is then recombined and a third model built using all of the data. This approach allows the model builder to use all available data for the actual model building process and thus the resulting model will be more accurate than one built using only part of the data. (27:165)

Several researchers have used this method since Mosier first proposed it; none report any problems using it. Gross et. al. used double cross-validation in their work on predicting flexion and peak torque in the human knee (17).

Van der Meer employed Mosier's method in his study of the interaction of the abundance of marine life in intertidal waters and the environment. He reports that the use of double cross-validation brings precision to the parameter estimates. (31)

Thorndike describes double cross-validation in detail as a method of enhancing the size of a data set during regression model building (30:165).

After an initial model is developed, the overall effectiveness of the model and the amount of contribution each variable has on the overall model must determined. Several steps are required before a model can be called a good model.

1) The overall model must be tested for goodness-of-fit.

2) The ability to accurately predict the dependent variable must be established.

There are several generally accepted methods for testing for goodness-of-fit in a regression model. Each independent variable in the final model can be tested for the level of contribution by examining related t-statistics. The F-statistic is used to evaluate the usefulness of the overall model. The amount of variability the independent variables account for in the model is expressed by the r-squared value. The term, r-squared, is also called the multiple correlation coefficient. The r-squared will measure what proportion of the variation from the mean y-bar is explained by the regression model (11:33). A final means of evaluating the goodness-of-fit in a regression model is to analyze a plot of residuals to determine if there are any non-linear terms in the independent variables.

Chapter Summary

A review of literature was made in four areas: 1) a general history of the maintenance structure of the United States Air Force 2) different air force maintenance structures, 3) previous research and 4) modelling techniques.

The U.S. Air Force has undergone many changes in aircraft maintenance organizational structure since the beginning of its history. The TACR 66-5 structure was a direct result of the Maintenance Posture Improvement Program. These requirements were validated by the Yom Kippur war of 1973. Tactical Air Command was sufficiently impressed with the Israelis' performance in that war to modify their own structure to emulate that of the Israelis'. Finally, the past cannot be forgotten. George Santayana has stated:

> Progress, far from consisting of change, depends on retentiveness... Those who cannot remember the past are condemned to fulfil it. (28:414).

Air Forces of different nations have structures with varying degrees of difference from our own. Some are very similar to our own, such as the Canadians, and some use a structure that splits the maintenance personnel between an operations manager and a logistics manager.

There are many methods of modelling a system, one method used by other researchers is multiple regression. Multiple regression uses independent variables to predict a dependent variable. The amount of contribution the independent variables make to the prediction is expressed by the r-squared value, the remaining information in the model is random error or unknown variables.

After an exhaustive search, no literature could be found on any study comparing the organizational structure of one air force's maintenance organization to another.

However, several studies were found that used regression analysis to predict an aircraft maintenance unit's effectiveness or productivity.

III. Methodology

Introduction

This chapter outlines the statistical techniques used to answer the research questions presented in Chapter I. Subsequently, these results will be applied to answer the problem statement.

One of the primary research objectives is to identify the independent variables which will allow an accurate prediction of the dependent variable, the Mission Capable (MC) Rate. The independent variables will be a subset of the key maintenance indicators tracked by senior Air Force and Navy managers to monitor and grade the performance of maintenance organizations.

Data Sources

The data analyzed in this comparison were obtained from official sources within the Department of Defense and are unclassified. Headquarters, Tactical Air Command (HQ TAC/LGMP) provided historical data on assigned aircraft as well as the number of personnel authorizations for each mission design series (MDS) of aircraft: F-4E, F-4G, F/EF-111A/D/G, F-15, F-16, F-117 and A/OA-10. The historical maintenance indicators covered a 24 month period from October 1989 through September 1991.

The Naval Sea Logistics Center provided the equivalent maintenance indicators for the F-14, F/A-18, A-6 and A-7 types of aircraft. The period covered by the data is from July 1989 through June 1991. Additional data on USN aircraft maintenance personnel authorizations came from the Naval Manpower Analysis Center (NAVMAC).

Two assumptions concerning the data have been made by the researchers. First, the data represents the true status of the affected MDS; i.e., no data has been falsified by the organizations responsible for the data. Secondly, any errors inherent in the data collection and recording systems are equal across all sources. For example, errors which normally occur collecting F-16 data are equivalent to those errors occurring in the F/A-18 system, effectively negating their effects on the statistical analysis. This however does not concern human errors which may be found in data collection and documentation. The researchers feel these human errors and differences can neither be identified nor compensated for.

The data sets received from each source have been subjected to a three part process to determine their applicability to the study. First, only two MDSs from each service will be examined. From the USAF, the F-15 and F-16 aircraft from operational wings will be used. The targets of analysis from the USN will be the F-14 and F/A-18 deployed at sea. Each of these MDSs represents the typical airframe currently in service. Additionally, a close similarity in mission and technology exists between the F-15 and F-14 as well as between the F-16 and F/A-18. This characteristic will facilitate the comparisons between the services and reduce any errors caused by dissimilar aircraft types.

The purpose of this study is to test the performance difference based on structure; therefore each supplied statistical variable will be judged as to whether or not it is a function of structure as shown in Table 1.

TABLE 1
KEY MAINTENANCE INDICATORS

USAF	USN	Abbreviation	Structure	Duplicate
Mission Capable	Mission Capable	MC	No	No
Not Mission Capable	Not Mission Capable	NMC	No	No
Total Not Mission Capable Maintenance	Total Not Mission Capable Maintenance	NMCM	No	Yes
Total Not Mission Capable Supply	Total Not Mission Capable Supply	NMCS	No	No
Total Not Mission Capable Both	Total Not Mission Capable Both	NMCB	No	Yes
Abort Rate	Aborts	ABRT	No	No
Aircraft Sortie Utilization Rate	Flight Utilization per Aircraft	SUTE	No	No
Aircraft Hourly Utilization Rate	Flight Hours	HUTE	No	No
Authorized Personnel per Aircraft	Maintenance Personnel per Aircraft	SPA	Yes	No
Maintenance Manhours per Flying Hour	Direct Maintenance Manhours per Flying Hour	MMH	Yes	No

The variables which represent structural influences will be eliminated from further selection processes. The influence demonstrated by a variable representing structure may be included in the error term associated with the statistical analysis of the data sets. The remaining variables may account for any organizational differences unrelated to structure.

Much of the data given to the researchers was duplicative and as such will not be included in the modelling process. For example, a regression model of:

$$\text{MC rate} = 1.00 - 1(\text{NMCM}) - 1(\text{NMCS})$$

could result from a stepwise regression analysis using all supplied factors. This model is not useful because it fails to include the factors of manpower availability, aircraft utilization functions and the intensity of labor required to keep the aircraft flying. It simply subtracts known values from a constant. The example model would theoretically have a r-squared value of 1.00. To account for this duplicity in statistical bookkeeping, each variable has been evaluated as to whether or not is represents unique data or data also represented in other variables (see Table 1).

Previous studies have attempted to model the aircraft maintenance system using as many as 32 independent variables (19). As reported in Chapter II, the results of these studies were mixed and inconclusive. The researchers feel a more parsimonious model will yield results different from earlier studies.

Analytical Tools

The SAS System for Elementary Statistical Analysis, Version 6.06 installed on the Air Force Institute of Technology's VAX cluster system will perform the regression analysis. The spreadsheet program Quattro Pro, Version 4.0 installed on a PC will be used for all other calculations. A sample SAS program is shown in Appendix B.

Correlation Analysis

Selection of the final variables for the model will be made using correlation analysis. Using the coefficient of correlation for each variable, as measured against the dependent variable MC rate, the relative value of the relationship of each independent variable will be examined. This step will identify those variables which explain the behavior of the dependent variable.

It can be argued whether the final variables are the sole determinants of the MC rate of a MDS. However, other studies have performed similar analysis on virtually all available variables and have failed to agree on the results. The combined 30 years of experience of the researchers will permit them to analyze the effects of the determinants used for this study. Considering the results of earlier studies and this combined experience, the researchers' technique of developing a more parsimonious model may prove to be more accurate and reliable.

Regression Analysis

From each data set obtained, 24 cases will be fitted to a probabilistic model using stepwise regression performed by the SAS System. Stepwise regression will be used to find the model which most closely predicts the dependent variable. The results of this treatment will yield one regression equation for each MDS of aircraft within each service.

Goodness-of-fit. Each model will be evaluated with a combination of the model's coefficient of determination (r-squared), the F-statistic and the p-value. Two other measures of goodness-of-fit are the t-value and an analysis of the residuals. These tests are commonly accepted measures for evaluating the usefulness of a regression model (30:540).

The r-squared of each equation is that fraction of variation in the model's independent variable which is attributable to the model itself (30:541). The r-squared statistic has a range of 0 to 1 with 1 representing a model whose entire variation is attributable to the model.

The second goodness-of-fit measure allows the model to be evaluated using various hypothesis. This F-statistic is "the ratio of the explained variability divided by the model degrees of freedom to the unexplained variability divided by the error degrees of freedom" (30:542). In practice, the value of the F-statistic indicates the degree to which the model accommodates the variability of the equation. The greater the value of the F-statistic, the more accurately the equation predicts the dependent variable.

The p-value (shown on the SAS outputs as Prob > F) expresses the probability that the actual F-statistic is greater than the F-statistic calculated by the regression equation.

The contribution of each independent variable to the overall model is another important aspect of this study. The analysis performed by SAS includes a valuable tool to determine this contribution. A t-value is calculated for each independent variable and is placed against the hypothesis that the coefficient of the variable is zero. The higher the t-value, the greater the variable contributes to the model (30:529).

The residuals from the models, the difference between actual and predicted independent variables, will be plotted and analyzed for trends and patterns to verify satisfaction of the basic regression assumption of normality of residuals (30:527). Any trends observed in the residual plots will result in transformation techniques being used to return the dependent variable to an additive form for greatest regression accuracy (30:679).

Validation. Validation of the model will use a technique first developed in 1951 (27:165). Each data set will have cases numbered from 01 to 24 representing consecutive calendar months. The data sets will be divided by odd/even numbered months and the two sets will be used to build separate regression models. Dividing odd and even months will tend to offset any seasonal fluctuations in the data and equally spread their affects across both models.

The separate models' goodness-of-fit will be evaluated as previously outlined. Each model will then be validated using the 12 months data from its sister model. This technique is called double cross-validation and allows the maximum number of points for building the overall experimental model (27:165). After each half-set model is cross validated, the data will be recombined to form a 24 case regression model.

Comparison Testing

Comparison tests will be made to determine if one organization performs at significantly higher levels than the other. One of the traditional indicators of an aircraft maintenance unit's performance is MC rate. In a regression equation, the factors that determine the predictor variable are the intercept, the independent variables and the error term. If the two models use the same independent variables, none of which influence structure, then the error term should contain all influences, including structure, not represented by the independent variables.

Two comparison tests will be performed on the results of the regression models.

First, paired t-tests will be performed on the difference between the predicted MC rates of the Air Force MDSs and the predicted MC rates of the USN MDSs. This test will determine if a significant difference exists between the two services as represented by the comparison MDSs.

Secondly, the independent variables from each aircraft type will be placed into the model of the comparison MDS. This will yield a predicted MC rate for each month of data for each comparison pair. The researchers will test each value of predicted MC rate against the actual rate using the paired difference t-test. The data pairs will be tested under the hypothesis:

$$H_0 : \text{MC rate}_{usaf} = \text{MC rate}_{navy}$$

$$H_A : \text{MC rate}_{usaf} \neq \text{MC rate}_{navy}$$

This examination is a parametric test designed specifically to compare paired groups. Results of this treatment will establish whether differences exist between the performance outputs of the USAF and USN.

Chapter Summary

Multiple regression is a powerful and dependable tool for developing models which can predict a value based on other factors. The multiple regression applications reviewed in this chapter will allow the researchers to answer the first three research questions. The parametric testing of actual and predicted MC rates will allow answering of the final research question.

IV. Findings and Analysis

Introduction

This chapter presents the results of the statistical analysis outlined in Chapter III. These results will be discussed in Chapter V. This discussion will attempt to answer the research questions presented in Chapter I. In addition to specific answers, the authors will present the conclusions they have drawn from the data. They will then attempt to generalize these conclusions to provide meaningful information concerning aircraft maintenance organization. This chapter follows the sequence of Chapter III. Tables summarizing the results of the analysis will be included for clarity as required. A discussion of the results will be included in each section.

Variable Selection

Characteristics of the key maintenance indicators were summarized in Chapter III, Table 1. Two characteristics of each indicator were examined.

1: Organizational structure. A determination was made whether or not each key maintenance indicator is a function of an organization's structure. The researchers found that the number of maintenance personnel per aircraft (SPA) was directly related to the type of structure an organization developed. For example, the COMO organization used a large staff function which tended to raise the average number of personnel authorized to a wing based on the number of assigned aircraft. Conversely, a deployed Naval Aviation wing has a smaller staff function and subsequently a lower number of authorized personnel per assigned aircraft.

2: Duplication. The researchers also determined if the indicator was an alternative statistic used to track information collected by other indicators. The researchers found TNMCM and TMNCB duplicated information tracked by NMCS and NMC. The indicator NMC was not included in the data sets. NMC was shown to be a simple arithmetic difference from 1.00 as discussed in Chapter III.

Variables found to exhibit the characteristics listed above were deleted from further consideration.

The indicator MMH was deleted from the data sets based on discussions with HQ TAC. HQ TAC no longer uses MMH as an indicator of maintenance performance because of its unreliability. In addition, it is not directly related to manhours expended for sortie generation. This is caused by management pressure to account for at least eight hours of labor per person per workday (26). There are many non-maintenance activities typically documented as maintenance labor. This causes an inflated MMH rate throughout all MDSs in the USAF.

The indicators chosen as independent variables for the statistical analysis were NMCS, SUTE, HUTE and ABRT. The dependent variable was MC.

Correlation Analysis

The SAS package calculated the correlation of each independent variable with respect to the dependent variable, MC. The results of this analysis are summarized in Table 2. For brevity, Table 2 lists each MDS with its independent variables as they correspond to MC rate. The full correlation table for each MDS is in Appendix D.

TABLE 2

CORRELATION COEFFICIENTS:
INDEPENDENT VARIABLES TO MC RATE
(BY MDS)

MDS	NMCS (p-value)	HUTE (p-value)	SUTE (p-value)	ABRT (p-value)
F-14	-0.90575 (0.0001)	-0.14234 (0.5070)	0.18275 (0.3927)	0.34586 (0.0978)
F-15	-0.37388 (0.0719)	-0.016706 (0.4352)	-0.11717 (0.5856)	-0.46222 (0.0230)
F-16	-0.93873 (0.0001)	-0.22965 (0.2804)	-0.48805 (0.0155)	-0.34902 (0.0946)
F/A-18	-0.94083 (0.0001)	0.41805 (0.0421)	0.36527 (0.0792)	-0.11630 (0.5884)

The p-value below each correlation coefficient is the probability that the coefficient is equal to zero. The associated p-values for each independent variable indicate the degree of significance of the correlation relationship. A correlation coefficient of 1.0 indicates a strong direct and a coefficient of -1.0 indicates a strong inverse relationship between the independent variable and the dependent variable. A correlation coefficient of zero indicates a lack of a relationship between the independent variable and the dependent variable.

The independent variable NMCS shows a strong negative correlation with all MDSs except the F-15. This indicates that as the NMCS rate increases, the MC rate decreases. Because NMCS is the percentage of time an aircraft is unavailable due to a lack of required parts, it follows NMCS will reduce the MC rate. All of the correlation coefficients are highly significant at the 0.0001 level with the exception of the F-15 with a p-value of 0.0719. This indicates NMCS has a strong relationship with MC rate for the F-14, F-16 and F/A-18. NMCS has a lesser relationship with the F-15 MC rate as indicated by its higher p-value and lower correlation coefficient.

The relationship of HUTE to MC is inconsistent among the four MDSs. The variable HUTE is negatively correlated within the F-14, F-15 and F-16 data sets. However, a positive correlation exists between HUTE and MC for the

F/A-18. Only the F/A-18 shows a significant correlation to the dependent variable with a p-value of 0.0421. The high p-values for the F-14 and F-15 indicate a strong probability that the true correlation coefficient is zero. The F-16 p-value indicates a lesser probability the true correlation coefficient is zero.

As in the case of the relationship of HUTE to MC, SUTE is also inconsistent among the four MDSs. The variable SUTE is negatively correlated within the F-15 and F-16 data sets. However, a positive correlation exists between SUTE and MC for the F-14 the F/A-18. This split is consistent among the services. USAF aircraft show a negative correlation while USN aircraft are positively correlated. The two oldest MDSs, the F-14 and the F-15 show a high p-value associated with their coefficients. This indicates a relatively high probability that their respective coefficients are zero. Conversely, the low p-values associated with the newer F-16 and F/A-18 indicate a low probability that their coefficients are zero.

The last independent variable, ABRT, again shows inconsistency among the MDSs. Unlike SUTE, there appears to be no consistency between services or aircraft age. The F-14 shows a positive correlation with the remaining MDSs all showing a negative correlation. The p-values for the F-14, F-15 and F-16 all indicate a fairly strong probability that the correlation is not zero. The high p-value for the

F/A-18 indicates a strong probability that a correlation between ABRT and MC is absent.

Regression Analysis

Stepwise regression was performed by SAS on the selected independent variables using all 24 cases. Table 3 shows the variables selected by SAS in the stepwise regression analysis.

TABLE 3

STEPWISE REGRESSION ANALYSIS
(BY MDS)

MDS	NMCS	HUTE	SUTE	ABRT
F-14	X		X	
F-15				X
F-16	X		X	
F/A-18	X			

(X indicates selection)

The results of the stepwise regression selection process closely match the results of the correlation analysis. All stepwise models used NMCS except the F-15. The F-15 correlation of NMCS to MC had a relatively high p-value. The independent variables entered into the other three MDS stepwise models were inconsistent. The F-14 and F-16 models both used NMCS and SUTE. The F-15 model only used ABRT while the F/A-18 only used NMCS.

The research questions center around comparing the performance results of the two different services based on similar aircraft. The inconsistency of independent variables selected by stepwise regression does not allow direct comparison of different aircraft types. Direct comparison requires that the models being compared use the same variables.

Using all four independent variables in the regression model would provide the most valuable comparison between different aircraft. The four independent variables account for the major measures of effect on MC rate. The choice of four independent variables is supported by the researchers' professional knowledge and experience.

TABLE 4

REGRESSION ANALYSIS SUMMARY
(BY MDS)

MDS	INTERCEPT (t-value)	NMCS (t-value)	HUTE (t-value)	SUTE (t-value)	ABRT (t-value)
F-14	82.898637	-1.772915	-0.135422	0.703684	-0.838504
	13.098	-8.660	-0.970	1.7710	-1.316
F-15	92.706294	-0.344407	0.003704	-0.09359	-0.946179
	24.535	-1.073	0.120	-0.613	-1.751
F-16	101.740902	-1.536554	-0.017743	-0.086954	-0.261857
	103.773	-12.988	-1.007	-1.469	-1.314
F/A-18	98.987526	-2.187920	0.0284450	-0.125657	-0.106498
	19.418	-11.245	0.261	-0.737	-0.164

Table 4 summarizes the results of multiple regression using four independent variables. Associated with each coefficient is a t-value that indicates the level of significance of that coefficient. For the purposes of this study, the researchers have selected a value $\geq |1.0|$ to be significant.

The coefficient for each NMCS value detracts from the overall MC rate as indicated by its negative sign. A similar effect is achieved by the variable ABRT. In both of these cases the magnitude of the coefficient varies from one MDS to another. The remaining two variables show inconsistency between MDSs in both magnitude and sign.

The significance of NMCS is high in all models except the F-15. This is consistent with the results from the correlation analysis.

The variable HUTE appears to be significant to both the F-14 and F-16. This is shown by the relatively high t-value of each when compared to the t-value of the F-15 and F/A-18.

Both the F-14 and F-16 show a fairly high level of significance for the variable SUTE. However, the F-15 and F/A-18 t-values are almost as high as those of the F-14 and F-16. The variable SUTE contributes to the predicted MC rate of the F-14 but subtracts from the predicted MC rate of the other MDSs.

The F-15 model exhibits the highest level of significance for the variable ABRT. The significance of the variable ABRT is extremely low in the F/A-18 regression model. The remaining two MDS models exhibit a high level of significance for this variable.

Overall these findings are consistent with the correlation analysis throughout all MDSs' regression models.

Goodness-of-fit. The r-squared value indicates the amount of variability explained by the regression model. Three MDSs show fairly high r-squared values. One MDS, the F-15, has a lower r-squared value of 0.2805. The F-14, F-16 and F/A-18 all have an r-squared value of at least 0.8557. See Table 5 for a complete listing of all the full regression model r-squared values.

TABLE 5

GOODNESS-OF-FIT TESTS
(BY MDS)

MDS	r-squared	F-Value	Prob > F
F-14	0.8557	28.171	0.0001
F-15	0.2805	1.852	0.1606
F-16	0.9361	69.592	0.0001
F/A-18	0.8924	39.398	0.0001

The difference of the r-value from 1 accounts for the factors not included as independent variables that have a relationship with the dependent variable. The F-14, F-16 and F/A-18 all account for a large amount of factors bearing on the dependent variable MC. The F-14 regression equation accounts for 85.6% of the factors influencing MC. The F-16 regression accounts for 93.6% of the factors influencing MC. Finally, the F/A-18 regression accounts for 89.2% of the factors influencing its MC. The F-15 regression equation only accounts for 28.1% of the factors that influence the MC rate.

The F-statistic of the F-14, F-16 and F/A-18 show the regression models are useful for predicting MC rate at the 0.01 significance level. The F-15 model only shows usefulness at the 0.1 significance level. The values underneath the Prob > F column in Table 5 agree with the r-squared and F-statistic values in explaining the value of each regression model. In the F-15 model, there is a 16% probability that the model does not explain a significant portion of the variation in the data. There is a 99% probability that the remaining three regression models explain a significant portion of the data variation.

The final goodness-of-fit test used by the researchers was a visual analysis of the plot of residuals generated by the SAS program. Plots were obtained for each of the four full regression models. The visual examination shows that all four plots exhibited randomness. This validates the assumption that the error variance is constant over the range of the independent variables. The residual plots for all four full regression models are located in Appendix C.

Validation. The data sets were maintained in chronological order as received from their sources. The oldest data element in each set was numbered as the first observation with the remaining elements being numbered sequentially.

The data sets were divided into two half-data sets, based on odd and even observations. These data sets were then subjected to double cross-validation techniques as outlined in Chapters II and III. Regression models were built for each half-data set using all four independent variables. Paired t-tests were performed between the actual MC rate and the predicted MC rate obtained from the opposite half-data set model.

The paired t-test between actual and predicted MC rates was evaluated with 99% confidence intervals. The confidence interval for each comparison pair included the value of zero. This indicates that there is no statistically significant difference between the two values. From the principles of double cross-validation, the researchers concluded the full 24 case regression models are valid. Table 6 summarizes the findings of the double cross-validation treatment, the full spreadsheet output is shown in Appendix E. The r-squared values of each half-data model closely approximate the r-squared value of the respective full regression models.

TABLE 6

DOUBLE CROSS-VALIDATION
(BY MDS)

MDS	MEAN	STANDARD DEVIATION	UPPER C.I. 99%	LOWER C.I. 99%	r-squared	F-Value
F-14						
EVEN	0.1024	3.1485	2.8791	-2.6743	0.8416	9.3
ODD	0.2149	2.0540	2.0263	-1.5965	0.9045	16.572
F-15						
EVEN	0.4239	0.8561	1.1789	-0.3311	0.2506	0.585
ODD	-0.4253	0.9273	0.3925	-1.2431	0.3950	1.143
F-16						
EVEN	-0.1644	0.5340	0.3065	-0.6353	0.9764	72.482
ODD	0.1014	0.3903	0.4456	-0.2428	0.9277	22.443
F/A-18						
EVEN	0.0303	1.1169	1.0153	-0.9547	0.9587	40.601
ODD	-0.2308	0.8557	0.5238	-0.9854	0.8891	14.026

Comparison Testing

The models developed have provided a means of predicting an organization's MC rate. The researchers have eliminated all known structural elements that contribute to the MC rate. These elements were eliminated for two reasons: 1) the researchers did not feel they could not identify and quantify all structural elements and, 2) the MMH data from HQ TAC was judged to be unreliable. Because they are specifically not included in the independent variables used, the structural factors that contribute to MC rate are contained in the error term of the regression model. MC rate was chosen as the comparison term because the error term is difficult to relate to an organization's level of performance.

Two comparisons were made between the predicted MC rates of the F-15 and the F-14 and between the F-16 and F/A-18.

For the first test, each predicted MC rate for one MDS was compared to its corresponding MDS's predicted MC rate. This comparison was made with an uncorrelated paired t-test using 99% confidence intervals. See Table 7 for a summary of the results.

The confidence intervals do not include zero, therefore the researchers conclude there is a significant difference between the MC rates of the two services.

TABLE 7

PAIRED T-TESTS:
USAF PREDICTED MC RATES TO USN PREDICTED MC RATES
(BY MDS)

MDS	MEAN	STANDARD DEVIATION	UPPER 99% C.I.	LOWER 99% C.I.
F-15 TO F-14	21.2417	3.6126	23.3042	19.1791
F-16 TO F/A-18	20.5500	4.0579	22.8608	18.2332

The mean for the comparisons was calculated by subtracting the predicted USN MC rate from the predicted USAF MC rate. This resulted in positive values for both means. Positive values in this operation indicates that MC values for USAF aircraft are higher than those for equivalent USN aircraft. The spreadsheet output for this test is shown in Appendix F.

For the second test, the independent variables from each MDS then were placed into the regression model developed for its comparison counterpart. This yielded a predicted MC based upon its comparison model for each observation. That is, the independent variables from the F-15 were placed into the regression model developed for the F-14. The predicted MC rate obtained from this step will be referred to as MC prime (MC').

The value, MC', was then subtracted from the original predicted MC rate to obtain a difference for use in the paired t-test. Again, 99% confidence intervals were established to provide consistency with the previous paired t-tests. The results of this test are summarized in Table 8. The full results from this test are shown in Appendix G.

The positive values of the mean and confidence intervals for the USAF aircraft indicate that higher levels of MC rate are achieved by using USAF data in the USAF regression models as opposed to using USAF data in the USN models. Additionally, negative values for the Navy aircraft indicate that higher MC rates are achieved for USN data when placed in USAF regression models.

The results from this test support the results from the first comparison test. The predicted MC rate achieved by using the USAF models for all four MDSs was significantly greater than the predicted MC rate using the corresponding USN models.

TABLE 8

PAIRED T-TESTS:
CROSS COMPARISON OF PREDICTED VALUES
USAF vs. USN
(BY MDS)

MDS	MEAN	STANDARD DEVIATION	UPPER 99% C.I.	LOWER 99% C.I.
F-14 (USN) TO F-14 (AF)	-15.9896	3.4574	-14.0157	-17.9636
F-15 (AF) TO F-15 (USN)	8.8851	2.0395	10.0496	7.7207
F-16 (AF) TO F-16 (USN)	4.6461	0.7624	5.0814	4.2108
F/A-18 (USN) TO F/A-18 (AF)	-13.7677	0.8508	-13.2819	-14.2535

Chapter Summary

This chapter presented the results of the statistical analysis outlined in Chapter III. The researchers first re-examined the key maintenance indicators to determine if the indicators chosen in Chapter III contained elements of organizational structure, were duplicative or were unreliable. The independent variables selected for use in the analysis were NMCS, SUTE, HUTE and ABRT.

The four independent variables were then subjected to a correlation analysis using the SAS software package. An examination of the output revealed the relationship between the independent variables and the dependent variable, MC.

Stepwise regression yielded inconsistent results which prevented comparison between models. Because of this inconsistency, the researchers chose not to use the results of stepwise regression.

All four independent variables were used to develop regression models. Goodness-of-fit tests were performed to establish the significance of the overall models and the significance of each independent variable. All four regression models were validated by the double cross-validation method.

Finally, comparisons tests between data sets were performed. A paired t-test between predicted USAF and USN MC rates was performed to test which service produced higher results. To complete the comparison tests, data was exchanged from one MDS to its comparison MDS's model. The USAF models, with either USAF or USN data, consistently produced higher MC rates than USN models.

V. Conclusions and Recommendations

Introduction

This chapter will present conclusions the authors have formed in answer to the research questions outlined in Chapter I. Findings to the research questions follow a restatement of each question and are based on the methodology developed in Chapter III as well as the analyses and results presented in Chapter IV. Following the discussion of the research questions, an overall conclusion is presented. Recommendations for further study are offered at the end of this chapter.

Discussion

This section will list the research questions first presented in Chapter I. Specific findings will be listed following each question.

1. Can a model (either mathematical or analytical) be developed which can accurately predict an organization's performance as reflected in the MC rate? Regression modelling allowed an accurate and valid prediction of an organization's performance in three of four MDSs examined, as measured by MC rate. The models developed exhibited a high degree of correlation between the actual and predicted MC rate for 24 months of data. The one exception was the

model for the F-15 which only accounted for 28% of the known variability.

2. What variables contribute to the prediction of this maintenance performance? The researchers established a selection process to identify existing key maintenance indicators that directly contributed to MC rate, did not duplicate one another and did not contain structural influences.

The researchers performed two types of regression to answer this question. The first regression technique used the SAS stepwise feature. Stepwise regression produced inconsistent independent variables between the four MDSs. Stepwise regression selected NMCS and SUTE for the F-14 and F-16 models. The F-15 model used only the variable ABRT while the F/A-18 used only NMCS. The F-15 model is the only one that did not use NMCS; it is also the only model that did not accurately predict the dependent variable, MC rate.

The second regression technique used four independent variables in developing the models. From the list of key maintenance indicators supplied by HQ TAC and the Naval Sea Logistics Center, this process identified the following independent variables: Not Mission Capable, Supply (NMCS), Aircraft Hourly Utilization Rate (HUTE), Aircraft Sortie Utilization Rate (SUTE) and Abort Rate (ABRT). These independent variables were chosen by the researchers to account for non-structurally related influences. In addition, the four variables were used to provide consistency among the four MDS's models to allow for comparison testing using the paired t-test procedure.

3. Are the variables in models of the USAF and USN organization's performance the same? Neither regression procedure showed consistency between the comparison pairs. The correlation matrix also showed inconsistencies in both the magnitude and direction of the independent variables to MC rate.

4. Do statistically significant differences exist between the levels of performance achieved by USAF and USN aircraft maintenance organizations as predicted by mathematical or analytical models? Based on the paired t-tests performed, the researchers conclude that there is a significant difference between the levels of performance achieved by the two different services. Consistently higher levels of performance were achieved by the models representing the pre-1992 USAF aircraft maintenance structure.

Conclusion

The researchers found that statistically significant differences exist between the performance levels of the USAF and USN aircraft maintenance organizations. These performance levels are measured by the MC rate. The researchers found that the maintenance organization represented by the USAF regression models are capable of producing consistently higher levels of performance than the organization represented by the USN models. Thus, the pre-1992 (COMO) organizational structure appears to be capable of producing significantly superior performance than post-1992 (Objective Wing) structures.

This study has focused on the structural differences between two aircraft maintenance organizations, the USAF and the USN, and their ability to produce mission capability. The researchers acknowledge there are many influences that may account for this difference in performance other than organizational structure alone. The following factors may contribute to performance differences:

1. Difficulties of maintaining aircraft while deployed at sea: lack of easy access to the logistics repair pipeline, increased corrosion potential, space limitation aboard the carrier and fewer airframes available to support the flying schedule.

2. Mission differences between the services.

3. A violation of the researcher's first assumption concerning the data provided. It is possible that some key maintenance indicators are inflated or deflated for reporting purposes.

4. The maintainability and reliability inherent in the design of the MDS.

5. The skill/education level of the technician for which the MDS was designed.

6. The planned maintenance concept and the planned organizational structure of the MDS.

7. Adequacy and depth of the spares provisioning.

8. The corporate philosophy of the maintainers.

Recommendations

1. A qualitative study comparing the aircraft maintenance structures of the pre-1992 organization and the post-1992 organization should be accomplished. This study should identify those advantages of each structure that will better support the new Air Force mission.

2. A statistical study should be performed of key maintenance indicators at one location using pre-1992 data vs. data from the same organization while under the post-1992 maintenance structure. The unit should be selected so that the only difference between the two data sets is the change in organizational structure. This should yield an accurate comparison of a pre- and post-1992 organization.

3. Reaccomplish the study outlined in this thesis with the exception of using independent variables that contain structural influences and allow all other influences to be included in the error term.

4. Expand the study to include additional maintenance organizations. The researchers attempted to include the RAF and Canadian Forces, Air Command but were unable to because

these services classify their key maintenance indicators. As outlined in Chapter II, the RAF maintenance structure is similar to the new USAF post-1992 maintenance structure and the Canadian structure is similar to the pre-1992 USAF structure. The inclusion of more services would present a larger population from which to draw a conclusion.

Summary

The researchers analyzed two different aircraft maintenance organizations representing two different organizational structures used by the USAF. This analysis attempted to establish whether one of the two structures produces higher levels of performance than the other. The measure of performance used in this study was MC rate.

Using multiple regression and paired t-tests, the structure represented by pre-1992 USAF aircraft maintenance consistently produced higher levels of performance than the structure representing the post-1992 aircraft maintenance structure. The post-1992 aircraft maintenance structure was represented by the aircraft maintenance structure of USN aviation units deployed at sea.

Several recommendations were made to expand and improve the findings of this study. Each recommended study would assist in establishing advantages of one structure over another as it relates to mission accomplishment.

Appendix A: Maintenance Data

F-14 Data Set

OBS	MC	NMCS	SUTE	HUTE	ABRT
1	70.4	10.0	18.4	29.0	7.03
2	66.3	11.9	19.9	32.0	7.83
3	66.2	13.1	18.6	29.7	6.85
4	59.5	13.7	19.7	32.0	7.87
5	70.0	9.4	17.4	26.1	7.20
6	66.2	10.0	14.0	23.0	7.76
7	68.5	9.0	20.7	32.7	7.13
8	68.0	10.1	17.3	27.7	6.90
9	69.4	8.9	19.3	30.8	6.94
10	64.3	11.3	16.8	26.9	7.47
11	63.9	13.7	17.9	28.4	6.19
12	58.7	14.1	16.7	25.9	6.83
13	56.9	13.5	14.8	23.5	6.87
14	60.4	13.7	18.1	28.8	7.12
15	61.6	13.7	17.5	29.3	5.42
16	55.2	17.3	16.7	30.2	6.04
17	58.7	15.4	16.8	27.5	6.02
18	62.5	13.0	14.6	25.5	5.24
19	60.8	14.0	21.3	42.2	7.17
20	59.1	15.1	20.6	47.3	6.16
21	63.7	13.1	17.6	30.9	7.17
22	62.5	14.1	17.8	28.3	7.17
23	60.8	13.8	17.7	29.6	6.85
24	62.5	12.7	17.1	28.8	6.33

F-15 Data Set

OBS	MC	NMCS	SUTE	HUTE	ABRT
1	84.2	7.2	20.75	29.73	3.8
2	83.0	8.7	19.00	25.77	5.3
3	83.8	8.8	16.43	20.99	4.4
4	84.5	8.7	20.94	27.03	3.6
5	85.5	7.8	19.28	24.45	4.0
6	85.8	7.0	21.45	29.27	4.0
7	86.2	6.5	21.94	29.86	3.5
8	86.0	7.5	20.72	26.13	3.6
9	84.2	7.5	21.28	28.72	2.9
10	84.4	7.3	20.33	28.12	4.2
11	81.7	6.6	19.17	33.85	4.2
12	84.2	6.0	17.27	25.50	4.1
13	82.0	7.9	19.94	34.29	4.7
14	82.3	7.4	19.54	34.07	4.3
15	85.5	7.4	17.14	30.29	3.9
16	83.9	8.2	22.84	60.68	5.2
17	83.9	8.0	20.95	66.34	4.9
18	87.2	6.3	17.94	38.94	3.3
19	84.6	6.8	18.58	28.13	4.3
20	85.5	6.7	19.75	26.47	4.5
21	84.1	7.0	19.82	27.77	4.7
22	84.8	7.7	20.95	29.82	4.8
23	82.8	10.0	20.14	28.06	4.4
24	85.8	7.8	12.97	16.76	4.5

F-16 Data Set

OBS	MC	NMCS	SUTE	HUTE	ABRT
1	88.3	6.3	31.64	21.17	4.1
2	89.0	5.8	28.29	20.08	4.9
3	89.0	6.3	25.27	18.19	5.1
4	88.3	6.9	30.44	21.38	3.8
5	88.4	6.8	26.94	17.76	3.8
6	90.1	4.9	31.68	21.39	4.0
7	90.8	4.6	31.57	21.89	3.4
8	90.2	5.0	29.80	20.18	3.1
9	88.9	6.1	31.83	20.97	2.9
10	90.9	5.1	30.65	21.16	3.6
11	91.1	4.9	32.09	19.51	3.8
12	91.0	4.8	27.08	16.99	4.4
13	92.3	4.5	33.14	20.52	3.9
14	92.7	4.3	32.89	19.13	3.4
15	93.3	4.0	31.34	17.66	3.8
16	90.2	4.5	52.37	20.68	4.4
17	90.0	4.8	68.07	28.63	3.6
18	93.0	4.2	26.17	12.70	2.9
19	94.7	2.8	23.29	15.42	3.3
20	93.5	3.4	25.58	17.43	3.8
21	92.0	4.4	26.93	19.39	3.4
22	92.5	4.0	27.3[illegible]	19.67	3.9
23	91.2	4.6	30.99	20.50	4.3
24	92.0	4.4	21.38	15.14	3.7

F/A-18 Data Set

OBS	MC	NMCS	SUTE	HUTE	ABRT
1	74.7	9.3	27.4	37.7	4.68
2	71.4	10.9	35.3	47.5	3.70
3	74.3	9.7	26.5	36.9	3.77
4	76.6	9.5	30.4	43.5	3.69
5	74.1	10.5	27.4	36.0	3.68
6	73.8	11.1	24.2	32.0	3.48
7	72.1	11.0	29.9	39.0	3.61
8	71.5	11.2	29.8	40.3	4.45
9	72.8	10.3	33.0	46.0	3.95
10	64.8	13.3	26.7	36.2	3.40
11	69.3	12.4	27.9	37.3	3.55
12	68.5	11.9	26.3	34.7	4.04
13	68.4	12.8	25.8	34.0	4.02
14	66.1	14.2	25.8	34.1	4.46
15	66.7	13.1	22.1	30.1	4.63
16	67.6	13.4	28.8	38.3	4.01
17	67.3	13.9	24.6	34.8	4.13
18	67.8	13.3	21.8	31.0	4.30
19	72.0	11.4	25.2	40.9	4.96
20	71.2	11.3	27.9	46.6	4.15
21	69.0	12.4	21.7	29.9	4.13
22	71.2	11.6	22.2	31.6	4.57
23	67.3	12.9	25.5	35.8	4.36
24	71.7	11.9	23.9	33.4	4.66

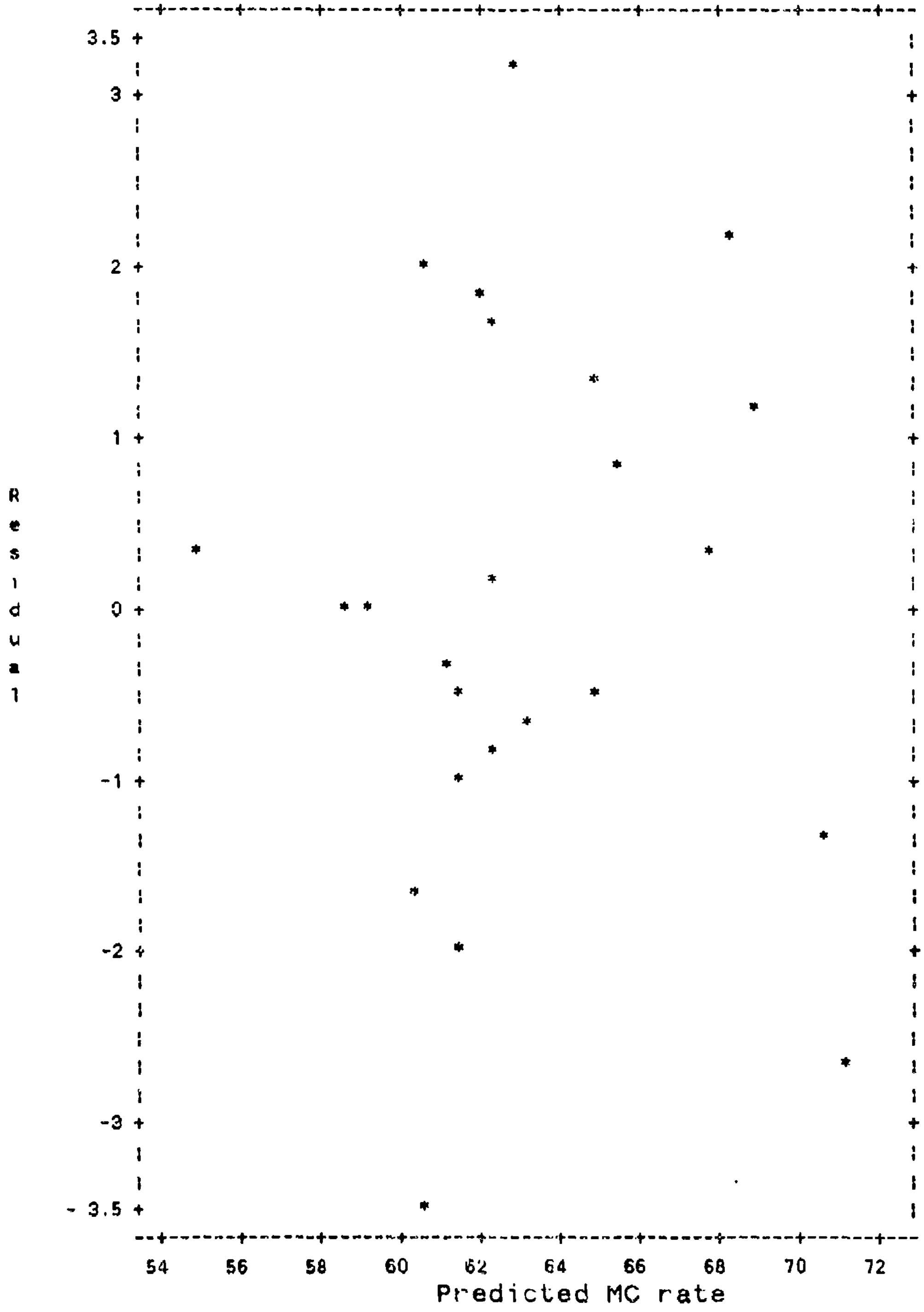
Appendix B

Sample SAS Program

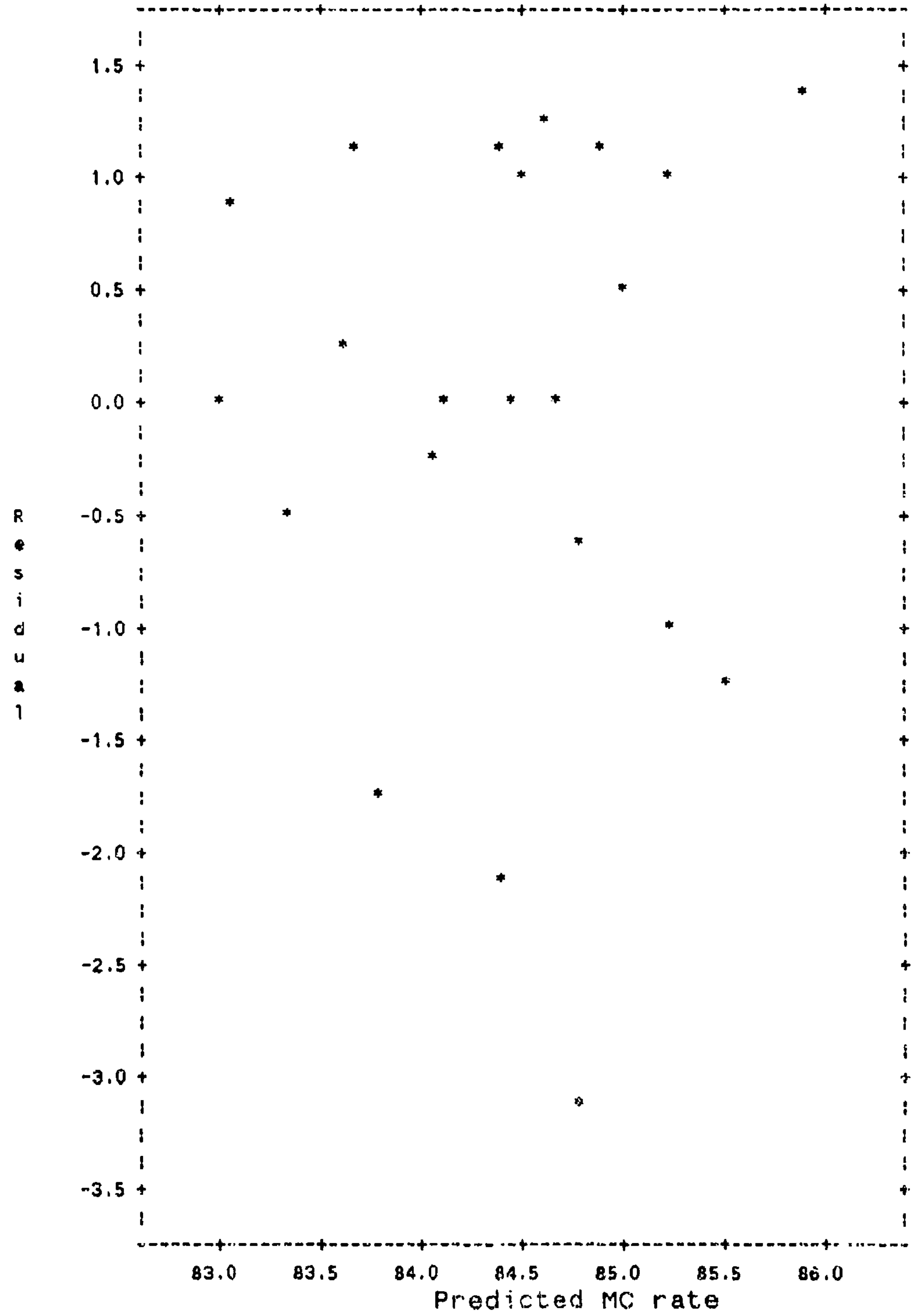
```
options linesize=80;
data mxstats;
infile "MDS.dat";
input mc nmcs hute sute abrt;

proc corr;
var mc nmcs hute sute abrt;
title '(MDS) Correlation Analysis';
run;

proc stepwise;
model mc=nmcs hute sute abrt;
title '(MDS) Stepwise Regression';

proc reg;
model mc=nmcs hute sute abrt/p;
title '(MDS) Regression Model';
plot residual.*predicted.='*';
print cli;

proc glm;
model mc=nmcs hute sute abrt/alpha=.01 cli;
title '(MDS) 99% Prediction Limits';
run;
```

Appendix C: Plot of Residuals

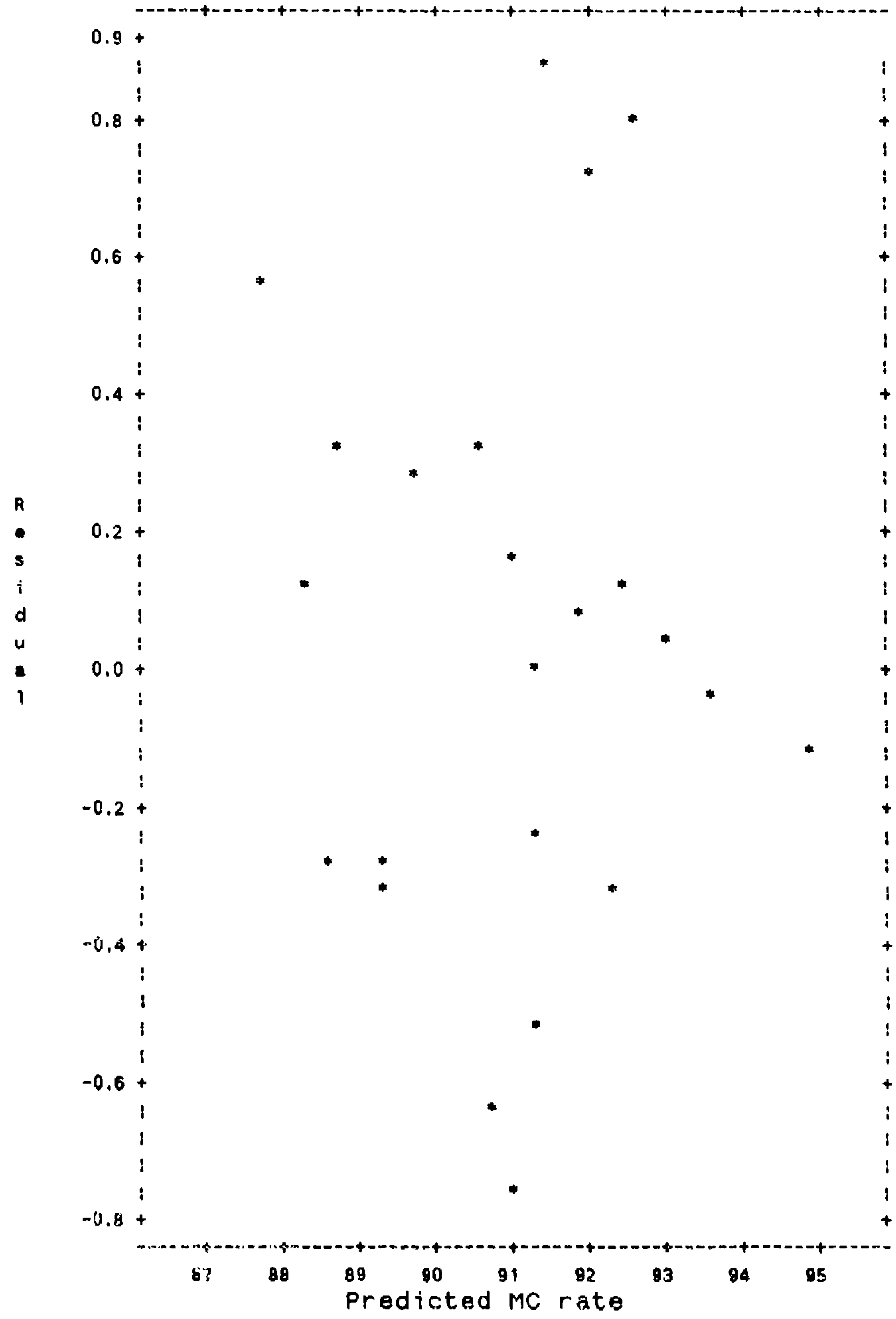
F-14



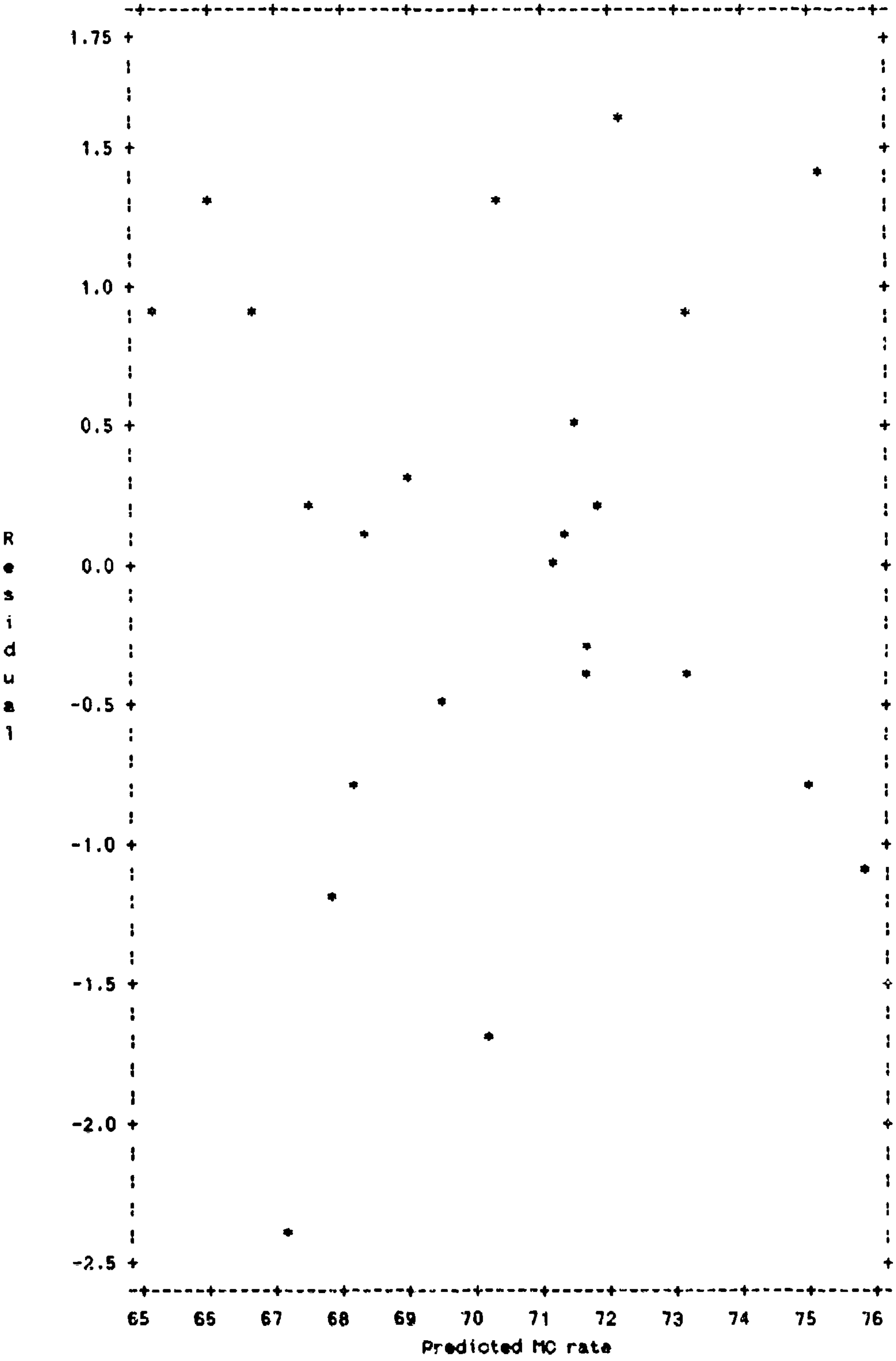
F-15


1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
Residual
83.0
83.5
84.0
84.5
85.0
85.5
86.0
Predicted MC rate

F-16


0.9
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
Residual
87
88
89
90
91
92
93
94
95
Predicted MC rate

F/A-18


1.75
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
Residual
65
66
67
68
69
70
71
72
73
74
75
76
Predicted MC rate

Appendix D: SAS Outputs

F-14 Correlation Analysis

```
                              Correlation Analysis

           5 'VAR' Variables:  MC        NMCS      HUTE      SUTE      ABRT


                               Simple Statistics

Variable            N       Mean     Std Dev         Sum     Minimum     Maximum

MC                 24    63.1708      4.2491        1516     55.2000     70.4000
NMCS               24    12.6917      2.1773    304.6000      8.9000     17.3000
HUTE               24    29.8375      5.2710    716.1000     23.0000     47.3000
SUTE               24    17.8042      1.8534    427.3000     14.0000     21.3000
ABRT               24     6.8150      0.6907    163.5600      5.2400      7.8700


    Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0 / N = 24

                    MC              NMCS              HUTE              SUTE              ABRT

MC             1.00000          -0.90575          -0.14234           0.18275           0.34586
               0.0               0.0001            0.5070            0.3927            0.0978

NMCS          -0.90575           1.00000           0.24741          -0.05074          -0.43918
               0.0001            0.0               0.2438            0.8139            0.0318

HUTE          -0.14234           0.24741           1.00000           0.80480          -0.02487
               0.5070            0.2438            0.0               0.0001            0.9082

SUTE           0.18275          -0.05074           0.80480           1.00000           0.25739
               0.3927            0.8139            0.0001            0.0               0.2247

ABRT           0.34586          -0.43918          -0.02487           0.25739           1.00000
               0.0978            0.0318            0.9082            0.2247            0.0
```

F-14 Stepwise Regression

```
                 Stepwise Procedure for Dependent Variable MC

Step 1   Variable NMCS Entered      R-square = 0.82038102   C(p) =   3.65266342

                    DF         Sum of Squares       Mean Square          F   Prob>F

 Regression          1           340.67928512      340.67928512     100.48   0.0001
 Error              22            74.59029821        3.39046810
 Total              23           415.26958333

                 Parameter         Standard           Type II
 Variable         Estimate            Error    Sum of Squares          F   Prob>F

 INTERCEP      85.60458554       2.26933601     4824.54222632    1422.97   0.0001
 NMCS          -1.76759702       0.17633569      340.67928512     100.48   0.0001

Bounds on condition number:             1,            1
-------------------------------------------------------------------------------

Step 2   Variable SUTE Entered      R-square = 0.83914294   C(p) =   3.18204812

                    DF         Sum of Squares       Mean Square          F   Prob>F

 Regression          2           348.47054010      174.23527005      54.78   0.0001
 Error              21            66.79904323        3.18090682
 Total              23           415.26958333

                 Parameter         Standard           Type II
 Variable         Estimate            Error    Sum of Squares          F   Prob>F

 INTERCEP      79.83407915       4.29259034     1100.24321988     345.89   0.0001
 NMCS          -1.75401738       0.17101947      334.60129734     105.19   0.0001
 SUTE           0.31442966       0.20090709        7.79125498       2.45   0.1325

Bounds on condition number:      1.002581,      4.010323
-------------------------------------------------------------------------------

All variables left in the model are significant at the 0.1500 level.
No other variable met the 0.1500 significance level for entry into the model.

         Summary of Stepwise Procedure for Dependent Variable MC

        Variable         Number   Partial    Model
 Step   Entered Removed      In      R**2     R**2       C(p)          F   Prob>F

    1   NMCS                  1    0.8204   0.8204     3.6527   100.4815   0.0001
    2   SUTE                  2    0.0188   0.8391     3.1820     2.4494   0.1325
```

F-14 Regression Model

```
Model: MODEL1
Dependent Variable: MC

                         Analysis of Variance

                            Sum of         Mean
      Source         DF    Squares       Square      F Value        Prob>F

      Model           4  355.35178     88.83794       28.171        0.0001
      Error          19   59.91780      3.15357
      C Total        23  415.26958

          Root MSE       1.77583     R-square        0.8557
          Dep Mean      63.17083     Adj R-sq        0.8253
          C.V.           2.81115

                         Parameter Estimates

                     Parameter       Standard    T for H0:
    Variable  DF      Estimate          Error   Parameter=0     Prob > |T|

    INTERCEP   1     82.898637     6.32890697        13.098         0.0001
    NMCS       1     -1.772915     0.20471805        -8.660         0.0001
    HUTE       1     -0.135422     0.13960198        -0.970         0.3442
    SUTE       1      0.703684     0.39726070         1.771         0.0925
    ABRT       1     -0.838504     0.63728724        -1.316         0.2039
```

F-14 Regression Model

```
          Dep Var   Predict
   Obs      MC        Value   Residual

     1   70.4000    68.2953     2.1047
     2   66.3000    64.9053     1.3947
     3   66.2000    62.9962     3.2038
     4   59.5000    61.5397    -2.0397
     5   70.0000    68.9056     1.0944
     6   66.2000    65.3996     0.8004
     7   68.5000    71.1018    -2.6018
     8   68.0000    67.6291     0.3709
     9   69.4000    70.7106    -1.3106
    10   64.3000    64.7801    -0.4801
    11   63.9000    62.1693     1.7307
    12   58.7000    60.4176    -1.7176
    13   56.9000    60.4359    -3.5359
    14   60.4000    61.4761    -1.0761
    15   61.6000    62.4116    -0.8116
    16   55.2000    54.8244     0.3756
    17   58.7000    58.6457     0.0543
    18   62.5000    62.2775     0.2225
    19   60.8000    61.3394    -0.5394
    20   59.1000    59.0529     0.0471
    21   63.7000    61.8617     1.8383
    22   62.5000    60.5816     1.9184
    23   60.8000    61.1354    -0.3354
    24   62.5000    63.2077    -0.7077

Sum of Residuals                      0
Sum of Squared Residuals        59.9178
Predicted Resid SS (Press)      89.9274
```

F-14 Regression Model

```
          Dep Var    Predict    Std Err   Lower95%   Upper95%
    Obs      MC        Value    Predict    Predict    Predict   Residual

      1   70.4000    68.2953      0.610    64.3654    72.2253     2.1047
      2   66.3000    64.9053      0.746    60.8739    68.9366     1.3947
      3   66.2000    62.9962      0.512    59.1280    66.8643     3.2038
      4   59.5000    61.5397      0.882    57.3896    65.6899    -2.0397
      5   70.0000    68.9056      0.680    64.9257    72.8855     1.0944
      6   66.2000    65.3996      1.322    60.7659    70.0332     0.8004
      7   68.5000    71.1018      0.981    66.8560    75.3476    -2.6018
      8   68.0000    67.6291      0.606    63.7020    71.5561     0.3709
      9   69.4000    70.7106      0.852    66.5883    74.3329    -1.3106
     10   64.3000    64.7801      0.608    60.8516    68.7086    -0.4801
     11   63.9000    62.1693      0.649    58.2118    66.1268     1.7307
     12   58.7000    60.4176      0.589    56.5019    64.3333    -1.7176
     13   56.9000    60.4359      0.761    56.3918    64.4799    -3.5359
     14   60.4000    61.4761      0.554    57.5823    65.3698    -1.0761
     15   61.6000    62.4116      0.902    58.2429    66.5804    -0.8116
     16   55.2000    54.8244      0.884    50.6723    58.9765     0.3756
     17   58.7000    58.6457      0.721    54.6345    62.6570     0.0543
     18   62.5000    62.2775      1.089    57.9173    66.6377     0.2225
     19   60.8000    61.3394      0.975    57.0991    65.5797    -0.5394
     20   59.1000    59.0529      1.487    54.2046    63.9012     0.0471
     21   63.7000    61.8617      0.516    57.9914    65.7320     1.8383
     22   62.5000    60.5816      0.612    56.6505    64.5126     1.9184
     23   60.8000    61.1354      0.433    57.3096    64.9611    -0.3354
     24   62.5000    63.2077      0.469    59.3636    67.0518    -0.7077

Sum of Residuals                       0
Sum of Squared Residuals         59.9178
Predicted Resid SS (Press)       89.9274
```

F-14 99% Prediction Limits

```
                         General Linear Models Procedure

Dependent Variable: MC
                                      Sum of            Mean
Source                   DF          Squares          Square   F Value     Pr > F

Model                     4     355.35177868     88.83794467     28.17     0.0001

Error                    19      59.91780465      3.15356867

Corrected Total          23     415.26958333

                  R-Square             C.V.         Root MSE             MC Mean

                  0.855713         2.811153        1.7758290           63.170833


Source                   DF        Type I SS     Mean Square   F Value     Pr > F

NMCS                      1     340.67928512    340.67928512    108.03     0.0001
HUTE                      1       2.95641263      2.95641263      0.94     0.3451
SUTE                      1       6.25671457      6.25671457      1.98     0.1751
ABRT                      1       5.45936637      5.45936637      1.73     0.2039

Source                   DF      Type III SS     Mean Square   F Value     Pr > F

NMCS                      1     236.51895759    236.51895759     75.00     0.0001
HUTE                      1       2.96754217      2.96754217      0.94     0.3442
SUTE                      1       9.89477810      9.89477810      3.14     0.0925
ABRT                      1       5.45936637      5.45936637      1.73     0.2039


                                       T for H0:    Pr > |T|   Std Error of
Parameter                 Estimate    Parameter=0                Estimate

INTERCEPT              82.89863693          13.10     0.0001     6.32890697
NMCS                   -1.77291521          -8.66     0.0001     0.20471805
HUTE                   -0.13542190          -0.97     0.3442     0.13960199
SUTE                    0.70368370           1.77     0.0925     0.39726070
ABRT                   -0.83850412          -1.32     0.2039     0.63728724
```

F-14 Regression Model

Observation	Observed	Predicted Residual	Lower 99% CLI Upper 99% CLI
1	70.40000000	68.29534577 2.10465423	62.92346852 73.66722302
2	66.30000000	64.90526342 1.39473658	59.39479016 70.41573668
3	66.20000000	62.99618077 3.20381923	57.70879336 68.28356817
4	59.50000000	61.53973913 -2.03973913	55.86682910 67.21264917
5	70.00000000	68.90558901 1.09441099	63.46539870 74.34577933
6	66.20000000	65.39956090 0.80043910	59.06573610 71.73338570
7	68.50000000	71.10182204 -2.60182204	65.29818771 76.90545637
8	68.00000000	67.62905619 0.37094381	62.26113771 72.99697467
9	69.40000000	70.71057378 -1.31057378	65.07578116 76.34536640
10	64.30000000	64.78010626 -0.48010626	59.41021436 70.14999816
11	63.90000000	62.16931424 1.73068576	56.75981787 67.57881061
12	58.70000000	60.41763984 -1.71763984	55.06523485 65.77004482
13	56.90000000	60.43586234 -3.53586234	54.90806027 65.96366440
14	60.40000000	61.47607339 -1.07607339	56.15370289 66.79844389
15	61.60000000	62.41160922 -0.81160922	56.71331633 68.10990212
16	55.20000000	54.82441524 0.37558476	49.14890510 60.49992538
17	58.70000000	58.64573173 0.05426827	53.16273711 64.12872634
18	62.50000000	62.27750111 0.22249889	56.31746571 68.23753651
19	60.80000000	61.33940797 -0.53940797	55.54336015 67.13545580
20	59.10000000	59.05286011 0.04713989	52.42566546 65.68005476
21	63.70000000	61.86166947 1.83833053	56.57133177 67.15200717
22	62.50000000	60.58158794 1.91841206	55.20819049 65.95498540
23	60.80000000	61.13536698 -0.33536698	55.90594587 66.36478809
24	62.50000000	63.20772316 -0.70772316	57.95320541 68.46224090

F-14 Regression Model

```
Sum of Residuals                                -0.00000000
Sum of Squared Residuals                        59.91780465
Sum of Squared Residuals - Error SS              0.00000000
Press Statistic                                 89.92738124
First Order Autocorrelation                      0.10590208
Durbin-Watson D                                  1.70590910
```

F-15 Correlation Analysis

```
                           Correlation Analysis

          5 'VAR' Variables:  MC        NMCS      HUTE      SUTE      ABRT


                             Simple Statistics

Variable           N       Mean    Std Dev         Sum    Minimum    Maximum

MC                24    84.4125     1.3901        2026    81.7000    87.2000
NMCS              24     7.5333     0.9135    180.8000     6.0000    10.0000
HUTE              24    19.5467     2.0967    469.1200    12.9700    22.8400
SUTE              24    31.2933    10.8973    751.0400    16.7600    66.3400
ABRT              24     4.2125     0.5856    101.1000     2.9000     5.3000


    Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0 / N = 24

                     MC          NMCS          HUTE          SUTE          ABRT

MC              1.00000      -0.37388      -0.11717      -0.16706      -0.46222
                    0.0        0.0719        0.5856        0.4352        0.0230

NMCS           -0.37388       1.00000       0.05170       0.03399       0.35439
                 0.0719       0.0           0.8104        0.8747        0.0893

HUTE           -0.11717       0.05170       1.00000       0.47770      -0.05475
                 0.5856        0.8104       0.0           0.0182        0.7994

SUTE           -0.16706       0.03399       0.47770       1.00000       0.30352
                 0.4352        0.8747        0.0182       0.0           0.1494

ABRT           -0.46222       0.35439      -0.05475       0.30352       1.00000
                 0.0230        0.0893        0.7994        0.1494       0.0
```

F-15 Stepwise Regression

```
                 Stepwise Procedure for Dependent Variable MC

Step 1    Variable ABRT Entered      R-square = 0.21365006    C(p) =  0.76618106

                        DF         Sum of Squares       Mean Square          F    Prob>F

 Regression              1             9.49594409        9.49594409       5.98    0.0230
 Error                  22            34.95030591        1.58865027
 Total                  23            44.44625000

                    Parameter         Standard           Type II
 Variable            Estimate            Error    Sum of Squares          F    Prob>F

 INTERCEP         89.03496592       1.90810828     3458.94346175    2177.28    0.0001
 ABRT             -1.09732129       0.44882690        9.49594409       5.98    0.0230

Bounds on condition number:              1,             1
------------------------------------------------------------------------------

All variables left in the model are significant at the 0.1500 level.
No other variable met the 0.1500 significance level for entry into the model.

          Summary of Stepwise Procedure for Dependent Variable MC

        Variable         Number   Partial    Model
 Step   Entered Removed      In      R**2     R**2       C(p)           F    Prob>F

    1   ABRT                  1    0.2137   0.2137     0.7662      5.9774    0.0230
```

F-15 Regression Model

```
Model: MODEL1
Dependent Variable: MC

                          Analysis of Variance

                             Sum of         Mean
Source             DF       Squares       Square      F Value       Prob>F

Model               4      12.46850      3.11712        1.852       0.1606
Error              19      31.97775      1.68304
C Total            23      44.44625

    Root MSE        1.29732      R-square        0.2805
    Dep Mean       84.41250      Adj R-sq        0.1291
    C.V.            1.53688

                          Parameter Estimates

                     Parameter      Standard    T for H0:
Variable  DF          Estimate         Error   Parameter=0    Prob > |T|

INTERCEP   1         92.706294    3.77854210         24.535        0.0001
NMCS       1         -0.344407    0.32091272         -1.073        0.2966
HUTE       1         -0.093590    0.15272488         -0.613        0.5473
SUTE       1          0.003704    0.03080959          0.120        0.9056
ABRT       1         -0.946179    0.54030253         -1.751        0.0950
```

F-15 Regression Model

```
           Dep Var    Predict
   Obs       MC         Value   Residual

     1    84.2000    84.7992    -0.5992
     2    83.0000    83.0124    -0.0124
     3    83.8000    94.0524    -0.2524
     4    84.5000    84.4440     0.0560
     5    85.5000    84.5213     0.9787
     6    85.8000    84.6116     1.1884
     7    86.2000    85.2132     0.9868
     8    86.0000    84.8746     1.1254
     9    84.2000    85.4941    -1.2941
    10    84.4000    84.4196    -0.0196
    11    81.7000    84.7905    -3.0905
    12    84.2000    85.2387    -1.0387
    13    82.0000    83.7992    -1.7992
    14    82.3000    84.3865    -2.0865
    15    85.5000    84.9756     0.5244
    16    83.9000    83.0492     0.8508
    17    83.9000    83.5997     0.3003
    18    87.2000    85.8793     1.3207
    19    84.6000    84.6610    -0.0610
    20    85.5000    84.3906     1.1094
    21    84.1000    84.0963    0.00371
    22    84.8000    83.6624     1.1376
    23    82.8000    83.3180    -0.5180
    24    85.8000    84.6103     1.1897

Sum of Residuals                      0
Sum of Squared Residuals        31.9778
Predicted Resid SS (Press)      48.7073
```

F-15 Regression Model

```
          Dep Var    Predict    Std Err   Lower95%  Upper95%
   Obs      MC        Value     Predict   Predict   Predict   Residual

     1    84.2000    84.7992     0.367    81.9774   87.6210    -0.5992
     2    83.0000    83.0124     0.672    79.9544   86.0705    -0.0124
     3    83.8000    84.0524     0.631    81.0330   87.0718    -0.2524
     4    84.5000    84.4440     0.630    81.4252   87.4629     0.0560
     5    85.5000    84.5213     0.338    81.7154   87.3273     0.9787
     6    85.8000    84.6116     0.445    81.7408   87.4824     1.1884
     7    86.2000    85.2132     0.576    82.2426   88.1839     0.9868
     8    86.0000    84.8746     0.438    82.0090   87.7402     1.1254
     9    84.2000    85.4941     0.721    82.3874   88.6007    -1.2941
    10    84.4000    84.4196     0.340    81.6129   87.2264    -0.0196
    11    81.7000    84.7905     0.402    81.9477   87.6332    -3.0905
    12    84.2000    85.2387     0.600    82.2468   88.2305    -1.0387
    13    82.0000    83.7992     0.355    80.9839   86.6146    -1.7992
    14    82.3000    84.3865     0.281    81.6084   87.1647    -2.0865
    15    85.5000    84.9756     0.494    82.0698   87.8815     0.5244
    16    83.9000    83.0492     0.831    79.8247   86.2736     0.8508
    17    83.9000    83.5997     0.957    80.2255   86.9739     0.3003
    18    87.2000    85.8793     0.776    82.7155   89.0432     1.3207
    19    84.6000    84.6610     0.386    81.8280   87.4940    -0.0610
    20    85.5000    84.3906     0.510    81.4729   87.3082     1.1094
    21    84.1000    84.0963     0.508    81.1805   87.0121    0.00371
    22    84.8000    83.6624     0.513    80.7422   86.5826     1.1376
    23    82.8000    83.3180     0.802    80.1254   86.5107    -0.5180
    24    85.8000    84.6103     0.899    81.3066   87.9140     1.1897

Sum of Residuals                    0
Sum of Squared Residuals      31.9778
Predicted Resid SS (Press)    48.7079
```

F-15 99% Prediction Limits

```
                    General Linear Models Procedure

                  Number of observations in data set = 24


Dependent Variable: MC
                                     Sum of           Mean
Source                  DF          Squares         Square  F Value      Pr > F

Model                    4      12.46849682     3.11712421     1.85      0.1606

Error                   19      31.97775318     1.68303964

Corrected Total         23      44.44625000

                  R-Square             C.V.       Root MSE              MC Mean

                  0.280530         1.536882      1.2973202            84.412500


Source                  DF        Type I SS    Mean Square  F Value      Pr > F

NMCS                     1       6.21290726     6.21290726     3.69      0.0698
HUTE                     1       0.42663247     0.42663247     0.25      0.6204
SUTE                     1       0.66756680     0.66756680     0.40      0.5363
ABRT                     1       5.16139030     5.16139030     3.07      0.0960

Source                  DF      Type III SS    Mean Square  F Value      Pr > F

NMCS                     1       1.93849202     1.93849202     1.15      0.2966
HUTE                     1       0.63203019     0.63203019     0.38      0.5473
SUTE                     1       0.02431984     0.02431984     0.01      0.9056
ABRT                     1       5.16139030     5.16139030     3.07      0.0960


                                      T for H0:    Pr > |T|   Std Error of
Parameter                Estimate    Parameter=0                Estimate

INTERCEPT             92.70629402          24.53     0.0001     3.77854210
NMCS                  -0.34440684          -1.07     0.2966     0.32091272
HUTE                  -0.09359045          -0.61     0.5473     0.15272438
SUTE                   0.00370356           0.12     0.9056     0.03080959
ABRT                  -0.94617873          -1.75     0.0960     0.54030253
```

F-15 Regression Model

Observation	Observed	Predicted Residual	Lower 99% CLI Upper 99% CLI
1	84.20000000	84.79919060	80.94202384
		-0.59919060	88.65635737
2	83.00000000	83.01242946	78.83232731
		-0.01242946	87.19253160
3	83.80000000	84.05237407	79.92514061
		-0.25237407	88.17960753
4	84.50000000	84.44403430	80.31750341
		0.05596570	88.57056520
5	85.50000000	84.52133393	80.68588811
		0.97866607	88.35677975
6	85.80000000	84.61161928	80.68751557
		1.18838072	88.53572298
7	86.20000000	85.21323784	81.15267680
		0.98676216	89.27379868
8	86.00000000	84.87457921	80.95756645
		1.12542079	88.79159196
9	84.20000000	85.49408588	81.24758563
		-1.29408588	89.74058613
10	84.40000000	84.41962369	80.58304337
		-0.01962369	88.25620401
11	81.70000000	84.79049478	80.90471646
		-3.09049478	88.67627309
12	84.20000000	85.23865390	81.14902003
		-1.03865390	89.32828777
13	82.00000000	83.79924145	79.95095440
		-1.79924145	87.64752850
14	82.30000000	84.38653775	80.58902986
		-2.08653775	88.18404565
15	85.50000000	84.97562687	81.00357319
		0.52437313	88.94768055
16	83.90000000	83.04915461	78.64162625
		0.85084539	87.45668297
17	83.90000000	83.59973767	78.98751874
		0.30026233	88.21195661
18	87.20000000	85.87934504	81.55464412
		1.32065496	90.20404596
19	84.60000000	84.66102956	80.78858908
		-0.06102956	88.53347003
20	85.50000000	84.39058577	80.40240993
		1.10941423	88.37876160
21	84.10000000	84.09629126	80.11070781
		0.00370874	88.08187471
22	84.80000000	83.66242369	79.67074507
		1.13757631	87.65410231
23	82.80000000	83.31804946	78.95401980
		-0.51804946	87.68207912
24	85.80000000	84.61031994	80.09447120
		1.18968006	89.12616868

F-15 Regression Model

```
Sum of Residuals                                 -0.00000000
Sum of Squared Residuals                         31.97775318
Sum of Squared Residuals - Error SS               0.00000000
Press Statistic                                  48.70785746
First Order Autocorrelation                       0.30078600
Durbin-Watson D                                   1.34294043
```

F-16 Correlation Analysis

```
            5 'VAR' Variables:  MC        NMCS      HUTE      SUTE      ABRT


                              Simple Statistics

Variable          N        Mean     Std Dev          Sum     Minimum     Maximum

MC               24     90.9750      1.8056         2183     88.3000     94.7000
NMCS             24      4.8917      1.0210     117.4000      2.8000      6.9000
HUTE             24     31.5338      9.6541     756.8100     21.3800     68.0700
SUTE             24     19.4808      3.0137     467.5400     12.7000     28.6300
ABRT             24      3.8042      0.5497      91.3000      2.9000      5.1000


     Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0 / N = 24

                  MC           NMCS           HUTE           SUTE           ABRT

MC           1.00000       -0.93873       -0.22965       -0.48805       -0.34902
              0.0           0.0001         0.2804         0.0155         0.0946

NMCS        -0.93873        1.00000        0.02643        0.30342        0.29211
              0.0001        0.0            0.9024         0.1495         0.1660

HUTE        -0.22965        0.02643        1.00000        0.75824        0.02227
              0.2804        0.9024         0.0            0.0001         0.9177

SUTE        -0.48805        0.30342        0.75824        1.00000        0.09217
              0.0155        0.1495         0.0001         0.0            0.6684

ABRT        -0.34902        0.29211        0.02227        0.09217        1.00000
              0.0946        0.1660         0.9177         0.6684         0.0
```

F-16 Stepwise Regression

```
                Stepwise Procedure for Dependent Variable MC

Step 1   Variable NMCS Entered      R-square = 0.88121497   C(p) = 15.32274192

                     DF         Sum of Squares      Mean Square           F   Prob>F

 Regression           1            66.07790471      66.07790471      163.21   0.0001
 Error               22             8.90709529       0.40486797
 Total               23            74.98500000

                  Parameter         Standard          Type II
 Variable          Estimate            Error   Sum of Squares           F   Prob>F

 INTERCEP       99.09536387       0.64876375    9445.97825957     23331.0   0.0001
 NMCS           -1.66004031       0.12994130      66.07790471      163.21   0.0001

Bounds on condition number:             1,            1
--------------------------------------------------------------------------------

Step 2   Variable SUTE Entered      R-square = 0.92670286   C(p) =  3.79614599

                     DF         Sum of Squares      Mean Square           F   Prob>F

 Regression           2            69.48881429      34.74440714      132.75   0.0001
 Error               21             5.49618571       0.26172313
 Total               23            74.98500000

                  Parameter         Standard          Type II
 Variable          Estimate            Error   Sum of Squares           F   Prob>F

 INTERCEP      101.12036089       0.76598182    4561.23448468     17427.7   0.0001
 NMCS           -1.53994003       0.10964379      51.62756492      197.26   0.0001
 SUTE           -0.13410553       0.03714776       3.41090958       13.03   0.0016

Bounds on condition number:        1.1014,     4.405599
--------------------------------------------------------------------------------

All variables left in the model are significant at the 0.1500 level.
No other variable met the 0.1500 significance level for entry into the model.

           Summary of Stepwise Procedure for Dependent Variable MC

        Variable         Number   Partial    Model
 Step   Entered Removed      In      R**2     R**2       C(p)           F   Prob>F

    1   NMCS                  1    0.8812   0.8812    15.3227    163.2085   0.0001
    2   SUTE                  2    0.0455   0.9267     3.7961     13.0325   0.0016
```

F-16 Regression Model

```
Model: MODEL1
Dependent Variable: MC

                          Analysis of Variance

                              Sum of         Mean
      Source          DF     Squares       Square       F Value      Prob>F

      Model            4    70.19390     17.54847        69.592      0.0001
      Error           19     4.79110      0.25216
      C Total         23    74.98500

          Root MSE       0.50216     R-square       0.9361
          Dep Mean      90.97500     Adj R-sq       0.9227
          C.V.           0.55197

                          Parameter Estimates

                       Parameter      Standard    T for H0:
     Variable  DF       Estimate         Error   Parameter=0    Prob > |T|

     INTERCEP   1     101.740902    0.98041890       103.773        0.0001
     NMCS       1      -1.536554    0.11830918       -12.988        0.0001
     HUTE       1      -0.017743    0.01761172        -1.007        0.3264
     SUTE       1      -0.086954    0.05918199        -1.469        0.1581
     ABRT       1      -0.261857    0.19921266        -1.314        0.2043
```

F-16 Regression Model

```
        Dep Var    Predict
 Obs      MC         Value   Residual

   1    88.3000    88.5848    -0.2848
   2    89.0000    89.2978    -0.2978
   3    89.0000    88.6951     0.3049
   4    88.3000    87.7444     0.5556
   5    88.4000    88.2750     0.1250
   6    90.1000    90.7423    -0.6423
   7    90.8000    91.3189    -0.5189
   8    90.2000    90.9629    -0.7629
   9    88.9000    89.2203    -0.3203
  10    90.9000    90.5780     0.3220
  11    91.1000    90.9509     0.1491
  12    91.0000    91.2554    -0.2554
  13    92.3000    91.4329     0.8671
  14    92.7000    91.9964     0.7036
  15    93.3000    92.5080     0.7920
  16    90.2000    90.9468    -0.7468
  17    90.0000    89.7255     0.2745
  18    93.0000    92.9593     0.0407
  19    94.7000    94.8204    -0.1204
  20    93.5000    93.5521    -0.0521
  21    92.0000    91.9259     0.0741
  22    92.5000    92.3773     0.1227
  23    91.2000    91.2144    -0.0144
  24    92.0000    92.3154    -0.3154

Sum of Residuals               -622E-16
Sum of Squared Residuals         4.7911
Predicted Resid SS (Press)       8.2625
```

F-16 Regression Model

```
          Dep Var    Predict    Std Err   Lower95%   Upper95%
   Obs      MC        Value     Predict    Predict    Predict   Residual

     1    88.3000    88.5848      0.180    87.4682    89.7014    -0.2848
     2    89.0000    89.2978      0.241    88.1316    90.4640    -0.2978
     3    89.0000    88.6951      0.293    87.4780    89.9121     0.3049
     4    88.3000    87.7444      0.241    86.5788    88.9101     0.5556
     5    88.4000    88.2750      0.271    87.0811    89.4689     0.1250
     6    90.1000    90.7423      0.156    89.6417    91.8429    -0.6423
     7    90.8000    91.3189      0.202    90.1862    92.4515    -0.5189
     8    90.2000    90.9629      0.187    89.8414    92.0844    -0.7629
     9    88.9000    89.2203      0.272    88.0253    90.4154    -0.3203
    10    90.9000    90.5780      0.153    89.4793    91.6768     0.3220
    11    91.1000    90.9509      0.103    89.8780    92.0237     0.1491
    12    91.0000    91.2554      0.185    90.1354    92.3754    -0.2554
    13    92.3000    91.4329      0.130    90.3472    92.5186     0.8671
    14    92.7000    91.9964      0.136    90.9076    93.0852     0.7036
    15    93.3000    92.5080      0.153    91.4095    93.6064     0.7920
    16    90.2000    90.9468      0.345    89.6721    92.2215    -0.7468
    17    90.0000    89.7255      0.414    88.3634    91.0876     0.2745
    18    93.0000    92.9593      0.361    91.6648    94.2538     0.0407
    19    94.7000    94.8204      0.255    93.6413    95.9994    -0.1204
    20    93.5000    93.5521      0.203    92.4188    94.6854    -0.0521
    21    92.0000    91.9259      0.162    90.8215    93.0303     0.0741
    22    92.5000    92.3773      0.189    91.2540    93.5005     0.1227
    23    91.2000    91.2144      0.173    90.1024    92.3263    -0.0144
    24    92.0000    92.3154      0.183    91.1970    93.4337    -0.3154

Sum of Residuals                 -622E-16
Sum of Squared Residuals           4.7911
Predicted Resid SS (Press)         8.2625
```

F-16 99% Prediction Limits

```
                         General Linear Models Procedure

                     Number of observations in data set = 24

Dependent Variable: MC
                                 Sum of            Mean
Source                  DF      Squares          Square    F Value      Pr > F

Model                    4  70.19389938     17.54847485      69.59      0.0001

Error                   19   4.79110062      0.25216319

Corrected Total         23  74.98500000

                  R-Square         C.V.        Root MSE               MC Mean

                  0.936106     0.551974       0.5021585             90.975000


Source                  DF     Type I SS    Mean Square    F Value      Pr > F

NMCS                     1   66.07790471    66.07790471     262.04      0.0001
HUTE                     1    3.14859434     3.14859434      12.49      0.0022
SUTE                     1    0.53171067     0.53171067       2.11      0.1628
ABRT                     1    0.43568966     0.43568966       1.73      0.2043

Source                  DF   Type III SS    Mean Square    F Value      Pr > F

NMCS                     1   42.53440453    42.53440453     168.68      0.0001
HUTE                     1    0.25593714     0.25593714       1.01      0.3264
SUTE                     1    0.54435642     0.54435642       2.16      0.1581
ABRT                     1    0.43568966     0.43568966       1.73      0.2043


                                      T for H0:    Pr > |T|   Std Error of
Parameter               Estimate     Parameter=0                Estimate

INTERCEPT            101.7409015          103.77     0.0001     0.98041890
NMCS                  -1.5365538          -12.99     0.0001     0.11830918
HUTE                  -0.0177430           -1.01     0.3264     0.01761172
SUTE                  -0.0869542           -1.47     0.1581     0.05918199
ABRT                  -0.2618573           -1.31     0.2043     0.19921266
```

F-16 Regression Model

Observation	Observed	Predicted Residual	Lower 99% CLI Upper 99% CLI
1	88.30000000	88.58478863	87.05855030
		-0.28478863	90.11102697
2	89.00000000	89.29779884	87.70370814
		-0.29779884	90.89188955
3	89.00000000	88.69507777	87.03145233
		0.30492223	90.35870321
4	88.30000000	87.74444478	86.15112795
		0.55555522	89.33776162
5	88.40000000	88.27497482	86.64304189
		0.12502518	89.90690775
6	90.10000000	90.74231007	89.23791082
		-0.64231007	92.24670932
7	90.80000000	91.31886525	89.77059249
		-0.51886525	92.86713801
8	90.20000000	90.96289769	89.42995794
		-0.76289769	92.49583744
9	88.90000000	89.22034784	87.58588879
		-0.32034784	90.85380689
10	90.90000000	90.57801700	89.07613474
		0.32198300	92.07989926
11	91.10000000	90.95088074	89.48438261
		0.14911926	92.41737887
12	91.00000000	91.25543876	89.72451342
		-0.25543876	92.78636410
13	92.30000000	91.43286265	89.94881517
		0.86713735	92.91691014
14	92.70000000	91.99640413	90.50812532
		0.70359587	93.48468294
15	93.30000000	92.50795166	91.00647896
		0.79204834	94.00942435
16	90.20000000	90.94682312	89.20442593
		-0.74682312	92.68922031
17	90.00000000	89.72549180	87.86364702
		0.27450820	91.58733658
18	93.00000000	92.95933656	91.18978464
		0.04066344	94.72888849
19	94.70000000	94.82035352	93.20867251
		-0.12035352	96.43203453
20	93.50000000	93.55208318	92.00292749
		-0.05208318	95.10123887
21	92.00000000	91.92588904	90.41623774
		0.07411096	93.43554035
22	92.50000000	92.37725039	90.84182690
		0.12274961	93.91267387
23	91.20000000	91.21435092	89.69437741
		-0.01435092	92.73432442
24	92.00000000	92.31536082	90.78671608
		-0.31536082	93.84400556

F-16 Regression Model

```
Sum of Residuals                              -0.00000000
Sum of Squared Residuals                       4.79110062
Sum of Squared Residuals - Error SS            0.00000000
Press Statistic                                8.26245707
First Order Autocorrelation                    0.25103756
Durbin-Watson D                                1.46023897
```

F/A-18 Correlation Analysis

```
                         Correlation Analysis

          5 'VAR' Variables:  MC       NMCS      HUTE      SUTE      ABRT

                           Simple Statistics

Variable          N       Mean     Std Dev         Sum     Minimum     Maximum

MC               24    70.4250      3.1061        1690     64.8000     76.6000
NMCS             24    11.8042      1.3911    283.3000      9.3000     14.2000
HUTE             24    36.9833      5.0639    887.6000     29.9000     47.5000
SUTE             24    26.6708      3.4254    640.1000     21.7000     35.3000
ABRT             24     4.0992      0.4337     98.3800      3.4000      4.9600

    Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0 / N = 24

                    MC          NMCS          HUTE          SUTE          ABRT

MC             1.00000      -0.94083       0.41805       0.36527      -0.11630
               0.0           0.0001        0.0421        0.0792        0.5884

NMCS          -0.94083       1.00000      -0.50091      -0.46595       0.15393
               0.0001        0.0           0.0127        0.0217        0.4727

HUTE           0.41805      -0.50091       1.00000       0.88242      -0.21058
               0.0421        0.0127        0.0           0.0001        0.3233

SUTE           0.36527      -0.46595       0.88242       1.00000      -0.42701
               0.0792        0.0217        0.0001        0.0           0.0374

ABRT          -0.11630       0.15393      -0.21058      -0.42701       1.00000
               0.5884        0.4727        0.3233        0.0374        0.0
```

F/A-18 Stepwise Regression

```
              Stepwise Procedure for Dependent Variable MC

Step 1   Variable NMCS Entered     R-square = 0.88516825   C(p) =  0.27832079

                     DF        Sum of Squares       Mean Square           F   Prob>F

 Regression           1          196.42326105      196.42326105      169.58   0.0001
 Error               22           25.48173895        1.15826086
 Total               23          221.90500000

                  Parameter          Standard           Type II
 Variable          Estimate             Error    Sum of Squares           F   Prob>F

 INTERCEP       95.22233601        1.91682684     2858.36892672     2467.81   0.0001
 NMCS           -2.10072737        0.16131562      196.42326105      169.58   0.0001

Bounds on condition number:               1,              1
------------------------------------------------------------------------------------

All variables left in the model are significant at the 0.1500 level.
No other variable met the 0.1500 significance level for entry into the model.

         Summary of Stepwise Procedure for Dependent Variable MC

        Variable          Number   Partial     Model
 Step   Entered Removed       In      R**2      R**2        C(p)           F   Prob>F

    1   NMCS                   1    0.8852    0.8852      0.2783    169.5846   0.0001
```

F/A-18 Regression Model

```
Model: MODEL1
Dependent Variable: MC

                              Analysis of Variance

                                  Sum of         Mean
         Source          DF      Squares       Square      F Value       Prob>F

         Model            4    198.02960     49.50740       39.398       0.0001
         Error           19     23.87540      1.25660
         C Total         23    221.90500

             Root MSE       1.12098     R-square       0.8924
             Dep Mean      70.42500     Adj R-sq       0.8698
             C.V.           1.59174

                              Parameter Estimates

                         Parameter       Standard    T for H0:
       Variable  DF       Estimate          Error   Parameter=0    Prob > |T|

       INTERCEP   1      98.987526     5.09777082        19.418        0.0001
       NMCS       1      -2.187920     0.19456550       -11.245        0.0001
       HUTE       1       0.028445     0.10903122         0.261        0.7970
       SUTE       1      -0.125657     0.17044287        -0.737        0.4700
       ABRT       1      -0.106498     0.64778203        -0.164        0.8711
```

F/A-18 Regression Model

```
              Dep Var    Predict
        Obs     MC         Value   Residual

          1   74.7000    75.7708    -1.0708
          2   71.4000    71.6606    -0.2606
          3   74.3000    75.0829    -0.7829
          4   76.6000    75.2267     1.3733
          5   74.1000    73.2035     0.8965
          6   73.8000    72.2003     1.5997
          7   72.1000    71.8881     0.2119
          8   71.5000    71.4106     0.0894
          9   72.8000    73.1931    -0.3931
         10   64.8000    67.2007    -2.4007
         11   69.3000    69.0344     0.2656
         12   68.5000    70.2033    -1.7033
         13   68.4000    68.2792     0.1208
         14   66.1000    65.1721     0.9279
         15   66.7000    67.9118    -1.2118
         16   67.6000    66.7128     0.8872
         17   67.3000    66.0343     1.2657
         18   67.8000    67.5727     0.2273
         19   72.0000    71.5138     0.4862
         20   71.2000    71.6418    -0.4418
         21   69.0000    69.5412    -0.5412
         22   71.2000    71.2302    -0.0302
         23   67.3000    68.1131    -0.8131
         24   71.7000    70.4018     1.2982

Sum of Residuals                   0
Sum of Squared Residuals     23.8754
Predicted Resid SS (Press)   38.3844
```

F/A-18 Regression Model

```
        Dep Var   Predict   Std Err  Lower95%  Upper95%
  Obs      MC       Value   Predict   Predict   Predict  Residual

    1   74.7000   75.7708     0.673   73.0339   78.5077   -1.0708
    2   71.4000   71.6606     0.652   68.9463   74.3748   -0.2606
    3   74.3000   75.0829     0.518   72.4987   77.6671   -0.7829
    4   76.6000   75.2267     0.507   72.6517   77.8016    1.3733
    5   74.1000   73.2035     0.433   70.6881   75.7188    0.8965
    6   73.8000   72.2003     0.588   69.5505   74.8501    1.5997
    7   72.1000   71.8881     0.408   69.3912   74.3851    0.2119
    8   71.5000   71.4106     0.490   68.8498   73.9714    0.0894
    9   72.8000   73.1931     0.505   70.6195   75.7666   -0.3931
   10   64.8000   67.2007     0.562   64.5763   69.8252   -2.4007
   11   69.3000   69.0344     0.403   66.5412   71.5276    0.2656
   12   68.5000   70.2033     0.293   67.7781   72.6284   -1.7033
   13   68.4000   68.2792     0.322   65.8382   70.7202    0.1208
   14   66.1000   65.1721     0.558   62.5510   67.7932    0.9279
   15   66.7000   67.9118     0.459   65.3769   70.4468   -1.2118
   16   67.6000   66.7128     0.475   64.1644   69.2613    0.8872
   17   67.3000   66.0343     0.447   63.5087   68.5599    1.2657
   18   67.8000   67.5727     0.427   65.0623   70.0831    0.2273
   19   72.0000   71.5138     0.678   68.7720   74.2557    0.4862
   20   71.2000   71.6418     0.872   68.6691   74.6144   -0.4418
   21   69.0000   69.5412     0.440   67.0210   72.0615   -0.5412
   22   71.2000   71.2302     0.451   68.7010   73.7594   -0.0302
   23   67.3000   68.1131     0.321   65.6725   70.5536   -0.8131
   24   71.7000   70.4018     0.408   67.9050   72.8987    1.2982

Sum of Residuals                    0
Sum of Squared Residuals      23.8754
Predicted Resid SS (Press)    39.3844
```

F/A-18 99% Prediction Limits

```
                         General Linear Models Procedure

                     Number of observations in data set = 24

Dependent Variable: MC
                                    Sum of           Mean
Source                   DF        Squares         Square    F Value      Pr > F

Model                     4   198.02959901    49.50739975      39.40      0.0001

Error                    19    23.87540099     1.25660005

Corrected Total          23   221.90500000

                   R-Square           C.V.       Root MSE                MC Mean

                   0.892407       1.591738      1.1209817              70.425000


Source                   DF      Type I SS    Mean Square    F Value      Pr > F

NMCS                      1   196.42326105   196.42326105     156.31      0.0001
HUTE                      1     0.83887071     0.83887071       0.67      0.4240
SUTE                      1     0.73350276     0.73350276       0.58      0.4542
ABRT                      1     0.03396450     0.03396450       0.03      0.8711

Source                   DF    Type III SS    Mean Square    F Value      Pr > F

NMCS                      1   158.90164843   158.90164843     126.45      0.0001
HUTE                      1     0.08552620     0.08552620       0.07      0.7970
SUTE                      1     0.68298750     0.68298750       0.54      0.4700
ABRT                      1     0.03396450     0.03396450       0.03      0.8711


                                         T for H0:    Pr > |T|   Std Error of
Parameter                 Estimate     Parameter=0                 Estimate

INTERCEPT              98.98752585           19.42      0.0001     5.09777082
NMCS                   -2.18792027          -11.25      0.0001     0.19456550
HUTE                    0.02844474            0.26      0.7970     0.10903122
SUTE                   -0.12565700           -0.74      0.4700     0.17044287
ABRT                   -0.10649837           -0.16      0.8711     0.64778203
```

F/A-18 Regression Model

Observation	Observed	Predicted	Lower 99% CLI
		Residual	Upper 99% CLI
1	74.70000000	75.77081971	72.02973025
		-1.07081971	79.51190918
2	71.40000000	71.66058379	67.95045701
		-0.26058379	75.37071057
3	74.30000000	75.08290063	71.55054134
		-0.78290063	78.61525992
4	76.60000000	75.22667751	71.70693596
		1.37332249	78.74641906
5	74.10000000	73.20345770	69.76517572
		0.89654230	76.64173968
6	73.80000000	72.20032866	68.57831049
		1.59967134	75.82234684
7	72.10000000	71.88814416	68.47509559
		0.21185584	75.30119272
8	71.50000000	71.41064533	67.91026721
		0.08935467	74.91102346
9	72.80000000	73.19305536	69.67527530
		-0.39305536	76.71083543
10	64.80000000	67.20074933	63.61339378
		-2.40074933	70.78810488
11	69.30000000	69.03440363	65.62642252
		0.26559637	72.44238474
12	68.50000000	70.20327445	66.88834679
		-1.70327445	73.51820211
13	68.40000000	68.27919336	64.94253375
		0.12080664	71.61585297
14	66.10000000	65.17209017	61.58930973
		0.92790983	68.75487060
15	66.70000000	67.91184970	64.44673703
		-1.21184970	71.37696236
16	67.60000000	66.71284754	63.22937883
		0.88715246	70.19631626
17	67.30000000	66.03431043	62.58206046
		1.26568957	69.48656040
18	67.80000000	67.57270747	64.14119069
		0.22729253	71.00422425
19	72.00000000	71.51383616	67.76596341
		0.48616384	75.26170890
20	71.20000000	71.64175296	67.57845752
		-0.44175296	75.70504841
21	69.00000000	69.54121693	66.09627487
		-0.54121693	72.98615898
22	71.20000000	71.23022141	67.77304162
		-0.03022141	74.68740121
23	67.30000000	68.11308951	64.77708675
		-0.81308951	71.44909227
24	71.70000000	70.40184410	66.98888515
		1.29815590	73.81480306

F/A-18 Regression Model

```
Sum of Residuals                                  -0.00000000
Sum of Squared Residuals                          23.87540099
Sum of Squared Residuals - Error SS               -0.00000000
Press Statistic                                   39.38444829
First Order Autocorrelation                        0.02040319
Durbin-Watson D                                    1.84058353
```

Appendix E: Double Cross-Validation

F-14

OBS	ACTUAL MC	ODD PRED	ODD FILE DIFFERENCE	EVEN PRED	EVEN FILE DIFFERENCE
1	70.4	68.2926	2.1074	*	
2	66.3	*		67.495	-1.195
3	66.2	62.6733	3.5267	*	
4	59.5	*		65.0976	-5.5976
5	70.0	68.9869	1.0131	*	
6	66.2	*		62.5182	3.6818
7	68.5	70.9786	-2.4786	*	
8	68.0	*		66.3131	1.6869
9	69.4	70.7467	-1.3467	*	
10	64.3	*		64.6066	-0.3066
11	63.9	61.7938	2.1062	*	
12	58.7	*		61.8335	-3.1335
13	56.9	60.4465	-3.5465	*	
14	60.4	*		63.494	-3.094
15	61.6	62.1241	-0.5241	*	
16	55.2	*		55.1403	0.0597
17	58.7	58.2553	0.4447	*	
18	62.5	*		58.1189	4.3811
19	60.8	61.2427	-0.4427	*	
20	59.1	*		54.5059	4.5941
21	63.7	61.8559	1.8441	*	
22	62.5	*		62.7454	-0.2454
23	60.8	60.9243	-0.1243	*	
24	62.5	*		62.1022	0.3978

CONFIDENCE INTERVALS FOR ODD FILE MODEL

MEAN	STD DEV	UPPER LIMIT	LOWER LIMIT	CONF INT
0.2149	2.0540	1.5069	-1.0770	95%
		2.0263	-1.5964	99%

CONFIDENCE INTERVALS FOR EVEN FILE MODEL

MEAN	STD DEV	UPPER LIMIT	LOWER LIMIT	CONF INT
0.1024	3.1485	2.0829	-1.8780	95%
		2.8791	-2.6742	99%

F-15

OBS	ACTUAL MC	ODD PRED	ODD FILE DIFFERENCE	EVEN PRED	EVEN FILE DIFFERENCE
1	84.2	85.2549	-1.0549	*	*
2	83.0	*	*	82.4627	0.5373
3	83.8	84.4918	-0.6918	*	*
4	84.5	*	*	84.1599	0.3401
5	85.5	84.9613	0.5387	*	*
6	85.8	*	*	84.1027	1.6973
7	86.2	85.6611	0.5389	*	*
8	86.0	*	*	84.493	1.507
9	84.2	86.1249	-1.9249	*	*
10	84.4	*	*	83.9312	0.4688
11	81.7	85.1612	-3.4612	*	*
12	84.2	*	*	84.7574	-0.5574
13	82.0	84.1861	-2.1861	*	*
14	82.3	*	*	83.9513	-1.6513
15	85.5	85.4496	0.0504	*	*
16	83.9	*	*	82.5435	1.3565
17	83.9	84.1697	-0.2697	*	*
18	87.2	*	*	85.6332	1.5668
19	84.6	84.9944	-0.3944	*	*
20	85.5	*	*	83.8054	1.6946
21	84.1	84.3669	-0.2669	*	*
22	84.8	*	*	83.0786	1.7214
23	82.8	83.8857	-1.0857	*	*
24	85.8	*	*	84.3073	1.4927

CONFIDENCE INTERVALS FOR ODD FILE MODEL

MEAN	STD DEV	UPPER LIMIT	LOWER LIMIT	CONF INT
-0.4253	0.9273	0.1580	-1.0086	95%
		0.3925	-1.2431	99%

CONFIDENCE INTERVALS FOR EVEN FILE MODEL

MEAN	STD DEV	UPPER LIMIT	LOWER LIMIT	CONF INT
0.4239	0.8561	0.9624	-0.1146	95%
		0.3925	-1.2431	99%

F-16

OBS	ACTUAL MC	ODD PRED	ODD FILE DIFFERENCE	EVEN PRED	EVEN FILE DIFFERENCE
1	88.3	88.5734	-0.2734	*	*
2	89.0	*	*	89.5181	-0.5181
3	89.0	88.476	0.524	*	*
4	88.3	*	*	87.4831	0.8169
5	88.4	88.3951	0.0049	*	*
6	90.1	*	*	90.6865	-0.5865
7	90.8	91.34	-0.54	*	*
8	90.2	*	*	90.7236	-0.5236
9	88.9	89.4861	-0.5861	*	*
10	90.9	*	*	90.3787	0.5213
11	91.1	90.8427	0.2573	*	*
12	91.0	*	*	91.776	-0.776
13	92.3	91.2649	1.0351	*	*
14	92.7	*	*	92.1784	0.5216
15	93.3	92.2902	1.0098	*	*
16	90.2	*	*	92.0811	-1.8811
17	90.0	89.2497	0.7503	*	*
18	93.0	*	*	93.6507	-0.6507
19	94.7	94.7034	-0.0034	*	*
20	93.5	*	*	93.8178	-0.3178
21	92.0	91.9543	0.0457	*	*
22	92.5	*	*	92.3929	0.1071
23	91.2	90.9897	0.2103	*	*
24	92.0	*	*	92.6576	-0.6576

CONFIDENCE INTERVALS FOR ODD FILE MODEL

MEAN	STD DEV	UPPER LIMIT	LOWER LIMIT	CONF INT
0.1014	0.3903	0.1580	-1.0086	95%
		0.3925	-1.2431	99%

CONFIDENCE INTERVALS FOR EVEN FILE MODEL

MEAN	STD DEV	UPPER LIMIT	LOWER LIMIT	CONF INT
-0.1644	0.5340	0.9624	-0.1146	95%
		0.3925	-1.2431	99%

F/A-18

OBS	ACTUAL MC	ODD PRED	ODD FILE DIFFERENCE	EVEN PRED	EVEN FILE DIFFERENCE
1	74.7	77.418	-2.718	*	*
2	71.4	*	*	72.0162	-0.6162
3	74.3	75.7832	-1.4832	*	*
4	76.6	*	*	75.6649	0.9351
5	74.1	73.6982	0.4018	*	*
6	73.8	*	*	72.3226	1.4774
7	72.1	72.0722	0.0278	*	*
8	71.5	*	*	70.7236	0.7764
9	72.8	73.5342	-0.7342	*	*
10	64.8	*	*	68.2074	-3.4074
11	69.3	68.6436	0.6564	*	*
12	68.5	*	*	69.8569	-1.3569
13	68.4	68.2864	0.1136	*	*
14	66.1	*	*	64.818	1.282
15	66.7	68.3936	-1.6936	*	*
16	67.6	*	*	66.8949	0.7051
17	67.3	65.5567	1.7433	*	*
18	67.8	*	*	67.5691	0.2309
19	72.0	72.1455	-0.1455	*	*
20	71.2	*	*	73.256	-2.056
21	69.0	69.8227	-0.8227	*	*
22	71.2	*	*	70 5297	0.6703
23	67.3	68.1846	-0.8846	*	*
24	71.7	*	*	69.6135	2.0865

CONFIDENCE INTERVALS FOR ODD FILE MODEL

MEAN	STD DEV	UPPER LIMIT	LOWER LIMIT	CONF INT
-0.2308	0.8557	0.1580	-1.0086	95%
		0.3925	-1.2431	99%

CONFIDENCE INTERVALS FOR EVEN FILE MODEL

MEAN	STD DEV	UPPER LIMIT	LOWER LIMIT	CONF INT
0.0303	1.1169	0.9624	-0.1146	95%
		0.3925	-1.2431	99%

Appendix F: Exchange of Independent Variables

F-15 to F-14

OBS	F-15 PRED MC	F-14 PRED MC	F-15 TO F-14 DIFFERENCE
1	84.7992	68.2953	16.5039
2	83.0124	64.9053	18.1071
3	84.0524	62.9962	21.0562
4	84.4440	61.5397	22.9043
5	84.5213	68.9056	15.6157
6	84.6116	65.3996	19.2120
7	85.2132	71.1018	14.1114
8	84.8746	67.6291	17.2455
9	85.4941	70.7106	14.7835
10	84.4196	64.7801	19.6395
11	84.7905	62.1693	22.6212
12	85.2387	60.4176	24.8211
13	83.7992	60.4359	23.3633
14	84.3865	61.4761	22.9104
15	84.9756	62.4116	22.5640
16	83.0492	54.8244	28.2248
17	83.5997	58.6457	24.9540
18	85.8793	62.2775	23.6018
19	84.6610	61.3394	23.3216
20	84.3906	59.0529	25.3377
21	84.0963	61.8617	22.2346
22	83.6624	60.5816	23.0808
23	83.3180	61.1354	22.1826
24	84.6103	63.2077	21.4026

CONFIDENCE INTERVALS FOR COMPARISON OF F-15 TO F-14 PRED MC RATES

MEAN	STD DEV	UPPER LIMIT	LOWER LIMIT	CONF INT
21.2417	3.6126	22.7637	19.7196	95%
		23.3042	19.1791	99%

F-16 to F/A-18

OBS	F-16 PRED MC	F/A-18 PRED MC	F-16 TO F/A-18 DIFFERENCE
1	88.5848	75.7708	12.8140
2	89.2978	71.6606	17.6372
3	88.6951	75.0829	13.6122
4	87.7444	75.2267	12.5177
5	88.2750	73.2035	15.0715
6	90.7423	72.2003	18.5420
7	91.3189	71.8881	19.4308
8	90.9629	71.4106	19.5523
9	89.2203	73.1931	16.0272
10	90.5780	67.2007	23.3773
11	90.9509	69.0344	21.9165
12	91.2554	70.2033	21.0521
13	91.4329	68.2792	23.1537
14	91.9964	65.1721	26.8243
15	92.5080	67.9118	24.5962
16	90.9468	66.7128	24.2340
17	89.7255	66.0343	23.6912
18	92.9593	67.5727	25.3866
19	94.8204	71.5138	23.3066
20	93.5521	71.6418	21.9103
21	91.9259	69.5412	22.3847
22	92.3773	71.2302	21.1471
23	91.2144	68.1131	23.1013
24	92.3154	70.4018	21.9136

CONFIDENCE INTERVALS FOR COMPARISON OF F-16 TO F/A-18 PRED MC RATES

MEAN	STD DEV	UPPER LIMIT	LOWER LIMIT	CONF INT
20.5500	4.0579	22.2597	18.8404	95%
		22.8668	18.2332	99%

Appendix G: Cross Model Comparison

F-15 and F-14 COMPARISON

OBS	F-15 PRED(AF)	F-15 PRED(USN)	F-14 PRED(USN)	F-14 PRED(AF)	USN DIFFERENCE	USAF DIFFERENCE
1	84.7992	77.5226	68.2953	79.9646	7.2765	-11.6693
2	83.0124	72.9103	64.9053	78.2781	10.1020	-13.3728
3	84.0524	72.3265	62.9962	79.0025	11.7258	-16.0063
4	84.4440	75.5303	61.5397	77.6195	8.9136	-16.0799
5	84.5213	75.9718	68.9056	80.2781	8.5494	-11.3725
6	84.6116	78.2644	65.3996	79.8191	6.3471	-14.4196
7	85.2132	79.8350	71.1018	79.8766	5.3781	-8.7748
8	84.8746	77.6249	67.6291	80.1707	7.2496	-12.5417
9	85.4941	78.2551	70.7106	80.2635	7.2389	-9.5529
10	84.4196	76.9324	64.7801	79.2911	7.4871	-14.5111
11	84.7905	76.5812	62.1693	79.5394	8.2092	-17.3701
12	85.2387	77.5226	60.4176	79.0256	7.7160	-18.6080
13	83.7992	74.3394	60.4359	79.4120	9.4597	-18.9761
14	84.3865	75.3096	61.4761	78.6227	9.0768	-17.1467
15	84.9756	74.4681	62.4116	80.1822	10.5074	-17.7707
16	83.0492	71.8552	54.8244	78.2685	11.1939	-23.4442
17	83.5997	70.3649	58.6457	79.1949	13.2347	-20.5492
18	85.8793	76.3129	62.2775	80.9385	9.5663	-18.6611
19	84.6610	76.5022	61.3394	77.2298	8.1587	-15.8905
20	84.3906	77.5599	59.0529	77.3267	6.8306	-18.2739
21	84.0963	76.7336	61.8617	78.5837	7.3626	-16.722
22	83.6624	75.9262	60.5816	78.4833	7.7361	-17.9018
23	83.3180	71.8523	61.1354	78.7674	11.4656	-17.632
24	84.6103	72.1537	63.2077	79.7109	12.4565	-16.5033

CONFIDENCE INTERVALS FOR F-15 PRED (USAF) TO F-15 PRED (USN) MC RATES

MEAN	STD DEV	UPPER LIMIT	LOWER LIMIT	CONF INT
8.8851	2.0395	9.7444	8.0259	95%
		10.0496	7.7207	99%

CONFIDENCE INTERVALS FOR F-14 PRED (USN) TO F-14 PRED (USAF) MC RATES

MEAN	STD DEV	UPPER LIMIT	LOWER LIMIT	CONF INT
-15.9896	3.4574	-14.5330	-17.4462	95%
		-14.0157	-17.9636	99%

F-16 and F/A-18 COMPARISON

OBS	F-16 PRED(AF)	F-16 PRED(USN)	F/A-18 PRED(USN)	F/A-18 PRED(AF)	USN DIFFERENCE	USAF DIFFERENCE
1	88.5848	83.0068	75.7708	87.9390	5.5779	-12.1683
2	89.2978	84.0572	71.6606	86.2502	5.2405	-14.5897
3	88.6951	83.0935	75.0829	87.4986	5.6015	-12.4158
4	87.7444	81.6655	75.2267	88.0489	6.0788	-12.8223
5	88.2750	82.2396	73.2035	86.3872	6.0353	-13.1837
6	90.7423	86.0540	72.2003	85.3104	4.6882	-13.1101
7	91.3189	86.7083	71.8881	85.8014	4.6105	-13.9134
8	90.9629	86.0296	71.4106	85.2424	4.9332	-13.8318
9	89.2203	83.6027	73.1931	86.9333	5.6175	-13.7403
10	90.5780	85.6586	67.2007	82.0938	4.9193	-14.8931
11	90.9509	86.3232	69.0344	83.5222	4.6276	-14.4878
12	91.2554	86.6522	70.2033	84.0692	4.6031	-13.8659
13	91.4329	87.0907	68.2792	82.6605	4.3421	-14.3813
14	91.9964	87.7491	65.1721	80.3923	4.2472	-15.2202
15	92.5080	88.5035	67.9118	81.7872	4.0044	-13.8755
16	90.9468	87.5643	66.7128	81.9257	3.3824	-15.2130
17	89.7255	86.4408	66.0343	80.8229	3.2846	-14.7886
18	92.9593	88.6379	67.5727	81.5243	4.3213	-13.9516
19	94.8204	91.2347	71.5138	84.3909	3.5856	-12.8771
20	93.5521	89.6813	71.6418	84.8903	3.8707	-13.2485
21	91.9259	87.3281	69.5412	82.9625	4.5977	-13.4213
22	92.3773	88.1276	71.2302	84.0898	4.2496	-12.8597
23	91.2144	86.7706	68.1131	82.3597	4.4437	-14.2467
24	92.3154	87.6723	70.4018	83.7212	4.6430	-13.3194

CONFIDENCE INTERVALS FOR F-16 PRED (USAF) TO F-16 PRED (USN) MC RATES

MEAN	STD DEV	UPPER LIMIT	LOWER LIMIT	CONF INT
4.6461	0.7624	4.9673	4.3249	95%
		5.0814	4.2108	99%

CONFIDENCE INTERVALS FOR F/A-18 PRED (USN) TO F/A-18 PRED (USAF) MC RATE

MEAN	STD DEV	UPPER LIMIT	LOWER LIMIT	CONF INT
-13.7677	0.8508	-13.4093	-14.1262	95%
		-13.2819	-14.2535	99%

Bibliography

1. Balassa, Bela and Luc Bauwens. "Intra-Industry Specialisation in a Multi-Country and Multi-Industry Framework," *Economic Journal, 97*: 923-939 (December 1987).

2. Bergstrand, Jeffrey H. "The Heckscher-Ohlin-Samuelson Model, the Linder Hypothesis and the Determinants of Bilateral Intra-Industry Trades". *Economic Journal, 100*: 1216-1229 (December 1990).

3. Beu, Major Norman J. and Major Richard C. Nichols. *More Maintenance in OMS*. Research Study. Air Command and Staff College, Air University, Maxwell AFB AL, May 1977 (AD-B019707).

4. Canadian Forces Base, Summerside. "1988 AMIT Information Book", Unpublished guide to CFB Summerside aircraft maintenance complex: April 1988.

5. Chief of Naval Operations. *The Naval Aviation Maintenance Program, Volume II*. OPNAVINST 4790.2E Volume II. Washington: Naval Printing Office, 1 January 1989.

6. Chief of Naval Operations. *The Naval Aviation Maintenance Program, Volume III*. OPNAVINST 4790.2E Volume III. Washington: Naval Printing Office, 1 January 1989.

7. Department of the Air Force. *Basic Aerospace Doctrine of the United States Air Force*. AFM 1-1. Washington: HQ USAF, 16 March 1984.

8. Department of the Air Force. *Aircraft Maintenance*. TACR 66-5. Washington: HQ USAF, 1 January 1992.

9. Department of the Air Force. *Aircraft and Unit Performance Report* AFRESR 66-12. Washington: HQ USAF, 13 December 1990.

10. Dornheim, Michael A. "U.S. Air Force May Move to Mixed Role Tactical Wings," *Aviation Week and Space Technology*: 99 (5 November 1990).

11. Draper, N. R. and H. Smith. *Applied Regression Analysis* (Second Edition). New York: John Wiley & Sons, Inc., 1981.

12. Egge, Major William L. "Logistics Implications of Composite Wings". Informal Review of Studies on Composite Wings, 25th Annual DoD Cost Analysis Symposium. AFLC AUCADRE/RIC, Maxwell AFB AL, 15 January 1992.

13. Emory, William C. and Donald R. Cooper. *Business Research Methods* (Fourth Edition). Homewood IL: Irwin, 1991.

14. Gililland, Captain Billy J. *Productivity Measurement in Aircraft Maintenance Organizations*. MS Thesis, AFIT/GLM/LSM/90S-20. School of Systems and Logistics, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, September 1991 (AD-A229239).

15. Glender, Lieutenant Commander Carlos, Master's Student Class 92S. Personal interview. Air Force Institute of Technology, Wright-Patterson AFB OH, 11 May 1992.

16. Gonnerman, Captain Valerie J. *Performance Evaluation of A-10 Aircraft Maintenance Units and Aircraft Using Constrained Facet Analysis*. MS Thesis, AFIT/GLM/LSM/84S-26. School of Systems and Logistics, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, September 1984 (AD-A146955).

17. Gross, Michael T. and others. "Validity of Knee Flexion and Extension Peak Torque Prediction Models," *Physical Therapy, 70*: 17-24 (January 1990).

18. Harris, Captain Barbara L. *Challenges to United States Tactical Air Force Aircraft Maintenance Personnel*. MS Thesis, AFIT/GLM/LSM/91S-28. School of Systems and Logistics, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, September 1991 (AD-A246742).

19. Jung, Captain Charles R. *Determining Production Capability in Aircraft Maintenance: A Regression Analysis*. MS Thesis, AFIT/GLM/LSM/91S-35. School of Systems and Logistics, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, September 1991 (AD-A246720).

20. Keller, Lieutenant Colonel George B. *A Restructured Maintenance System*, Professional Study, Air War College (AU), Maxwell AFB AL, April 1975.

21. Krisinger, Major Chris J. "A Carrier Air Wing For The Air Force," *Airpower Journal, 6*: 32-42 (Spring 1992).

22. McClave, James T. and George P. Benson. *Statistics for Business and Economics* (Fourth Edition). San Francisco CA: Dellen Publishing Company, 1988.

23. McIntyre, Squadron Leader M. E., RAF. Personal interview. Wright-Patterson AFB OH, 19 November 1991.

24. McNiff, Senior Master Sergeant William E. USAF Retired. Personal interview. Pease AFB NH, 29 December 1991.

25. McPeak, General Merrill A. "For the Composite Wing," *Airpower Journal, 4*: 4-12 (Fall 1990).

26. Merry, E. Director of Performance Analysis. Telephone interview. HQ TAC/LGM, Langley AFB VA, 4 June 1992.

27. Mosier, C.I. "Problems and designs of cross-validation," *Educational and Psychological Measurement, 11*: 5-11 (1951).

28. *The Oxford Dictionary of Quotations* (Third Edition). New York: Oxford University Press, 1980.

29. "The U.S. Air Force in Facts and Figures," *The Air Force Magazine*: 38-57 (May 1991).

30. Thorndike, Robert M. *Correlational procedures for Research.* New York: Gardner Press, Inc 1978.

31. Van Der Meer, J. "Exploring macrobenthos-environment relationship by canonical correlation analysis," *Journal of Experimental Marine Biology and Ecology, 148*: 105-120 (1991).

32. Vogel, Ezra F. *Japan As Number One, Lessons For America.* Cambridge MA: Harvard University Press, 1979.

33. Vogel, Ezra F. *Comeback, Case By Case: Building The Resurgence of American Business.* New York: Simon and Schuster, 1985.

34. Wayne, Lieutenant Colonel Richard E. *Should the Tactical Fighter Wing Utilize the Squadron or Consolidated Maintenance System.* Unpublished report No. 3214. Air War College, Maxwell AFB AL, 1966

35. West, Joe. "'New Force' to stress peacetime operations," *The Air Force Times*: 12, 28 (6 January 1992)

36. Wyatt, Major Milton R. and Major Carroll M. Statten. "Maintenance in the U.S. Air Force", *Logistics Management LOG 224, Volume I*, 17.23-17.46. Edited by Dennis L. Hull and Albert Rogers. Air Force Institute of Technology, Wright-Patterson AFB OH (1985).

37. Zimmerman, S.A. *History of AMC Maintenance Programs and Problems 1945-1950*. Historical Study Number 51S-19195-2. Air Material Command Historical Office, Wright-Patterson AFB OH, 1952

Vita

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13. ABSTRACT (*Maximum 200 words*)

This study compares the aircraft maintenance structure being implemented by General Merrill A. McPeak with that of the previous structure typified by TACR 66-5. Historical aircraft data is used to compare organizational structures. Data from the USAF and USN is used to build regression models to determine if organizational structure contributes to combat capability. Statistical tests are used to determine if a significant difference exists between the two organizational structures.

Regression analysis and comparison of the results lead the researchers to conclude that a significant difference exists in the performance measures of COMO and Objective Wing organizations. While many reasons may account for this difference, the structure of the organization is a key determinant of performance.

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