AFIT/GIM/LAL/99S-2

# A STATISTICAL ANALYSIS OF THE VARIABILITY EXPERIENCED IN DLA ADMINISTRATIVE AND PRODUCTION LEAD TIME

THESIS

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THESIS

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Kieran F. Keelty

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## Abstract

This study examined the variability experienced in the administrative and production lead times of consumable items managed by the Defense Logistics Agency (DLA). Assets were categorized based on an item manager's determination that an asset was a problem part, and whether the asset was purchased for stock replenishment or direct vendor delivery. The methodology was a two-sample t-test of aggregated data to determine if significant differences existed between the mean deviations from the system lead times of various combinations of categories. The study produced results indicating that a significant difference did not exist between the mean deviations of problem parts and non-problem parts, but substantial variability did exist for all categories of consumable items. The degree of variability was such that the author suspected this as a possible cause for individual assets entering problem part status. The study also confirmed that while the DLA methodology used for forecasting lead times of stock replenishment purchases was accurate over aggregated data, the variability present is, to some extent, contributing to excess inventory levels.

# A STATISTICAL ANALYSIS OF THE VARIABILITY EXPERIENCED IN DLA ADMINISTRATIVE AND PRODUCTION LEAD TIME

## I. Background and Problem Presentation

### Introduction

By nature, maintenance, repair, and overhaul environments such as Air Force depots experience unpredictable demand patterns. That is, repair facilities can not know which components of a particular end item have failed until the end item is disassembled and inspected. This varying demand often causes work stoppages due to lack of component parts. The impact of such work stoppages on Air Force readiness, though yet to be measured, is considered to be significant. For this reason, significant research and operational effort has been expended in the area of inventory management and requirements computations in examining the issue of demand forecasting. The systems used for these activities, however, frequently rely on many variables, some of which experience considerable variability. This study examines the variability in forecast errors for consumable items managed by the Defense Logistics Agency (DLA).

Problem Statement

The relationship between the readiness of Air Force weapon systems and reparable end-items has received much attention in recent years. By extension, weapon system readiness is also directly related to the effective determination of requirements for consumable parts used to repair these end-items. The Department of Defense (DoD) relies on the Wilson Economic Order Quantity (EOQ) model to manage consumable items at DLA, and at all echelons in the Air Force logistics chain. EOQ is a reorder point system that attempts to compute the most economical order size by balancing ordering cost and holding cost. It is a deterministic model in that all of the parameters, including lead-time, are assumed to be known or can be calculated with certainty (Tersine, 1994: 91). Of the many parameters used in inventory management and requirements forecasting, arguably, the two most critical are demand and lead-time. The issue of demand forecasting continues to receive well-deserved attention. The lead time of consumable items, on the other hand, appears to take second billing in terms of academic and operational research. This study focuses on the impact of lead time variability.

Procedurally, DLA uses a weighted average of the lead times of the previous two purchases to determine the forecast for the next purchase. In the parlance of DLA, this forecast is termed "system" lead time, or "lead time of record." The specifics of the lead time methodology are discussed further in Chapter II. These lead-times, which may be frequently violated in the real-world acquisitions environment, are the focus of this research effort. There are two specific management questions addressed in this study. First, are inaccurate system lead times a contributing factor in the classification of parts as problem items or the accumulation of excess inventory, and second, are the system lead times utilized by inventory management programs accurate approximations of actual lead times experienced in the acquisitions process?

Specifically, this study focuses on consumable parts used in the F100-GE-110 and F100-GE-129 engines. The F100-110 engine was chosen based on the fact that it is the primary driver of F-16 mission capable rates as of the date of this study (Stevens, 1999).

## Research Objectives

The main purpose of this study is to examine the nature and accuracy of the lead times utilized for requirements computations by DLA. Chapter II establishes a need for this research through a review of DoD inventory management theory and practice. The quantitative nature of the system lead times, and their accuracy based on actual contracting actions is analyzed in Chapter IV. Chapter IV also includes aggregate statistical analyses of various categories of consumable assets, and inferences based on the descriptive statistics.

The justification and foundation for this research is demonstrated through a discussion of the influence of lead time on inventory levels based on current DLA inventory policy. This is followed with a thorough review of reports on DoD secondary item management issued over the past decade by organizations such as the General Accounting Office (GAO) and the Logistics Management Institute. Finally, the data must be analyzed to answer the research questions presented below.

Research Questions

To meet the research objective and answer the management questions, particular research questions must be answered. These questions are listed below.

1. What is the impact of lead-time variability on consumable item inventory levels in the DoD?
2. What methodology does DLA use to assign lead times to assets?
3. Is there a difference in the distributions of deviations from system lead times for items classified as problem parts versus items that are not (Case 1)?
4. Is there a difference in the distributions of deviations from system lead times for items purchased for stock replenishment versus direct vendor delivery (DVD) contracts (Case 2)?
5. Is there a difference in the distributions of deviations from system lead times for problem parts bought for stock replenishment versus problem parts under DVD contracts (Case 3)?
6. Is there a difference in the distributions of deviations from system lead times for non-problem parts bought for stock replenishment versus non-problem parts under DVD contracts (Case 4)?
7. Is there a difference in the distributions of deviations from system lead times for problem parts bought for stock replenishment versus non-problem parts bought for stock replenishment (Case 5)?

8. Is there a difference in the distributions of deviations from system lead times for problem parts under DVD contracts versus non-problem parts under DVD contracts (Case 6)?

## Hypothesis

Thus, this study examines a small slice of consumable items to determine the accuracy of the system lead times used by DLA in requirements computations. The overarching hypothesis, then, is:

Null Hypothesis: the current DLA methodology for computing system lead times for requirements computations ensures cost-effective and appropriate inventory levels.

Alternate Hypothesis: the current DLA methodology for computing system lead times for requirements computations does not ensure cost-effective and appropriate inventory levels.

This hypothesis is tested through statistical analysis of historical data. Additionally, the nature of lead time variability is explored with regard to various categorizations of consumable items in order to determine if the lead times of certain categories may warrant closer management attention. Specific hypotheses regarding categorical lead times are formulated in Chapter III.

Methodology

The approach is a two-sample t-test to determine if significant differences exist between the groups tested for each of the six cases outlined above. The system lead times for each item are subtracted from their actual lead times, as established in the DLA Integrated Data Base, and a two-sample hypothesis test is conducted on the mean deviations. The DLA Integrated Data Base interfaces with the Standard Automated Materiel Management System (SAMMS) to obtain data and reports. Appendix G-2 in DLA Manual 4140.2 defines SAMMS as:

> The computer system which is used to process transactions of the construction supplies Stock Fund. The system connects the major directorates at [Defense Supply Centers] and provides the necessary data for management of the Stock Fund inventory. SAMMS consists of five subsystems: Distribution, Requirements, Contracting, Technical and Logistics, and Financial.

There are four categories used to differentiate the items in the sample. The first two, problem parts and non-problem parts, are the result of a determination by an asset's item manager. A definition of "problem part" is left for Chapter III. The second set of categories are defined by type of purchase. That is, whether the item was purchased to replenish DLA stock or for direct delivery by the vendor to the user. Research questions three and four, examine the first two categories. Research questions five through eight examine combinations of the four main categories. Questions five and six seek to determine if a difference in lead time exists between problem parts and non-problem parts in the two categories of type of purchase. Similarly, research questions seven and eight compare the type of purchase across problem part and non-problem part categories. The same statistical procedure is applied to all tests.

## Assumptions

The assumptions necessary for this study are primarily statistical in nature. One assumption that applies throughout this study is that the parts used for sample data are representative of the entire population of DLA managed consumable items in terms of the categories used for analysis. In addition, there are a number of assumptions related to the statistical analysis that are necessary for two-sample hypothesis testing. These are discussed with the test heuristic in Chapter III.

Additionally, the methodology for computing the average system lead times as discussed in Chapter III is assumed to approximate the actual system lead times in SAMMS for specific purchases at the time of the acquisition.

## Limitations of the Research

The scope of this study is restricted to DLA managed consumable items for the F100-110 and F100-129 engines. Additionally, as the Defense Supply Center (DSC) - Columbus and DSC - Richmond manage all of the items in the sample data, any findings can not be generalized beyond these centers.

There are two specific limitations on the scope of this study. The first relates to the boundaries of the data and is driven by practicality. Although the number of parts in the sample data is relatively low compared to the vastness of the DoD inventory, the parts selected resulted in over a ten-fold increase in number of data points to be analyzed.

The second limitation is a function of the methodology employed in this study. That is, for analysis purposes the data are aggregated to determine if findings can be generalized to a category of parts. As a result, none of the findings can be applied to individual parts used in the sample data.

## Organization of Research

Chapter II begins with a brief synopsis of the supply terminology found in this study. This is followed with a discussion of the theory behind EOQ and the variations that DLA applies to the EOQ model in determining consumable requirements. With this foundation laid, a review of recent literature relating to DoD inventory management establishes the need for this research. The literature review will aid in formulating answers to the management questions as well as research questions one and two, while the statistical analysis will answer research questions three through eight.

Chapter III explains the methodology employed to analyze lead time variability. It begins with a review of the data collection process, including delineation of sample categories and definitions of the variables used for categorization and statistical analysis. The core of the chapter is the heuristic for conducting the two sample hypothesis tests.

Chapter IV is the analysis of the results of the hypothesis tests conducted for this research. Additionally, observations based on means and standard deviations of the categories are discussed. A summary is found in Chapter V along with general inferences based on the analysis and recommendations for areas of future research.

# II. Literature Review

## Introduction

Although the focus of this study is an exploration of the variability experienced in lead times for DLA assets and the impact of that variability on requirement computations, it is necessary for this chapter to begin with an overview of inventory management within the Department of Defense (DoD). This widening of scope to the DoD is necessary as the Defense Logistics Agency (DLA) manages the majority of DoD consumable items (Hanks, 1990: 1-3). The percentage of items managed by DLA has further increased in recent years due to the transfer of many consumable items to DLA. As a result, much of the literature concerning DoD consumable inventory can be generalized to DLA. Following this discussion, the relevant methodology employed by DLA in inventory management is explained in concert with the role of lead time in DLA requirement computations. Finally, a justification for further analysis of lead time variability is presented through numerous General Accounting Office (GAO) reports on DoD inventory management and by directly linking consumable items to the readiness of Air Force weapon systems.

Most discussions of DoD inventory management is tend to overflow with rather unique terminology. Before reviewing the pertinent literature on this subject, an explanation of key terms found within this research effort is provided.

Explanation of Relevant Terms

This section provides definitions or brief explanations of supply terms found in the order in which they appear in this study. The first three terms are technical codes for classifying assets. A complete definition of these codes, as found in DLA Manual 4140.2, Volume II, Part 1, Appendix G-2, can be found in Appendix A. Although these terms may be commonplace to those in the inventory career field, they are provided here for the purpose of easy reference.

Item Category Code (ICC). A code assigned to an item to indicate whether it is to be managed as a replenishment demand type or a numeric stockage objective.

Supply Status Codes (SSC). A series of codes used to reflect, in materiel management records and in the Federal Cataloging System, decisions made by inventory managers as to the normal means-of-supply stockage/nonstockage status of each assigned NSN.

Standardization Status Code (STDZ, SSC). Item Standardization Status Codes denote that an item is authorized for purchase or not authorized for purchase, and where and why the decision was made.

Direct Vendor Delivery (DVD). DVD is an improvement initiative whereby DLA utilizes long-term contracts and electronic data interfaces to permit suppliers to deliver directly to the end user (GAO, 1997b:7). In a statement before the Senate Subcommittee on Readiness and Management Support on 17 March 1999, Lieutenant General Henry Glisson reported that one of DLA's goals in corporate contracting was to use DVD. Specifically, he stated, "Where feasible, long-term DVD contracts are issued for the vendor's entire catalog of applicable parts and use their commercial distribution system or network..." (Glisson, 1999).

Prime Vendor. Prime vendor is a term for a single vendor that stores and distributes assets directly to customers. The relationship is marked by a close partnership between the supplier and customer and the use of electronic ordering systems (GAO, 1997b:3).

Integrated Suppliers. Integrated suppliers essentially adopt total responsibility for a customer's inventory management function. The system requires an on-site representative of the supplier to order and replenish assets. The assets remain in the supplier's warehouse, and are delivered on a just-in-time concept (GAO, 1997b:4).

Lead Times. Total acquisition lead time (TALT), also referred to as procurement lead time, is comprised of administrative lead time (ALT) and production lead time (PLT). Their definitions, as found in Appendix G-2 of DLA Manual 4140.2, are as follows:

> Administrative Lead Time. A three digit numeric field used in the [Supply Control File] SCF to express the time interval between the date of the supply control information indicating a need for purchase and the award of an order or contract to a vendor. This time interval includes both the time required to review the SCF and the time required to award the order or contract. This time interval, when used for purchase purposes, is limited to the time interval between citation of the PR and the award date.
>
> Procurement Lead Time. The time interval between the award of a contract and the availability of the initial significant delivery of materiel.

To elaborate, procurement lead time ends with receipt of the first largest contract line item number (CLIN). CLINs are employed to identify specific shipments in contracts with split quantities shipped to multiple locations. The terminology "first largest" refers to cases where there are two or more CLINs, for equal quantities, that are also the largest quantity in the contract (Shields, 1999b).

Mission Capable (MICAP). MICAP is an Air Force term used to reflect the priority of an item in terms of the repair of mission essential equipment. MICAPs occur when a high priority, or MICAP reportable, weapon system or end item becomes not mission capable (NMC) or partially mission capable (PMC). MICAP also refers to the procedures and system used to obtain the assets needed to maintain mission capability (AFMAN 23-110, 1999: Ch 17).

## Department of Defense Consumable Inventory Management

DLA is at the top of a multi-echelon structure in terms of DoD consumable item management. Demand for consumable items at DLA originate at the retail or base level as a result of the failure of a reparable or consumable end item, or a consumable component of a reparable end item. As shown in Figure 1, demands for reparable end items are forwarded to Air Logistics Centers, who, in turn, may place a demand on DLA for a consumable component of that end item. Additionally, demands for consumable parts are placed on DLA from individual bases and other services. These demands are compiled by DLA, and become DLA's total demand.

Economic Order Quantity (EOQ). At each echelon, a variation of Wilson's Economic Order Quantity (EOQ) is the basic inventory model used to determine order quantities. Before discussing the DLA adaptations relevant to this study, a brief overview of EOQ is necessary.

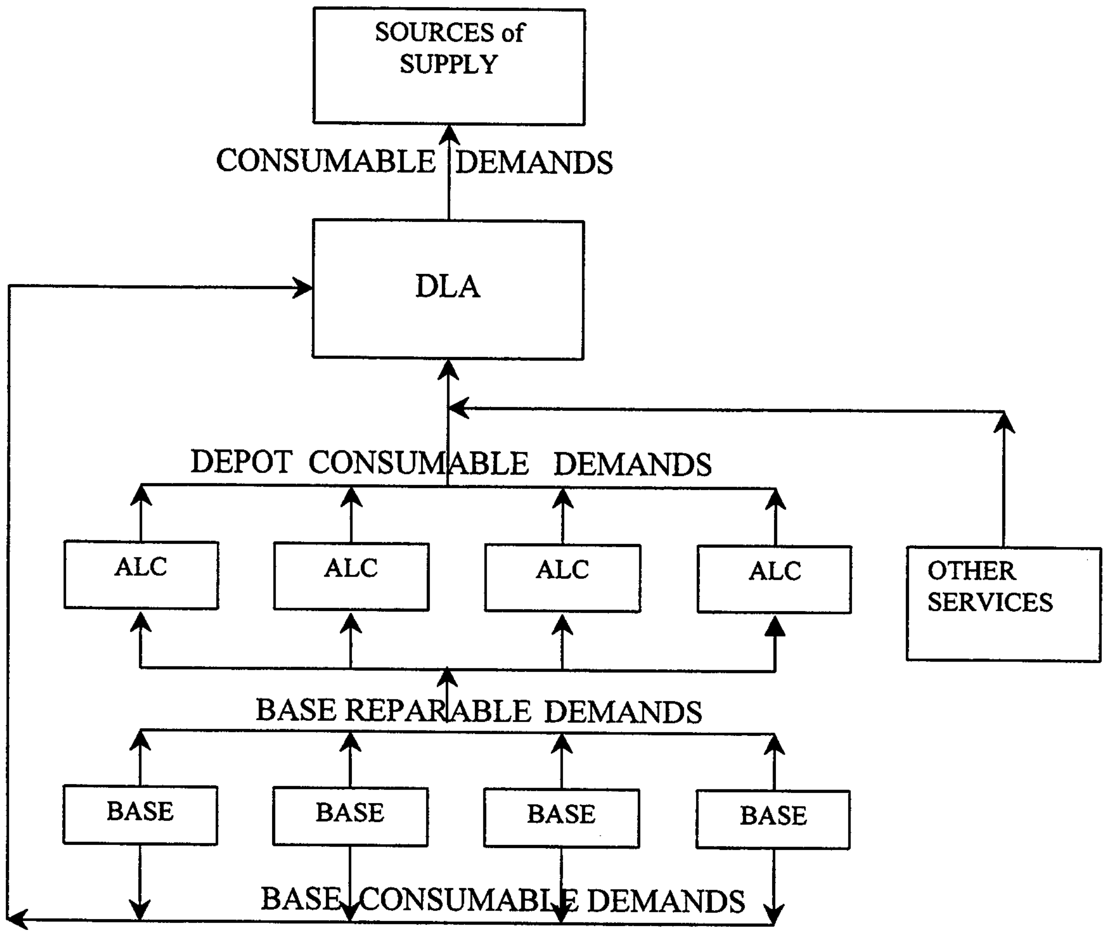



Figure 1. Demand Stream for Consumable Items
(Adapted from Gaudette, 1998:3)

In its purest form, the initial order quantity (Q) sets the inventory level. EOQ assumes units are withdrawn at a constant demand rate. Knowing this demand rate, a reorder point is established based on the "known" lead-time or the number of days required to receive the order of Q units. When inventory reaches the reorder point, an order is placed for Q units, and as the remaining units are withdrawn the order for Q units is produced and shipped. EOQ also assumes the entire quantity of new units is received at one time. Theoretically, the order is received just as the inventory level reaches zero (Tersine, 1994: 92). Figure 2 depicts this process in the classical saw tooth diagram associated with EOQ.

Although EOQ is dependent on a total of eight assumptions, it is generally considered a "robust" model, or one that is relatively insensitive to changes in the model's parameters. In other words, even if the assumptions are faulty, the model will still produce output reasonably close to the optimal solution (Tersine, 1994: 102).

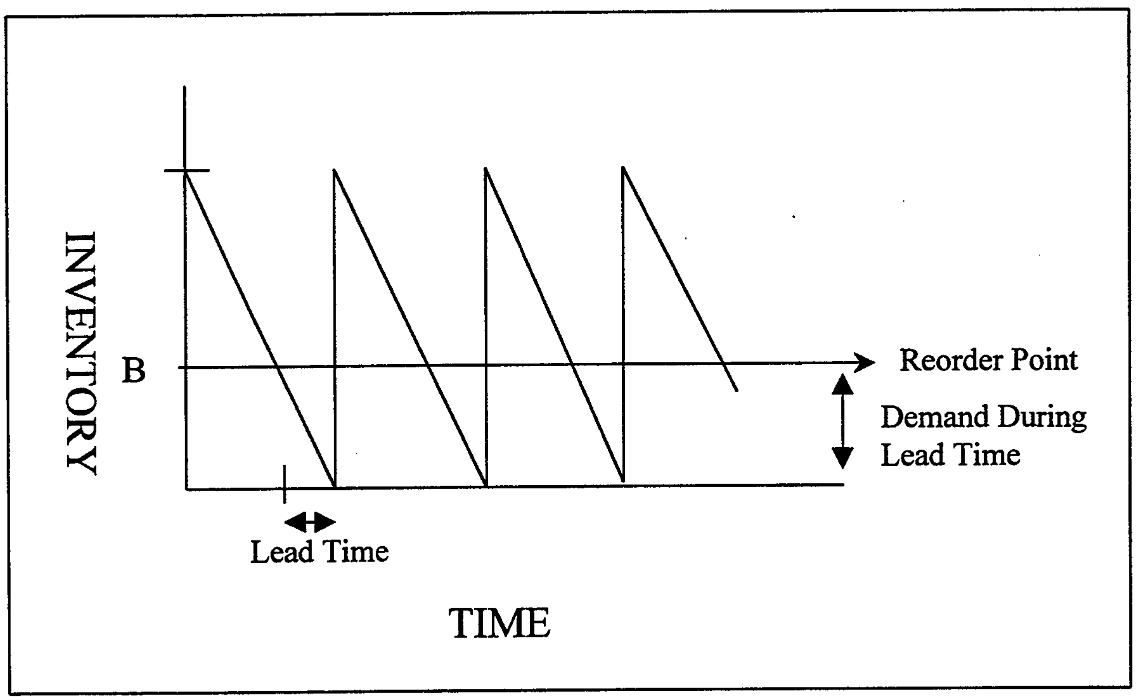



Figure 2. Classical EOQ Model (Adapted from Tersine, 1994:93)

DLA Variations of EOQ. The two variations to the fundamental EOQ model relevant to this study concern the safety level and reorder point calculations. Lead time is an independent variable in each, so variability in lead time can result in inaccurate calculations.

Safety Levels. A primary purpose of inventory, in general, is to serve as a buffer against variations in demand or lead time. Specifically, safety stock is a classification of inventory used to account for short-term variations in these factors (Lambert and Stock, 1993: 399-404). Figure 3 illustrates the role of safety stock in the classical EOQ model. In this hypothetical case, an unexpected increase in demand or lead time results in the EOQ being insufficient to meet the requirements of the third cycle.

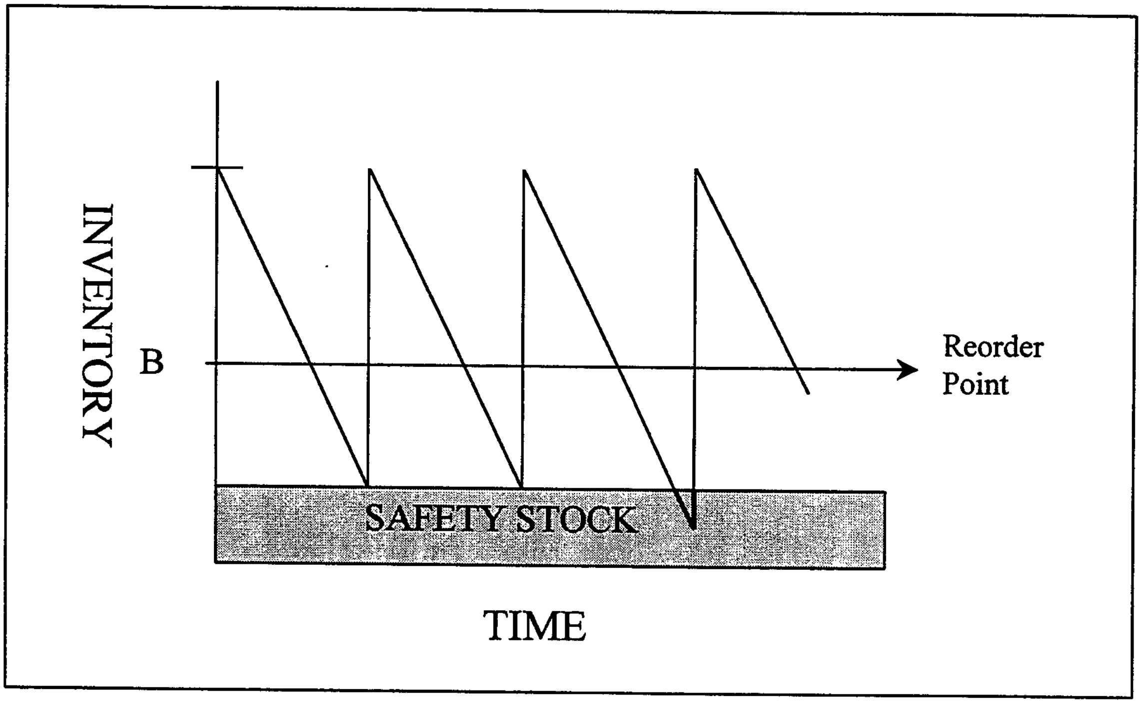



Figure 3. Classical Inventory Model with Safety Stock
(Adapted from Tersine, 1994: 539)

DLA uses two types of safety stock, fixed safety levels (FSL) and variable safety levels (VSL). Fixed safety levels are mainly applied to non-stocked items, items in the DLA system less than two years, items with an item category code 1 or P, and items with a supply status code of 6. The assignment of an FSL to any other established item, or one in the DLA system over two years, requires the approval DLA headquarters (DLAM 4140.2, 1965: Ch 56).

Variable Safety Levels are the common approach for most items. VSLs attempt to minimize both the number of backorders and the time a requisition is backordered. This is known as time-weighted requisitions short. In theory, VSL customizes the safety level to the particular traits of each asset, "thereby making maximum use of available funds by neither overinvesting nor underinvesting in safety stock" (DLAM 4140.2). VSLs allow for the possibility of a greater number of backordered requisitions that are in backorder status for a shorter period of time. Some of the factors that are considered in computing VSLs are demand, variance of demand, lead time, unit price, number of requisitions, and average requisition size.

The entire process for calculating both types of safety levels is complex to say the least. Appendix D-187 of DLA Manual 4140.2, Safety Level Computations, contains the 21 page flow-chart describing this methodology. As this study pertains to DLA lead time variability, this section highlights the primary areas where lead time impacts the safety level calculation.

The formula for computing lead time demand for replenishment of item *i* is shown below as given in section 1a, sub-section 9a of Appendix D-187.

$$LTD_i = \frac{QFD_i}{91} xPLT_i \text{, where}$$

$QFD_i$ = Quarterly Forecasted Demand of unit *i*.

$PLT_i$ = Procurement Lead Time

Dividing the QFD by 91 creates a daily demand rate. The procurement lead time, or TALT, determines the number of expected demands during TALT. This demonstrates the basic relationship of lead time to requirements determination. That is, long lead times result in a larger lead time demand, which, in turn, results in a higher safety level. If lead times are artificially long, the result is unnecessary investment in safety levels. Similarly, artificially short lead times result in too little safety stock, the consequence of which may be a stockout condition.

The next step is the computation the mean absolute deviation of demand during TALT (MADLT) and a ratio, $R1_i$. The equation, as given in Appendix D-187, is:

$$R1_i = \frac{2.560xS_i xQ_i xC_i xB}{Z_i x(MADLT_i)}, \text{ where}$$

$S_i$ = Average requisition size

$Q_i$ = EOQ

$C_i$ = unit cost

B = backorder rate

$Z_i$ = Safety Level Essentiality Factor

Again, lead time plays a critical role. In this case, a lead time that experiences a high degree of variability causes a lower $R1_i$. This is critical because the ratio $R1_i$ determines the VSL in the following manner.

If $R1_i < 0.0144$, then $VSL_i = 3x1.25xMADLT_i$

If $R1_i >= 0.0144$, then $VSL_i = K_i xMADLT_i$, where $K_i$ is a service level factor obtained from Safety Level Table III (DLAM 4140.2, 1965:Appendix D-187).

This excerpt demonstrates the importance of accuracy and variability in lead times used in DoD safety level computations. This translates directly to inventory levels through the computation of reorder points.

Reorder Point. One of the assumptions EOQ is founded upon is a constant and known lead-time that is used to compute a reorder point. In the classical model, the reorder point (B) is computed by multiplying the annual demand (R) for the item by the lead time (L), and the product is divided by the length of time corresponding to the lead time expression. For example, for lead times expressed in days the equation reads, B=(R*L)/365. When on hand assets plus on-order assets minus backordered assets equals the reorder point quantity, another is placed for Q units (Tersine, 1994:94-95). If the expected lead time is artificially long, the reorder point is set higher than necessary to account for the demands during the actual lead time, which, in turn, results in unnecessary inventory investment. On the other hand, if the expected lead time is shorter than the actual lead time, a materiel shortage may result at some point prior to receipt of the order quantity.

DLA determines the reorder point for replenishment demand items by summing five factors. The five factors are the System Safety Level Quantity (SSLQ), special levels to support the Atlantic and Pacific fleets, Other War Reserve Materiel quantities, special levels established for items assigned a Supply Status Code 6 with Standardization Status Code 3 or E, and "all requirements through a time period equal to the PLT [procurement lead time] (ALT plus PLT)" (DLAM 4140.2, 1965: Ch 32). The effect of erroneous lead time data on SSLQ was demonstrated in the previous section. For the purposes of this study, the only other factor that is reliant on accurate lead time data is the determination of demand during lead time. In inventory parlance, this is the pipeline quantity. As in the classical EOQ model, lead times that are actually longer than anticipated result in insufficient quantities to meet demand during lead time, and shorter actual lead times result in more assets than are needed to meet said demand.

Therefore, lead time affects two of the five determinants of reorders point, safety level and pipeline quantity. Inaccurate data may result in reorder points either above or below the optimal level. Artificially high reorder points result in the inefficient use of inventory funds through the premature purchase of assets, while artificially low reorder points result in lower inventory levels, that may effect weapon system readiness.

DLA Lead Time Methodology. The procedure for calculating both ALT and PLT is remarkably simple. Both are automatically computed on a weekly basis using only representative procurement processes. DVD lead times are not considered as representative procurements. The automatic update to ALT and PLT is only averted when the rate of change between the new lead time and previous lead time exceeds a parameter normally set at ± 50 percent. If the new computed lead time exceeds this tolerance, a management notice is generated for review (DLAM 4140.2, 1965: Ch 32).

Administrative Lead Time. ALT computations are generated by the Contracting Subsystem by an Award Leadtime Transaction. The interval is the time between the recommended buy date and award date. A 30-day minimum is assigned to all stock replenishment items unless an item is procured under a "requirements type contract". In this case, ALT equals the interval between the recommended buy date and "the date a call is placed against a contract" (DLAM 4140.2, 1965: Ch 32).

New ALTs are computed using a weighted average of the past two contracting actions. The most common calculation is the sum of 67 percent of the "latest actual" ALT and 33 percent of the previous ALT. Any deviation from these weights requires DLA-OSR approval (DLAM 4140.2, 1965: Ch 32).

Production Lead Time. PLT computations begin with the Award Leadtime Transaction, and the estimated contract delivery date is used for the end date. This is automatically updated when a receipt transaction is processed for 51 percent of the CLIN or for a specific quantity assigned to that item. The new PLT is computed as described above for ALT.

In terms of the management questions presented in Chapter I, expected lead times shorter than actual lead times may lead to stockout conditions, which could be a contributing factor in the determination of an item as a problem part. Conversely, longer expected lead times result in reorder points set higher than necessary, which may contribute to the accumulation of excess materiel.

## Performance of EOQ in the Department of Defense

There are two primary reasons to scrutinize the performance of EOQ in the DoD. First, in the past decade the Government Accounting Office (GAO) has issued a plethora of reports criticizing defense inventory management. The second compelling reason to investigate consumable item lead time variability is the potential to increase weapon system readiness.

GAO Criticisms of Defense Inventory Management. In the late 1980's, by the direction of the House of Representatives Committee on Government Reform and Oversight and the Senate Committee on Governmental Affairs, the GAO began examining DoD stockage policies. Due to the subject's budgetary implications, it was soon raised to the GAO's "High Risk Series" (Gaudette, 1998:19). In a 1992 report, the GAO stated that one-half of the $77.5 billion DoD inventory was excess. Furthermore, the GAO recommended that the DoD change its standard practices, increase the use of commercial practices, revise its performance measures, and integrate improved computer technology to better control inventory (GAO, 1995:9).

Defense inventory management has remained on GAO's High-Risk Series throughout the decade, with GAO reports continuing to give emphasis to the use of commercial practices. In 1990 the GAO identified an increase in DoD lead time requirements during the previous decade of $13 billion. It directed the services and DLA to initiate measures designed to reduce lead times by 25 percent. This goal was based on a 1986 DoD memorandum, which cited a DoD initiated study by the Logistics Management Institute, that claimed a 25 percent decrease was feasible by employing commercial practices. Moreover, the memorandum underscored the importance of lead time by stating that a one day reduction equated to a $10 million reduction in future purchases. As a result of this report, DoD directed the services and DLA to undertake lead time reduction initiatives which included the establishment of total acquisition lead time (TALT) goals, the reduction of production lead time in contract negotiations, and the expansion of multiyear contracts and indefinite quantity contracts (GAO, 1994:2-3).

In a 1995 follow-up report, GAO found limited progress across DoD in TALT. Table 1 shows the change in average lead time, in days, for each service and DLA from 1990 to 1994. Among the specific findings relating to the sources of supply, the report found that DLA did not implement the first two of DoD's 1990 lead time reduction initiatives. As of October 1994, although DLA proposed a 30 percent reduction in lead time, this policy had yet to be implemented. GAO further recommended a periodic validation of recorded lead times based on a review of two Air Force Air Logistics Centers and the U.S. Army Aviation and Troop Command. As a result of the latter's recent production lead time (PLT) review, changes were made to 75 percent of the assets reviewed, and 94 percent of those changes were decreases. "The command estimated net annual procurement savings of $88 million from using updated lead times to compute buy requirements" (GAO, 1994:4).

A 1996 GAO report focusing on requirements determination cited inaccuracies in the data in Air Force and Navy automated requirements computation systems that contributed to a combined $132 million more than required for aircraft engine spares. The sample included the Air Force's F-100-100 engine and the Navy's F-404 engine. Among other data elements specifically cited as "unsupported or incorrect" were lead times (GAO, 1996:2).

Table 1. Changes in Average Lead Time Days between 1990 and 1994 (GAO, 1994:2)

| COMPONENT | 1990 | 1994 | DAYS | PERCENT CHANGE |
|---|---|---|---|---|
| NAVY | 715 | 522 | 193 | 27.0 |
| ARMY | 711 | 690 | 21 | 3.0 |
| AIR FORCE | 614 | 620 | (6) | (1.0) |
| DLA | 309 | 293 | 16 | 5.0 |
| DoD AVERAGE | 587 | 531 | 56 | 9.0 |

GAO's vigilant monitoring of defense inventory continued in earnest in 1997. In a follow-up to the 1995 High-Risk Series report, GAO listed 12 findings citing DoD's limited or non-existent progress in changing the management culture. The report credited DoD for the reduction in secondary inventory to $69.6 billion. The GAO defines secondary inventory as spare and repair parts, clothing, medical supplies, and other support items (GAO, 1997d:1). For all intensive purposes, this includes all inventories except equipment items. Of the $69.6 billion total inventory, $19.2 billion was consumable items (GAO, 1997a:4). The report still claimed, however, that half of the total was not needed for war reserve materiel or to support current operations (GAO, 1997d:1). The GAO refers to this as "unneeded" inventory. A July 1997 report focused on consumable items in particular. The report criticized DLA management of consumable inventory totaling approximately four million items valued at $11.1 billion (GAO, 1997b: 4). GAO recommendations concentrated on the use commercial best practices, including moving away from direct vendor delivery (DVD) contracts and towards increased use of prime vendors or integrated suppliers. GAO also found that delivery of items under DVD contracts averaged twice as long as delivery of items stocked in DLA supply points (GAO, 1997b:7).

Continuing with the review of GAO reports, another 1997 report claimed that unneeded inventory totaled $41.2 billion. According to this report, of the $26.6 billion of unneeded with demand data, $1.1 billion would account for at least 100 years of supply (GAO, 1997c:3). Table 2 provides a summary of the unneeded inventory as found in this report. In 1998, GAO mined further into the consumable inventory and reported on DoD's hardware inventory. This category included items such as bearings, valves, and bolts, which totaled $5.7 billion. This report was particularly critical of DLA as the manager of the majority of consumable items, of which 97 percent were classified as hardware items (GAO, 1998:2). The report again criticized DLA for excess inventory levels stemming from inefficient management and failure to institute commercial best practices on a wide-scale basis.

The criticisms of DoD inventory management, and of DLA in particular can be summarized into two primary areas. First, the organizational culture within the inventory management arena of DoD remains resistant to a reengineered logistics system. Although some progress is evident, GAO continues to emphasize the use of best practices as a means of affecting the necessary change. Second, excess inventory remains a critical problem. In an era of stagnant or declining defense budgets and increasing concern over readiness of weapon systems, excess inventory is a critical target as money saved by not buying unneeded items can be redirected to more critical repair assets.

Table 2. Unneeded Secondary Inventory by DoD Component
(GAO, 1997c:4)

| | INVENTORY ANALYZED (value in billions) | | UNNEEDED INVENTORY (value in billions) | |
|---|---|---|---|---|
| COMPONENT | ITEMS | VALUE | ITEMS | VALUE |
| ARMY | 117,610 | $9.0 | 63,362 | $4.8 |
| NAVY | 334,337 | 17.6 | 172,325 | 11.2 |
| AIR FORCE | 289,438 | 31.1 | 140,220 | 19.1 |
| DLA | 2,515,231 | 9.3 | 1,548,545 | 6.1 |
| TOTAL | 3,256,616 | $67.0 | 1,924,452 | $41.2 |

Consumable Items and Air Force Readiness

DLA manages over 4 million items, and has annual sales to the armed services nearing $13 billion (Glisson). Obviously, not all of these items are directly related to a weapon system. In order to identify those that are related, DLA instituted a Weapon System Support Program (WSSP) in 1981, which allows the services to identify those items that are components to critical end-items. As EOQ is the model DLA uses to manage its inventory, this large volume of business suggests the importance of EOQ to the readiness of those critical end-items.

MICAP Incidents. One general method of gauging the importance of consumables to readiness is via Air Force MICAP incidents. As stated earlier, a MICAP incident occurs because a weapon system, or other end item coded with a MICAP reportable designator, is either NMC or PMC due to lack of an asset on hand to plug the "hole" caused by the failure of a component. The following data summarize three reports generated by the Air Force Materiel Command Readiness Assessment Module (RAM). The complete reports are provided in Appendix B. RAM pulls data directly from the WSMIS database. In fiscal year (FY) 1998, there were 457,319 new MICAP incidents Air Force wide, which totaled 140,559,191 hours. Of these, 132,856 incidents, totaling 43,613,214 MICAP hours, could be traced to DLA as the source of supply (Air Force Materiel Command). Thus, DLA assets accounted for 29.1 percent of Air Force MICAP incidents and 31.0 percent of MICAP hours in FY98. Furthermore, 199,294, or 43.6 percent, of all Air Force MICAPs were consumable items. Put another way, two-thirds of all consumable MICAPs in FY98 were DLA managed. In terms of MICAP hours, consumable items accounted for 40 percent of the total Air Force MICAP hours, and DLA managed items accounted for 77,6 percent of the total consumable hours. This data is provided to demonstrate that DLA consumable items remain a significant portion of both MICAP incidents and MICAP hours. However, further quantification of the potential impact of consumable items on readiness has rarely been attempted.

Aircraft Availability. A 1990 report by Christopher Hanks of the Logistics Management Institute (LMI) directly tied consumable items to weapon system readiness by adapting a fundamental concept of the aircraft availability model to consumables. Hanks focused on base-level unit expected backorders (EBOs) because the lack of a desired part at the base level is directly related to the NMC status of a weapon system (1-5). The backorders are later tied to aircraft availability, but first, an interim step relating high priority due outs to mission capable rates is needed.

Hanks was able to focus on weapon systems through limiting his study to parts in the WSSP and those with priority 1 and 2 "due-outs" under the DoD Uniform Materiel Movement and Issue Priority System guidelines. Priority 1 is reserved for units in combat, while priority 2 is used for other essential requisitions such as MICAPs, items awaiting parts in repair shops, and readiness spares packages. A "due-out," in Air Force terminology, simply represents an asset that was not available at the time it was requested. In 1989, there were approximately 200,000 high priority due outs for DLA and Air Force Logistics Command assets. By multiplying the sum of the aggregated NMC and PMC rates for FY 89 times the fleet size of 9100, he was able to generalize that the 200,000 priority 1 and 2 requisitions corresponded to 1300 aircraft either NMC or PMC. Hanks acknowledged that all priority 2 requisitions are not necessarily causing a MICAP condition, nor are they all related to aircraft (1-12).

The connection, according to Hanks, is that this procedure can be used to predict, "within a reasonable range," the change in aircraft in NMC and PMC status based on changes in the number of high priority requisitions. For example, since DLA items accounted for 25-33 percent of all high priority due-outs, a 10 percent increase in DLA high priority due-outs for DLA managed items would result in approximately 32-43 (2.5-3.3 percent of 1300) additional aircraft in NMC or PMC status (1-13).

Finally, Hanks developed a model to equate changes in wholesale safety levels to aircraft availability. A wholesale inventory model approximating the SAMMS methodology for over 170,000 assets was designed to predict the percentage change in EBOs at the wholesale level based on changes in safety levels. The model showed that an aggregate 20 percent reduction in safety levels equated to a 25 percent increase in wholesale EBOs (2-16). He used the model to develop a baseline that "every $10 million reduction in wholesale safety levels at DLA for demand-based WSSP/USAF items has the potential to ground or render PMC 6 to 8 aircraft..." (2-3).

It must be acknowledged that DLA's influence on readiness is to a large degree constrained by retail level inventory decisions. Although the RAM output referenced above does not provide MICAP cause codes, only one of the five most common reasons for a MICAP incident can be tied to wholesale supply (Hanks, 1993:3-4).

## Summary

Chapter II provided a foundation for this research through a review of the Wilson EOQ model used as the basis for DoD consumable inventory management, and on the DLA variations to the model. Particular attention was paid to the components of DLA requirements determination where lead time impacts inventory levels. Finally, a justification for analysis of lead time variability was presented through numerous General Accounting Office (GAO) reports on DoD inventory management and by demonstrating the impact of consumable items on the readiness of Air Force weapon systems.

# III. Methodology

## Introduction

The purpose of this chapter is to explain the procedures used to answer investigative questions three through eight posed in Chapter I, including the data collection process and a roadmap for the statistical analysis. The ultimate goal of these investigative questions is to identify if significant differences exist in administration lead time (ALT) and production lead time (PLT) for problem parts versus non-problem parts for the F110-100 and F100-129 engines, and determine the degree of variability experienced in deviations from the system lead times. To accomplish these goals, various categories of consumable items are analyzed in an effort to uncover a possible source of any significant deviation from the system lead times utilized by the Defense Logistics Agency (DLA). The existence of a significant difference may lend weight to the need to devote further study to the issue of lead times in DLA requirements computations.

## General Approach

In general, this study is directed at examining the acquisition lead times used by DLA in consumable item management to determine if sufficient variability or uncertainty exists to warrant a reevaluation of this methodology at the wholesale level of supply in the Air Force. To that end, the remainder of this study concentrates on the two components of total acquisition lead time (TALT), administrative lead time (ALT) and production lead time (PLT).

As individual items are generally assigned unique ALTs and PLTs, the data must be standardized before it is analyzed. This is accomplished by subtracting the forecasted lead time as found in the Standard Automated Materiel Management System (SAMMS) from the observed lead time, and these deviations then become the sample of interest. The next step is to conduct statistical analyses with the purpose of drawing inferences that will aid in answering management and research questions stated in Chapter 1.

## Data Collection

In order to answer the investigative questions, lead time data was collected for 14 Air Combat Command (ACC) problem items and 23 bench stock items with a serviceable balance. The data was validated and examined for outliers using histograms and box and whiskers plots. The remainder of this chapter explains the data collection and validation process as well as the statistical tests performed.

First, a list of problem parts was sought from the ACC Regional Supply Squadron (RSS). The ACCRSS was formed to provide centralized supply support to all ACC bases, and global supply, fuels accounting, and computer support to warfighting Commander-in-Chiefs (ACCRSS, 1999). One of the many supply functions that were centralized was the management of MICAP items. As a result, the ACCRSS now manages all MICAPs for all ACC bases. Moreover, the regionalized MICAP section has visibility over all ACC MICAPs and maintains daily contact with item managers, hence, it is the ideal source for obtaining this portion of the data. The samples used to assess the lead time assumptions come from the population of XB3 coded parts for the F110-100 and F110-129 engines. ACC was chosen as the initial source for acquiring the two sample sets of data, as a substantial proportion of the F-16 aircraft that use these engines are ACC assets.

Second, a set of non-problem items was selected as a control group. The source selected for this data was the Shaw Air Force Base Bench Stock account. By definition, a Bench Stock is a group of consumable assets, used with such frequency by maintenance activities that they are issued to users before they are needed and forward located at the user's facility (AFMAN 23-110, 1999:25-1). Additionally, the 20th Fighter Wing at Shaw is the largest F-16 combat wing in the Air Force. These two factors made its Bench Stock a feasible starting point for non-problem item data collection.

<u>Problem Parts</u>. The first sample of interest is naturally the focus of the study, and is that subset of the population that is considered problem parts. For this study, problem parts are items determined to be the fleet problem/pacing items by the weapon system spares manager, based on MICAP hours/incidents, known or anticipated spares shortfalls, and modifications (Regional Supply Squadron, 1999a). As of 22 April 1999, 15 of the top 30 F100-110 engine MICAP drivers for ACC were consumable items managed by DLA (Regional Supply Squadron, 1999b).

<u>Bench Stock</u>. The items in this sample were selected from the Shaw Air Force Base jet engine shop's bench stock. A total of 30 bench stock National Stock Numbers (NSNs) were provided by the 20th Supply Squadron Customer Service element. Of

these, three were eliminated as they were also on the problem parts list provided by the ACCRSS.

## Analysis of Data

The 42 NSNs were forwarded to Air Force Material Command's Requirements Interface Process Improvement Team to validate the source of supply. A search of an AFMC database revealed that all 42 NSNs were DLA managed items. The NSNs were then forwarded to Business Analysis Unit's Corporate Performance Team at the Defense Supply Center Columbus (DSCC). The data returned was the end of quarter lead time forecast for the last eight quarters, and the end of year forecast through 1989 for 14 of the 15 problem parts, and 24 of the 27 bench stock items. A total of 903 CLINs, or observations, were contained in the raw data. DSCC also identified DSC Richmond and DSC Philadelphia as the managers of the 42 items. Appendix C lists each NSN for which data was available along with the associated nomenclature from the Standard Base Supply System.

The data provided by DSCC were the historical records in the DLA Integrated Data Base system dating back to 1989. As such, it also indicated whether the contract was direct vendor delivery (DVD) or stock replenishment, which enabled this study to further categorize the data and complete additional hypothesis tests.

## Data Validation

Several problems were encountered with the raw data. Some of these were the result of the nature of the procurement process and varying information systems used among the different branches of service, retail supply organizations, and DLA.

Receipt Dates. Since receipt dates determine the end of PLT, it is important to understand the methodology used to track inventory transactions in the DLA Integrated Data Base. This methodology affects the PLT of both types of purchase discussed below.

Stock Replenishment. Split quantity stock replenishment orders occur when contracts are let for multiple quantities or partial shipments are received. The receipt date in the database in this instance is the most recent, or longest, delivery date. For example, a vendor can ship 90 items one week and the remaining 10 the following week. The DLA contract file will overlay the date received with the most current date. Hence, the file contains the longer lead time (Shields, 1999a)

Direct Vendor Deliveries (DVD). A similar issue exists in terms of parts contracted for DVD. The receipt date for items procured for direct vendor delivery to the end user is dependent upon the end user's input into their applicable management system. This date can be suspect because in many cases there are multiple deliveries set for a single contracting action. Thus, the possibility exists for a lag in the input and/or a lag in any services management system updating the DLA files. DVD encompasses those parts shipped directly from the manufacturer or retailer to the end user. DLA must rely on the receipt date input by the receiving organization as its receipt date. Given the quantity and variety of customers receiving DVD items, it is this author's opinion that individual verification by DLA of these dates is infeasible and offers little value. For the purposes of this research effort, the dates were accepted as accurate reflections of receipt dates.

Incomplete Records. Another problem encountered was that the records of a significant portion of the NSNs were missing programmed lead times. As these represented a significant portion of the total observations, they were identified to DSCC and further research was necessary to obtain the data. It was determined that the cause was the transfer of items from closing facilities due to Base Realignment and Closing, and DSCC was able to provide the missing data.

Multiple Contracting Lines. Some of the observations in the database were the result of multiple CLINs. This is the result of partial quantities being ordered for the same recommended buy under a single contract. Thus, when the contract is awarded, multiple observations occur with the same ALT. Similarly, the partial quantities were frequently received on the same date, resulting in multiple PLT observations. These duplicate observations weighted the data, and to avoid biasing the results, only one observation per CLIN was included in the analysis.

Open Contracting Actions. The final problem was that in a number of cases contracting actions were not complete, and no receipt date was available. Thus, an actual PLT could not be calculated. This resulted in different sample sizes for the statistical analysis.

After validating the raw data, a total of 473 observations remained to be analyzed. Of these, 185 were for problem parts, and 288 were for non-problem parts. In the type of purchase category, 202 were DVD contracts, and 271 were for stock replenishment. However, for the reasons explained above, not all observations had usable values for both

ALT and PLT. Appendix D contains all 473 observations with which the analysis was conducted.

## Variables Used in Analysis

The variables below were used for both categorization and data analysis. Deriving system lead times from the end of quarter and end of year values required some manipulation. As these values were the actual forecast for the subsequent period, they were considered as the system lead time for the first contracting action in the subsequent period. For all other observations in a period, the system lead time utilized for analysis was an average of the forecast for the period in which the observation occurred and the forecast for the next period. Actual lead times were computed by taking the difference between the Julian dates provided in the data file. The recommended buy date and contract award dates were used for ALT, and contract award date and receipt dates were used for PLT.

System ALT. The system ALT refers to the administrative lead time as contained in the SAMMS database.

ALT (actual). ALT (actual) is the actual number of days between the recommended buy date and contract award for any particular contracting action.

System PLT. The system PLT is the production lead time as contained in the SAMMS database.

PLT (actual). PLT (actual) is the actual number of days between contract award and receipt of a significant quantity (51 percent) of the first largest order for stock buys, or, for direct vendor delivery, the date input into the system by the receiving unit.

Reason for purchase. This variable represents whether a particular purchase was undertaken for DLA stock replenishment or DVD.

In the cases where different actual ALTs and PLTs were observed for multiple CLIN DVD contracts, each distinct value was accepted as a separate observation. For different lead times in multiple CLIN stock replenishment contracts, the lead time corresponding to 51 percent of the first largest CLIN was used in this analysis.

## Preliminary Evaluation of Data

Before delving into a discussion of the data, a brief review of the organization of the sample data is warranted. This is followed by a description of the statistic to be tested under the two-sample t-test heuristic.

Organization of Data. Each of the six cases compares the ALT and PLT of two categories of items. Cases 1 and 2 examine the difference in ALT and PLT between problem parts and non-problem and DVD and stock replenishment, respectively. Cases 3 and 4 examine the problem part and non-problem part columns, respectively, on the basis of type of purchase. Finally, Cases 5 and 6 compare lead times of problem parts purchased for stock replenishment versus non-problem parts purchased for stock replenishment, and problem parts purchased for DVD and non-problem parts purchased for DVD, respectively.

Derivation of Test Statistic. Although the data for each NSN in this study is a chronological history of contracting actions, it is not suspect to auto-correlation. This is due to the aggregate analysis statistical method described below. In each of the six cases, the system ALT and PLT for every item in both categories are subtracted from the observed values ($x_i$) for every contracting action. This difference ($D_i$) is totaled across each category and the mean ($\overline{D}_i$) is compared to the mean of the differences for the corresponding category.

Nature of Data. In order to make an initial assessment of the data to be analyzed, a histogram and box and whiskers chart of the calculated differences for each category are created. Any points identified as outliers are individually examined to ascertain the nature of the unusual measurement. Outliers that are determined to be members of a different population or incorrectly recorded or computed are removed from the sample, and new histograms and box and whiskers charts are run for that sample. Finally, a critical underlying assumption of the parametric tests used in this study is that the sample distribution of the test statistic is approximately normal. Due to the large sample size, the Central Limit Theorem can be invoked and this sampling distribution can be assumed to be approximately normal. As stated in Statistics for Business and Economics,

> Consider a random sample of *n* observations selected from a population (*any* population) with mean $\mu$ and standard deviation $\sigma$. Then, when *n* is sufficiently large, the sampling distribution of $\overline{x}$ will be approximately a normal distribution with mean $\mu_{\overline{x}} = \mu$ and standard deviation $\sigma_{\overline{x}} = \sigma/\sqrt{n}$. The larger the sample size, the better will be the normal approximation to the sampling distribution of $\overline{x}$ (McClave, Benson, and Sinich, 1998:254).

## Test Heuristic

As stated, the data was originally categorized based on whether it was deemed a problem part as defined earlier. This is the first case for which an aggregate analysis is completed. The result will allow an inference to be made as to whether a significant difference exists between the variance in ALT and PLT between problem parts and non-problem parts. The additional analyses are accomplished in order to widen the scope of this study.

The following variation of the V-heuristic is used in conducting the two sample t-test (Reynolds, 1988):

(1) Statement of the focus question.
(2) Statement of the hypothesis being tested from (1).
(3) Declare the level of significance ($\alpha$) under which the test is analyzed.
(4) State the test statistic, rejection region, and decision rule.
(5) State the statistical assumptions.
(6) Conduct the test.
(7) Analyze the results.
(8) Make an inference based on the analysis.

## Comparing Two Population Means

Focus Question. Research questions 3-8 seek to determine if sufficient evidence exists to conclude that there is a difference between the actual ALT and PLT of problem parts versus non-problem parts, stock buy versus DVD items, and the combinations of these four categories. Hence, a two-sample hypothesis test is needed to determine if the mean of the differences between the observed lead times for each contracting action and the corresponding ALTs and PLTs of record for one category are significantly different from the mean of the differences of the corresponding category.

Statement of Hypothesis. In order to determine if the mean of the differences for the aggregate ALT and PLT lead times of one group ($\overline{D}_1$) is statistically different from the similarly defined mean for the corresponding group ($\overline{D}_2$), the following hypotheses are tested for both variables:

*Null Hypothesis* ($H_o$): $\overline{D}_1 - \overline{D}_2 = \overline{D}_0$

*Alternative Hypothesis* ($H_a$): $\overline{D}_1 - \overline{D}_2 \neq \overline{D}_0$

Where $\overline{D}_0$ is the theoretical difference between the means, or 0.

Significance Level. The observed significance level, or p-value, is used in all tests. The p-value is "the probability (assuming $H_o$ is true) of observing a value of the test statistic that is at least as contradictory to the null hypothesis, and supportive of the alternative hypothesis, as the actual one computed from the sample data" (McClave, Benson, and Sinich, 332). For the purposes of this study, a p-value less than .05 is considered statistically significant.

Test Statistic, Rejection Region, and Decision Rule. The test statistic for large sample tests is $z = \frac{(\overline{D}_1 - \overline{D}_2) - \overline{D}_0}{\sigma_{(\overline{D}_1 - \overline{D}_2)}}$. Since each test is two-tailed, the rejection region is $|z| > z_{\alpha/2}$, where $z_{\alpha/2}$ is based on ($n$-1) degrees of freedom. Thus, if the calculated value of the test statistic falls in the rejection, the null is rejected.

Assumptions. Since the Central Limit Theorem guarantees an approximately normal sampling distribution of $\overline{D}$, no assumptions are necessary. Steps six and seven of the heuristic are the focus of Chapter IV, and will be discussed as that chapter unfolds. The inferences and conclusions of step eight are left for Chapter V.

## Summary

This chapter addressed the methodology for the forthcoming data analysis in the next chapter. All of the assets chosen were consumable items for two types of F-16 engine. The particular NSNs were selected due to either their categorization as problem parts by item managers, or as bench stock. The data for analyzing the variation of ALT and PLT from the system values utilized by the SAMMS system were obtained through the DSSC. Data were analyzed to determine if significant differences existed in ALT and PLT in various aggregated categories using two-sample hypothesis testing.

# IV. Analysis and Results

## Introduction

The hypothesis tests described in Chapter III were designed expressly to answer the quantitative research questions of this study. To review, the quantitative based research questions were:

1. Is there a difference in the distributions of deviations from system lead times for items classified as problem parts versus items that are not (Case 1)?
2. Is there a difference in the distributions of deviations from system lead times for items purchased for stock replenishment versus direct vendor delivery (DVD) contracts (Case 2)?
3. Is there a difference in the distributions of deviations from system lead times for problem parts bought for stock replenishment versus problem parts under DVD contracts (Case 3)?
4. Is there a difference in the distributions of deviations from system lead times for non-problem parts bought for stock replenishment versus non-problem parts under DVD contracts (Case 4)?
5. Is there a difference in the distributions of deviations from system lead times for problem parts bought for stock replenishment versus non-problem parts bought for stock replenishment (Case 5)?

6. Is there a difference in the distributions of deviations from system lead times for problem parts under DVD contracts versus non-problem parts under DVD contracts (Case 6)?

In order to determine whether or not a difference exists in the mean deviation from the system lead times for items in the cases listed above, it is necessary to perform a two-sample hypothesis test for each case. The assumption of normality required for the parametric tests performed in this chapter is met via the Central Limit Theorem, as described in Chapter III. However, it is necessary to analyze the original data set in each category for outlying observations.

## Outlier Analysis

During the preliminary analysis some suspicious data was discovered. In particular, three production lead time (PLT) observations for the same non-problem part purchased for DVD required over 2300 days for delivery. Thus, it affected all of the sample sets except for cases 3 and 5. This most unusual observation was over nine standard deviations from the mean in case 1, over eight standard deviations in case 2, over seven standard deviations for cases 4 and 6. As an extreme outlier, it was automatically removed from all cases where it appeared. The three observations represented .333% of the 903 total observations.

The other criterion used to evaluate outliers in the sample data was the removal of all observations outside an interval of plus or minus three standard deviations from the mean. This interval was selected as the capping point as this theoretically includes 99 percent of the observations in a normal distribution. The capping of individual observations is a method of minimizing bias in the data resulting from exceptional circumstances, and is an accepted procedure in defense inventory studies. In other words, it is not prudent to allow a small percentage of observations to skew results that are the basis for strategic and operational management decisions. In fact, the Logistics Management Institute generally uses two standard deviations as a cap in its inventory analyses (Mattern, 1997:2). It should be noted that removing outliers results in a new three standard deviation interval, and hence, new outliers. However, further removal jeopardizes the original criterion of retaining 99 percent of the observations. Graphical summaries of both lead times after removal of the outliers are shown for each case in Appendix E.

Table 3 shows the number of observations remaining for each data set after removal of multiple CLINs and outliers.

Table 3. Sample sizes

| | ALT | PLT | | ALT | PLT |
|---|---|---|---|---|---|
| PP | 173 | 141 | NPP | 276 | 246 |
| DVD | 193 | 164 | STK | 258 | 198 |
| PPDVD | 62 | 51 | PPSTK | 111 | 92 |
| NPPDVD | 131 | 114 | NPPSTK | 147 | 131 |

## Results

The methodology to compute the test statistic was to subtract the system lead time from the actual lead time. A mean deviation was then computed for each of the eight categories shown in Table 3, and utilized as the test statistic. Positive means represent aggregate actual lead times that were longer than the system lead time, and negative values represent those instances where the aggregate actual lead time was shorter than the system value. Table 4 summarizes the means of the aggregated differences from the system ALT and PLT.

Table 4. Summary of Means by Category

| | | μALT | μPLT | | μALT | μPLT |
|---|---|---|---|---|---|---|
| Case 1 | PP | -48.93 | -63.63 | NPP | -36.72 | -44.65 |
| Case 2 | DVD | -82.22 | -11.38 | STK | -5.12 | -8.67 |
| Case 3 | PPDVD | -116.58 | -173.67 | PPSTK | -11.05 | 3.30 |
| Case 4 | NPPDVD | -68.96 | -85.87 | NPPSTK | -0.65 | -7.30 |

The hypotheses being tested in each case is whether the mean of the differences for the aggregate ALT and PLT lead times of one group ($\overline{D}_1$) is statistically different from the similarly defined mean for the corresponding group ($\overline{D}_2$). The following hypotheses are tested for both variables:

*Null Hypothesis* ($H_o$): $\overline{D}_1 - \overline{D}_2 = \overline{D}_0$

*Alternative Hypothesis* ($H_a$): $\overline{D}_1 - \overline{D}_2 \neq \overline{D}_0$

Where $\overline{D}_0$ is the theoretical difference between the means, or 0.

The rest of this chapter discusses the analysis of the hypothesis tests. While the results of the tests are presented in simplified form in this chapter, complete results of all tests conducted can be found in Appendix F.

Case 1: Problem Parts versus Non-problem Parts. The issue explored in this case is whether or not lead times deviate significantly for items classified as problem parts versus those that are not. Recall from Chapter III that an item is termed a problem part based on the determination of the item manager. All of the problem parts in this study are on the ACC MICAP board, and thus, are affecting engine availability. In theory, longer than expected lead times result in out of stock conditions, and hence, could partially explain their presence on the problem item list. Table 5 shows the results of the two-sample test for problem part and non-problem part ALT and PLT. Based on the results for the test for equality of variances, the unequal variance assumption was required for both tests. The resulting p-values of .1369 and .1500 are not statistically significant. Thus, there is insufficient evidence to reject the null hypotheses that the mean aggregate deviations of problem parts from their system lead times are significantly different than the mean aggregate deviations of non-problem parts from their system lead times.

Table 5. Two-Sample T-test Results, Case 1

| Variable | Mean | Standard Deviation | Standard Error | Test for Equality of Variances | P-value |
|---|---|---|---|---|---|
| PPALT | -48.93 | 93.892 | 7.1385 | .0000 | .1369 |
| NPPALT | -36.72 | 69.603 | 4.1896 | | |
| PPPLT | -63.63 | 142.23 | 11.978 | .0000 | .1500 |
| NPPPLT | -44.65 | 89.594 | 5.7123 | | |

Two interesting observations result from the analysis of this case. The first observation of interest is the negative value of the means in all categories. Actual lead times of non-problem parts averaged 80 days shorter than the system value, while problem part lead times were approximately 112 days shorter than the system value. Examining the histograms for these categories reveals that these skews are a result of a greater number of purchases received ahead of schedule, rather than the magnitude of the negative tail. The negative values also allow an inference related to problem parts. That is, supplier lead times can not be said to be a significant factor, overall, in the determination of problem part status. Although the assets may not be available when they are needed, which is the primary concern of demand forecasting, they tend to arrive quicker than expected once the acquisition process begins.

The second observation worth noting is the large standard deviations of all four samples. In fact, the minimum spread of the samples was over 415 days for non-problem part ALT. The extent of this variability is seen clearly in Figures 4 and 5. Although a significant difference did not exist in this case, the large standard deviations provide evidence of substantial variability in lead times for DLA consumable assets.

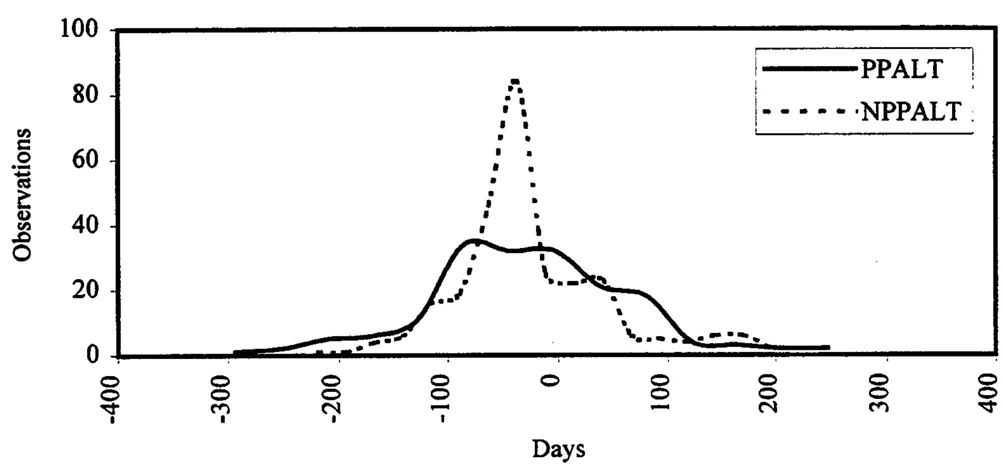



Figure 4. Comparison of Distributions of Deviations in ALT From System Lead Times: Problem Parts v Non-Problem Parts

Case 2: DVD versus Stock Buy. This case examined lead time deviations based on the nature of the purchase. As in Case 1, all of the sample observations were available for the analysis. Table 6 contains the results of the two-sample test for the DVD and stock buy categories. The unequal variance p-value applied for ALT, while the equal variance p-value was used for PLT. Nevertheless, the p-values <<.05 for both ALT and PLT are significant. Consequently, sufficient evidence exists to reject the null hypothesis in both tests, and a significant difference can be said to exist between the mean of the deviations from the system lead times.

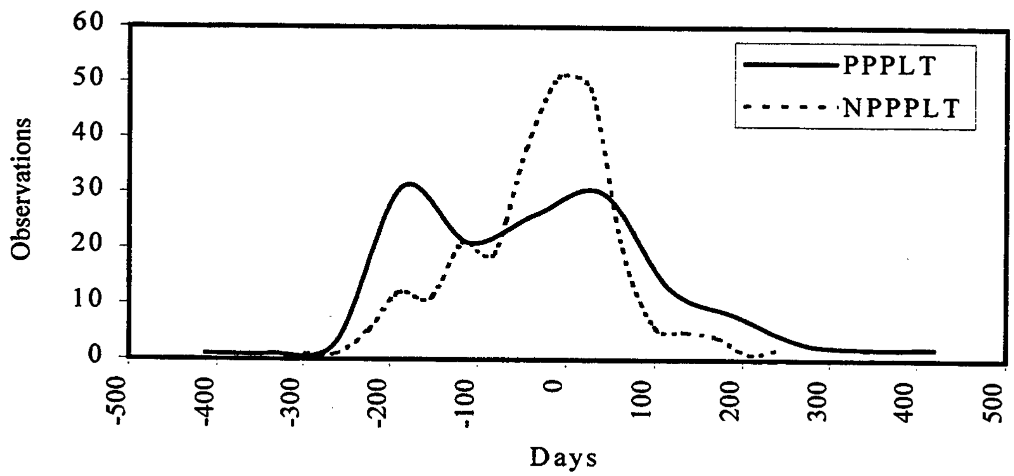



Figure 5. Comparison of Distributions of Deviations in PLT From System Lead Times: Problem Parts v Non-Problem Parts

Given the expedited nature of many DVD purchases, this result is not surprising. However, the means and standard deviations are again worth noting. The data suggests that the average ALT for DVD items is 82 days shorter than the expected value under stock replenishment contracts. Similarly, PLT for DVD items is 111 days shorter than expected in a stock replenishment. Thus, the DVD process reduced total acquisition lead time (TALT) by approximately 193 days. In terms of stock replenishment items, the weighted average was exceptionally accurate. Actual lead times deviated from the system ALT and PLT by under six and nine days, respectively. However, this result must be qualified as 50 percent of the deviations are in excess of the means, and the standard deviations for both ALT and PLT of stock replenishment purchases were over 85 days. Hence, the longer lead times, as shown in the upper tails of Figures 6 and 7, are potential causes of future problem items, or, if this variability is being captured in the reorder point, they are to some extent contributing to excess inventory.

Table 6. Two-Sample T-test Results, Case 2

| Variable | Mean | Standard Deviation | Standard Error | Test for Equality of Variances | P-value |
|---|---|---|---|---|---|
| DVDALT | -82.22 | 50.672 | 3.6474 | .0000 | .0000 |
| STKALT | -5.12 | 85.099 | 5.298 | | |
| DVDPLT | -111.38 | 90.043 | 7.0312 | .0518 | .0000 |
| STKPLT | -8.67 | 101.83 | 7.2364 | | |

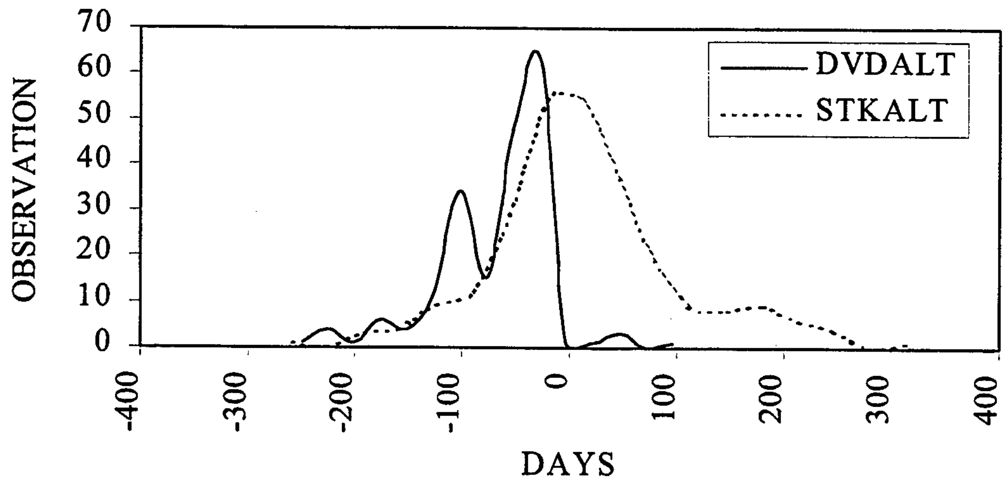



Figure 6. Comparison of Distributions of Deviations in ALT From System Lead Times: DVD v Stock Replenishment

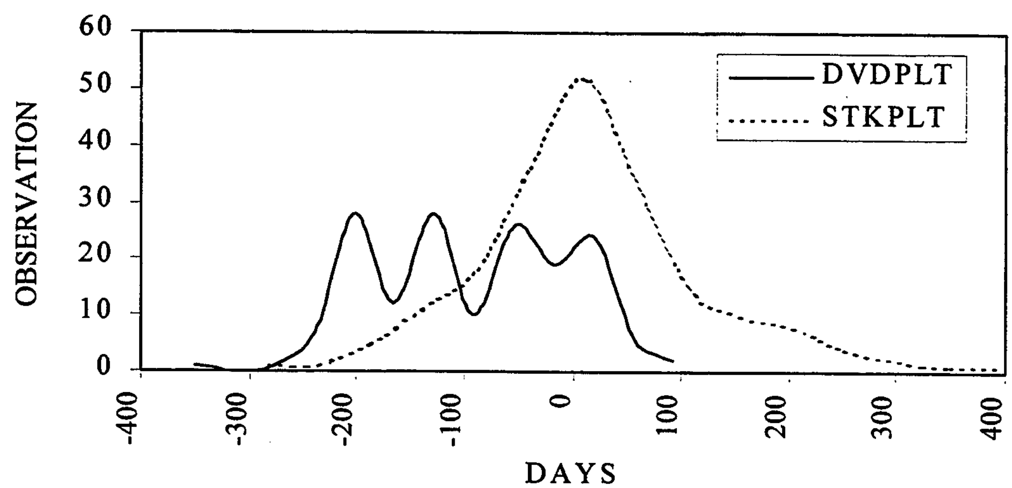



Figure 7. Comparison of Distributions of Deviations in PLT From System Lead Times: DVD v Stock Replenishment

<u>Case 3: Problem Parts for DVD versus Problem Parts for Stock Buy</u>. Case 3 subdivides the problem part category to determine if a difference exists within problem parts

between DVD and stock replenishment purchases. Although this division reduced the sample sizes by over 50 percent, the remaining observations still yielded an *n* sufficient to invoke the Central Limit Theorem. Additionally, since DVD and stock replenishment lead times are from separate populations, any inferences drawn must be in relation to the individual effect of contract type on problem parts. Furthermore, for the DVD category, the deviations are relative to the system lead times for stock replenishment, and any inferences must be compared to expected stock replenishment lead times

The results of the statistical tests for Case 3 are shown in Table 7. Based on the results for the tests for equality of variances, the unequal variance assumption was used in both tests. The resulting p-values were less than .0000 for both ALT and PLT. Thus, sufficient evidence exists to conclude that the differences of the means of the deviations from the system lead times are not equal.

Table 7. Two-Sample T-test Results, Case 3

| Variable | Mean | Standard Deviation | Standard Error | Test for Equality of Variances | P-value |
|---|---|---|---|---|---|
| PPDVDALT | -116.58 | 66.054 | 8.3889 | .0139 | .0000 |
| PPSTKALT | -11.05 | 85.60 | 8.1248 | | |
| PPDVDPLT | -173.67 | 94.082 | 13.174 | .0009 | .0000 |
| PPSTKPLT | 3.3043 | 142.32 | 14.838 | | |

In the search to determine a link between lead time and problem parts, Case 3 demonstrates rather decisively that the primary driver of an asset being declared a problem part is not related to supplier lead times. In each of the classifications in this case, only the aggregated PLT of stock replenishment items was longer than the expected, and then by a marginal amount of time. Case 3 does indicate, as shown in Figures 8 and 9, that two very separate lead time populations do exist between DVD and stock replenishment contracts.

Finally, an interesting comparison can be made between problem parts under DVD contracts versus all DVD contracts. The ALT of problem parts under DVD contracts is 34 days less, or quicker, than that of all DVD items. More significantly, the PLT for problem parts bought under DVD contracts is 62 days shorter than that of all DVD items. Thus, it can be seen that the various pressures and rewards applied throughout the acquisition cycle result in a significant improvement in lead times for problem parts.

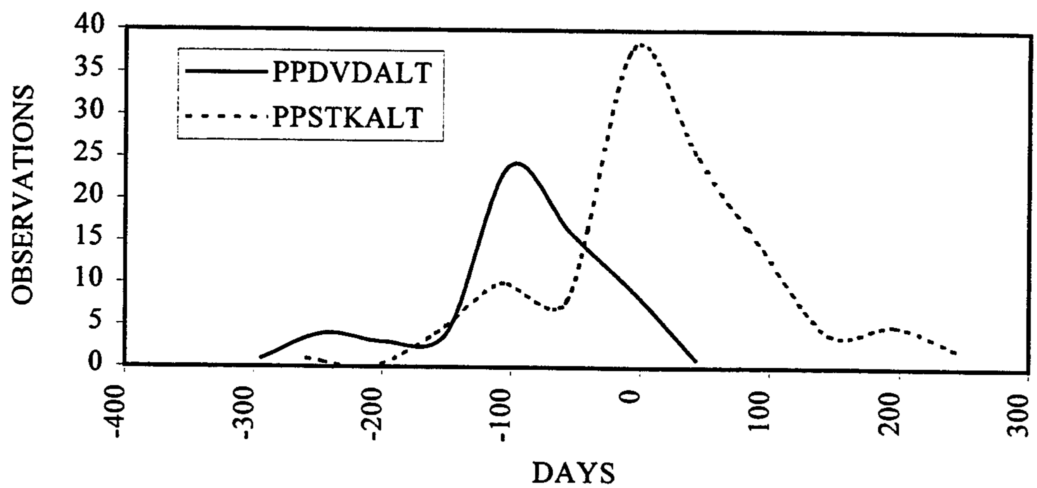



Figure 8. Comparison of Distributions of Deviations in ALT From System Lead Times: Problem Part DVD v Problem Part Stock Replenishment

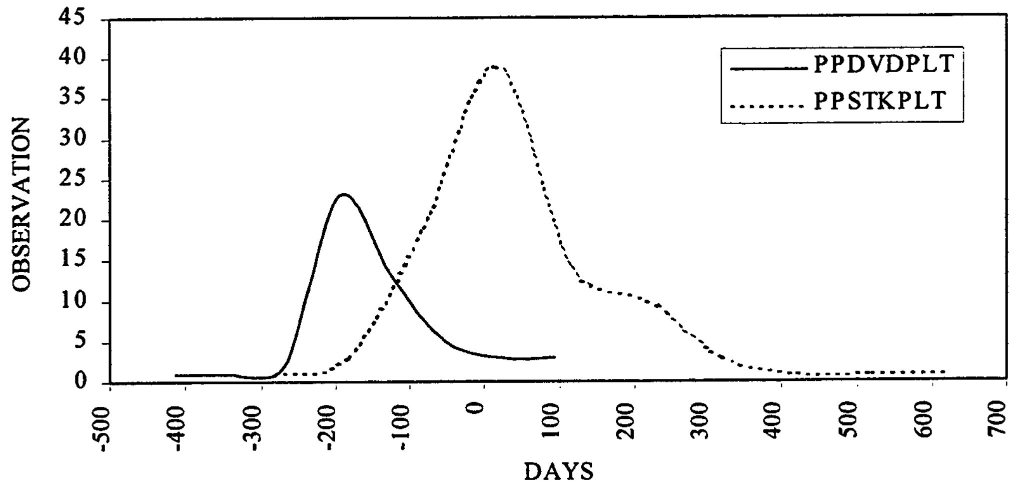



Figure 9. Comparison of Distributions of Deviations in PLT From System Lead Times: Problem Part DVD v Problem Part Stock Replenishment

<u>Case 4: Non-problem Parts for DVD versus Non-problem Parts for Stock Buy</u>. Case 4 provides further evidence of the significant variability experienced in consumable item lead times. The same restrictions apply in this case in relation to inferences drawn as in Case 3. Table 8 shows the results of the two-sample test for non-problem part DVD and non-problem part stock replenishment. As in Case 2, the ALT test required the unequal variance p-value, and the PLT test used the equal variance p-value. The resulting p-values << .0000 for the both the tests provide sufficient evidence to reject the null hypotheses.

Case 4 confirms that the true difference between problem parts and non-problem parts lies in the type of contract. ALT and PLT for non-problem parts under DVD contracts is at least two months quicker than the expected under stock replenishment contracts. On the other hand, TALT for non-problem items bought for stock is eight days shorter than forecasted. Figures10 and 11 demonstrate that the distinct difference in lead times between the contract types is also present in this category.

Table 8. Two-Sample T-test Results, Case 4

| Variable | Mean | Standard Deviation | Standard Error | Test for Equality of Variances | P-value |
|---|---|---|---|---|---|
| NPPDVDALT | -68.96 | 36.275 | 3.1693 | .0000 | .0000 |
| NPPSTKALT | -0.65 | 84.633 | 6.9804 | | |
| NPPDVDPLT | -85.87 | 78.399 | 7.3428 | .3410 | .0000 |
| NPPSTKPLT | -7.30 | 81.415 | 7.1132 | | |

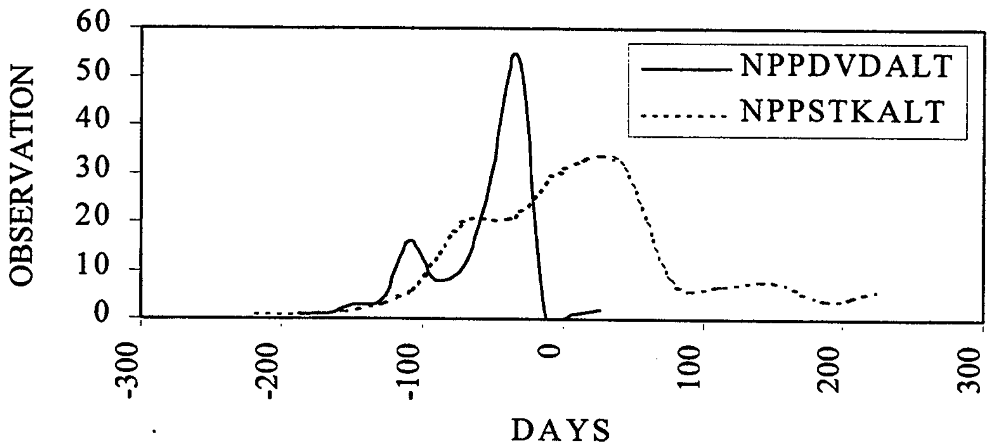



Figure 10. Comparison of Distributions of Deviations in ALT From System Lead Times: Non-Problem Part DVD v Non-Problem Part Stock Replenishment

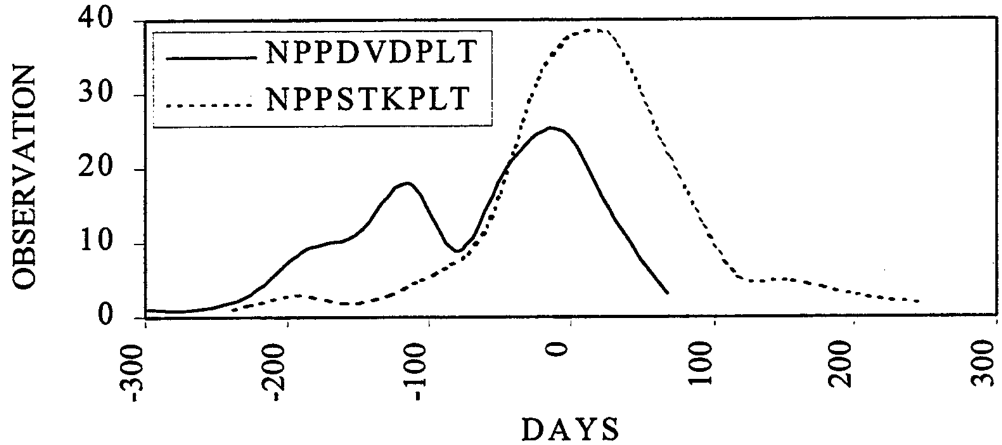



Figure 11. Comparison of Distributions of Deviations in PLT From System Lead Times: Non-Problem Part DVD v Non-Problem Part Stock Replenishment

<u>Case 5: Problem Parts for Stock Buy versus Non-problem Parts for Stock Buy</u>. To complete the analysis of the sample data, the type of purchase was kept constant in Cases 5 and 6, and problem parts were again compared to non-problem parts. Table 9 shows the results of the two-sample test for problem part and non-problem part lead times under a stock replenishment acquisition. In this case ALTs met the equality of variances test at the .05 level of significance. The unequal variance p-value was used for PLT. The resulting p-values were .3316 for ALT and .5279 for PLT. Therefore, the null hypotheses are rejected for both ALT and PLT.

As seen in Figures 12 and 13, the distributions of the deviations for problem parts and non-problem parts are remarkably similar. Additionally, the weighted average approach is reaffirmed as an accurate method of computing lead times, however, this is qualified as in Case 2 due to the large standard deviations exhibited.

Table 9. Two-Sample T-test Results, Case 5

| Variable | Mean | Standard Deviation | Standard Error | Test for Equality of Variances | P-value |
|---|---|---|---|---|---|
| PPSTKALT | -11.05 | 85.60 | 8.1248 | .4461 | .3316 |
| NPPSTKALT | -0.65 | 84.633 | 6.9804 | | |
| PPSTKPLT | 3.3043 | 142.32 | 14.838 | .0000 | .5279 |
| NPPSTKPLT | -7.30 | 81.415 | 7.1132 | | |

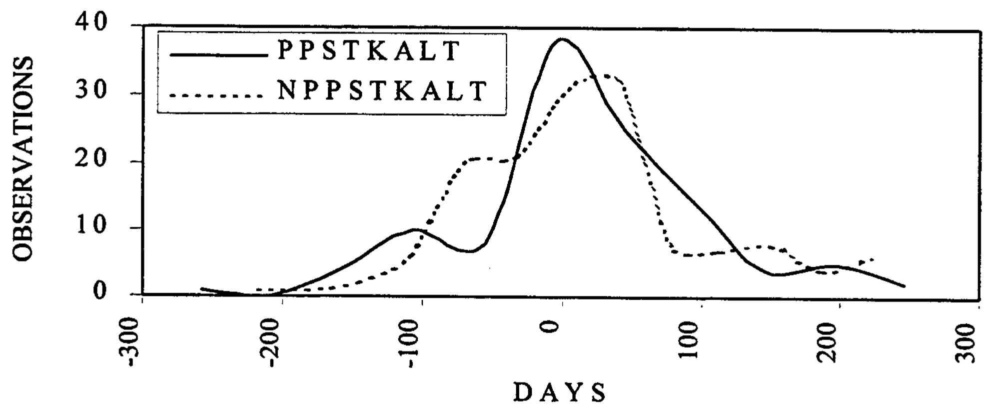



Figure 12. Comparison of Distributions of Deviations in ALT From System Lead Times: Problem Part Stock Replenishment v Non-Problem Part Stock Replenishment

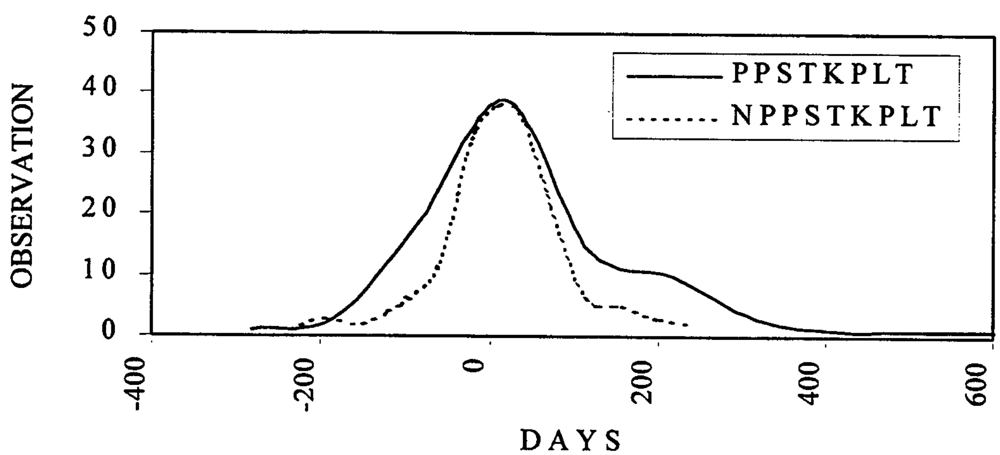



Figure 13. Comparison of Distributions of Deviations in PLT From System Lead Times: Problem Part Stock Replenishment v Non-Problem Part Stock Replenishment

Case 6: Problem Parts for DVD versus Non-problem Parts for DVD. In Case 6, problem parts and non-problem parts purchased for DVD are examined. Again, the results are presented as a comparison to expected values under stock replenishment contracts. Table 10 shows the results of the two-sample t-test. Using the unequal variance p-value for ALT and the equal variance p-value for PLT, the resulting p-values << .0000 in both tests provide sufficient evidence to reject the null hypotheses. Thus, a significant difference between the differences of the means of the deviations from the system lead times does exist.

Table 10. Two-Sample T-test Results, Case 6

| Variable | Mean | Standard Deviation | Standard Error | Test for Equality of Variances | P-value |
|---|---|---|---|---|---|
| PPDVDALT | -116.58 | 66.054 | 8.3889 | .0000 | .0000 |
| NPPDVDALT | -68.958 | 36.275 | 3.1693 | | |
| PPDVDPLT | -173.67 | 94.082 | 13.174 | .0574 | .0000 |
| NPPDVDPLT | -85.868 | 78.399 | 7.3428 | | |

This case serves to reemphasize the impact of DVD on lead time. Regardless of the classification of the asset, parts under DVD contracts experience considerably accelerated lead times. Moreover, a significant difference exists between problem parts and non-problem parts within the DVD category. Thus, it appears problem parts receive additional attention in both lead time components of the acquisitions process. The profound deviations from the forecasted values are shown in Figures 14 and 15.

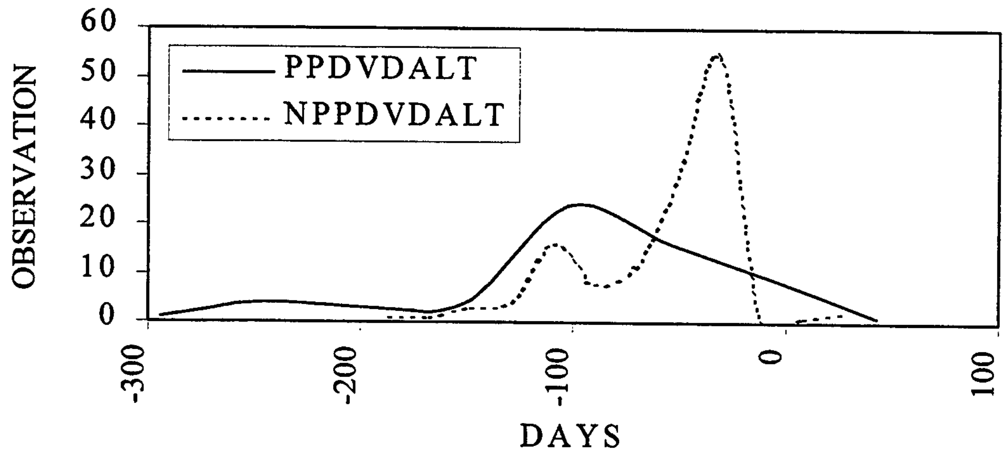



Figure 14. Comparison of Distributions of Deviations in ALT From System Lead Times: Problem Parts DVD v Non-Problem Parts DVD

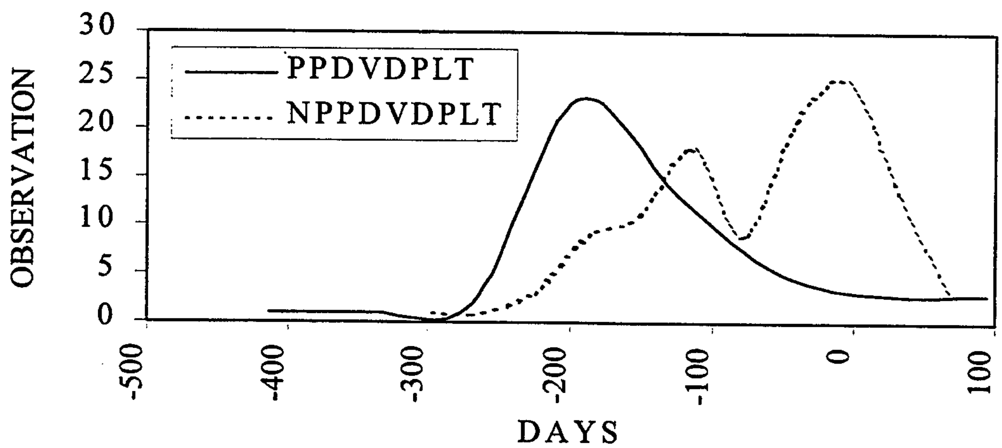



Figure 15. Comparison of Distributions of Deviations in PLT From System Lead Times: Problem Parts DVD v Non-Problem Parts DVD

## Summary

The analysis of sample data demonstrated that the weighted average method of determining lead times for stock replenishment items performed well over the aggregate data. However, particularly large standard deviations in the differences from the system values temper this finding. To some extent, lead times significantly shorter than the system value used in requirements computations are contributing to excess inventory levels. In terms of problem parts, the analysis suggested that lead times are not significant contributors to the initial determination of an asset being a problem part. This finding can be generalized to individual parts as very few assets classified as problem parts had excessively large positive deviations.

In terms of the variables considered in this study, the type of purchase was shown to the primary differentiating factor. Both ALT and PLT were significantly reduced when the part was purchased under a DVD contract. The distinction between problem parts and non-problem parts generated significant differences only in terms of DVD contracts. Case 6 revealed that under DVD, actual lead times for problem parts averaged 47 and 88 days faster than non-problem parts for ALT and PLT, respectively. Finally, observations of means and standard deviations yielded a strong indication of substantial variability in actual lead times.

In this research effort, eight classifications of parts were examined for ALT and PLT, resulting in a total of 16 mean differences. As previously shown in table 4, seven categories had a mean deviation from the system lead time of less than two weeks. Six of these were localized to the stock replenishment category, and eight of the remaining nine categories, all DVD, had average lead times accelerated by over seven weeks.

Chapter V provides a summary of this study, conclusions regarding each of the investigative questions, and discusses potential areas of further research in the area of consumable item lead times.

# V. Conclusion and Recommendations

## Introduction

The accurate computation of requirements for spare parts is a critical component of military logistics. The effectiveness of such computations is heavily dependent on a multitude of variables, one of which is total acquisition lead time (TALT). Simply stated, TALT is the length of time between the date the purchase request is initiated and receipt of the order. This time period is utilized to compute the inventory level, or reorder point, at which the acquisition process should begin in order satisfy the expected demands during TALT. Inaccurate lead times can result in inaccurate reorder points. The consequences of erroneous reorder points are either too much or too little stock relative to demand. Both of these conditions directly affect weapon system readiness through misallocation of supply dollars or work stoppages.

The two classifications of spares in the Air Force are reparables and consumables. Chapter II established the importance of consumable items in terms of management efficiency and weapon system readiness within the Department of Defense. Chapters III and IV examined the variability experienced in TALT among various classifications of consumable items. This chapter collects the findings of the previous chapters to answer the management and research questions posed in this study.

## Conclusions

This section restates each research question along with the conclusions reached based on the information presented throughout this study.

1. *What is the impact of lead-time variability on consumable item inventory levels in the DoD?*

Chapter II discussed the theoretical foundation of the EOQ model and the function of lead time in DoD requirements computations. Lead time variability directly impacts safety stock calculations and pipeline quantity, which are two factors in determining the reorder point of an asset. Reorder points higher than necessary result in the misallocation of funds through the premature purchase of assets, while artificially low reorder points result in lower inventory levels, that could affect weapon system readiness through work stoppages. The acquisition of consumable items at DLA does experience a high degree of lead time variability. To some extent, this variability, in particular stock replenishment purchases in the range of one to two standard deviations may be affecting reorder points, and hence, be contributing to the problem of excess inventory that the General Accounting Office has repeatedly criticized in its reports.

2. *What methodology does DLA use to assign lead times to assets?*

Chapter II also examined DLA methodology for consumable requirements computations. DLA updates lead times weekly using a simple weighted average for both administrative lead time and production lead time. Although exceptions do occur, the standard computation for determining a new lead time is the sum of 67 percent of the latest lead time and 33 percent of the previous lead time.

3. *Is there a difference in variability of lead times for items classified as problem parts versus items that are not (Case 1)?*

The results of the hypothesis test on the aggregated data showed insufficient evidence to conclude that a significant difference existed between the mean of the deviations of problem parts, including those under DVD contracts, and the mean of the deviations of non-problem parts from their respective system lead times. While individual items of either category can experience lead times well in excess of the system lead time, these cases are generally confined to stock replenishment contracts. Therefore, the conclusion can be drawn that lead time is not a major contributor to problem parts as a whole.

The two categories in Case 1, which included the entire set of sample data, displayed large standard deviations. Although no statistically significant difference between the two categories was evident, in terms of the broader issue of lead time variability, substantial variability exists in TALT for consumable items. After the removal of outlying observations, the maximum deviations in ALT were 247 days in excess and 294 days ahead of the forecasted lead time. For PLT, the maximum deviations were 419 days and 413 days, respectively, and both were observed in the problem parts category. This leads to the inference that the degree of variability in production lead time contributes, on an individual basis, to the classification of items as problem parts.

4. *Is there a difference in variability of lead times for items purchased for stock replenishment versus direct vendor delivery (Case 2)?*

This hypothesis test yielded sufficient evidence to conclude, for both ALT and PLT, that a significant difference does exist between these categories in their mean of the deviations from the programmed lead times. Most notably, TALT of direct vendor delivery items averaged 193 days faster than expected under stock replenishment buys.

The weighted average method proved accurate for stock replenishment parts, which averaged 14 days shorter than the system value. From a statistical standpoint, approximately 50 percent of the actual lead times had positive deviations, equating to lead times in excess of the system value. This may result in a slight increase in inventory levels, however, given the cost of consumable items, the frequency of purchase, and the simplicity of the weighted average forecast, a 14-day acceleration can not be considered a significant problem. However, the high variability of stock replenishment lead times must be suspected of increasing inventory levels, or causing stockout conditions to some extent. Quantifying this impact is left for future research.

5. *Is there a difference in variability of lead times for problem parts bought for stock replenishment versus problem parts that are DVD (Case 3)?*

Within the category of problem parts, the differences of the means of the deviations from the system lead times between DVD and stock replenishment items was significant. This result is not surprising due to the dominating effect of DVD that was observed in Case 2. Problem parts under DVD contracts also had the largest deviation in TALT, almost 290 days faster than the stock replenishment TALT. This nine-month improvement in lead time demonstrates the benefit of contracting under DVD for problem parts. However, if the DVD contract was let because an item was a problem part, this accelerated lead time will not eliminate the original cause, which may be the high degree of variability this study uncovered. Thus, from the aggregate perspective, ALT and PLT can not be considered one of the causes of an item being classified as a problem part, but their variability is certainly suspect.

6. *Is there a difference in variability of lead times for non-problem parts bought for stock replenishment versus non-problem parts that are DVD (Case 4)?*

Case 4 compared non-problem parts using type of purchase as the independent variable. In this case, sufficient evidence again existed to reject the null hypothesis for both ALT and PLT. Here, the weighted average approach again proved accurate, with actual lead times for stock replenishment items within one week of the system values. The effectiveness of DVD contracts was also evidence through a 155 day acceleration in TALT.

7. *Is there a difference in variability of lead times for problem parts bought for stock replenishment versus non-problem parts bought for stock replenishment (Case 5)?*

Case 5 tested the variability of stock replenishment purchases across the categories of problem parts and non-problem parts. The statistical test showed no significant difference in the mean differences for either ALT or PLT. This result reveals that little difference exists in the lead times of problem parts and non-problem parts for stock replenishment. Additionally, this case demonstrated the accuracy of the weighted average forecast for stock replenishment. Considering the sizable standard deviations, the degree of the accuracy observed is somewhat surprising. With regard to stock replenishment contracts, the conclusions can be drawn that lead times are not significantly contributing to the excess inventory in DLA, and the weighted average forecast is performing effectively.

8. *Is there a difference in variability of lead times for problem parts bought for DVD versus non-problem parts that are DVD (Case 6)?*

Case 6 tested problem parts and non-problem parts purchased under DVD contracts. A significant difference did exist in both tests between the differences of the means of the deviations from the forecasted lead times. The statistical analysis of this case offered further insight into the impact of DVD on lead time. Average ALTs of both categories were at least 68 days faster than system values for stock replenishment. In terms of PLT, problem parts were received 173 days faster than expected, and non-problem parts averaged 85 days shorter in the PLT cycle.

## Summary of Findings

Three primary conclusions can be reached based on the qualitative and quantitative information provided in this study. The first two relate to the specific issues addressed in the management questions presented in Chapter I, while the third confirms the performance of DVD contracts.

The first problem explored by this research effort was whether inaccurate lead time determination was a contributing factor in the classification of parts as problem items. Relative to the entire class of problem parts, the answer is a cautious no. Overall, ALT and PLT of problem parts was approximately 49 days and 64 days faster than the system lead times, respectively. When analyzed based on type of purchase, the aggregated mean deviation in TALT of problem parts under DVD contracts was 290 days faster than expected. On the other hand, ALT of problem parts purchased for stock replenishment averaged only 11 days faster than expected, and PLT averaged 3 days slower.

All of these figures must be considered in their context as averages in samples that experience considerable variability. Although these deviations may not seem significant, approximately 50 percent of items had lead times in excess of these averages. Therefore, on an individual basis, there is cause to suspect unusually long lead times to be a contributing factor in problem parts. The only instance where this issue seems to be eliminated is the case of DVD contracts, where unusually long lead times are noticeably rare occurrences.

The second problem addressed was the accuracy of the system lead times utilized by DLA in relation to the actual lead times experienced in the acquisitions process. The findings in this study support the conclusion that sufficient variability exists in both ALT and PLT to at least warrant further efforts to reduce this variability through close cooperation with suppliers. The minimum standard deviation in the sixteen sample sets was 36 days, and most were over 80 days. Although the excessive deviations were not confined to any particular category of asset, the weighted average used to determine system lead times are taken from the prior two representative contracting actions. Hence, if the last two procurements of an asset were for stock replenishment, and the lead times were particularly long, the newly computed reorder point will be artificially high, and DLA will accumulate some excess inventory.

This study also confirmed, from a statistical viewpoint, the dramatic reduction in lead time that occurs with DVD contracts. Relative to DLA inventory, the importance of this reduction is only seen in light of its increased use of DVD contracts. The greater use of DVD should equate to lower inventory levels for DLA as suppliers directly fill field requirements. The question then becomes how much safety stock should DLA hold in order to meet demands during DVD lead times.

Recommendations for Future Research

Several ideas arose during the course of this study, which create opportunities for follow-on research. This study could easily be expanded using a greater number of stock numbers across a larger number of weapon systems or end items. This would greatly increase the extent to which this analysis can be generalized.

Another possible extension is the change in the cost of safety stock, given DVD lead times and the percentage of demands for particular assets filled through DVD. This could be accomplished empirically, through the use of actual transaction histories used to recreate the inventory cycle using recalculated reorder points based on the two factors listed above. Any recommended buy date serves well as an initial reorder date as long as the inventory position of the asset on that date is known.

A third potential research effort is a regression analysis to analyze the impact of other variables such as specific type of contract, weapon system or end-item, and diminishing manufacturing sources and material shortages. Similar analyses has already been accomplished in the area of reparable components, but as yet, is left incomplete for consumable items.

Summary

The overriding purpose of this study was to examine lead time variability for consumable items in the Air Force wholesale supply system. DLA manages the majority of these assets, and is caught between end users clamoring for support to maintain the readiness of its weapon systems, and congressional oversight committees continually criticizing the dollar value of excess inventory. This study examined a small piece of an extremely complex environment in order to determine if there was sufficient reason to mine further into the lead time issue.

Overall, the weighted average forecasting method used by DLA tended to accurately reflect actual lead times. Lead times of problem parts were not found to be significantly different from those of non-problem parts, except within the category of DVD contracts. The limitations of this study in terms of generalizing the findings were discussed and recommendations for future research were suggested.

# Appendix A: Supply Codes

## ITEM CATEGORY CODE (ICC)

| Code | Definition |
|---|---|
| P | Replenishment Demand Type Item (program oriented) - an item for which demand forecasts are based on program data as well as historical demand data. |
| 1 | Replenishment Demand Type Item (demand oriented) - an item for which demand forecasts are based on historical demand data. |

(DLAM 4140.2, 1965:Vol.II, Part 3, Appendix A-87)

## STANDARDIZATION STATUS CODE (STDZ, SSC)

| Code | Term | Explanation |
|---|---|---|
| 3 | Item not authorized for purchase | An item, which as a result of a formal item reduction study, is accepted as not authorized for purchase |
| E | Item not authorized for purchase | An item no longer authorized for purchase which has been replaced by a new item as the result of new or revised superseding specifications or standards being promulgated. |

(DLAM 4140.2, 1965:Vol.II, Part 3, Appendix A-101)

## SUPPLY STATUS CODES (SSC)

| Code | Term | Explanation |
|---|---|---|
| 6 | Terminal, Stocked | Item in stock and being issued until exhausted. Not authorized for future procurement. |

(DLAM 4140.2, 1965:Vol.II, Part 3, Appendix A-50)

Appendix B: Air Force Materiel Command Readiness Assessment Module Reports

FY98 Air Force MICAP Incidents

DATE: 08/09/99 - 14.12.21 C.T. D165B-MIC : 08/08/99
AGGREGATE SUMMARY REPORT FOR D165B-MICAP HISTORY
SUBSETS SELECTED: MONTH: 97/10-98/09

| Command | Opening MICAP Incidents | Active MICAP Incidents | Closing MICAP Incidents | MICAP Period Hours |
|---|---|---|---|---|
| | 0 | 1 | 1 | 121 |
| AAC | 0 | 0 | 0 | 0 |
| AAG | 5 | 6 | 5 | 1585 |
| ACC | 124342 | 127792 | 123933 | 37303845 |
| ADC | 14 | 15 | 15 | 4443 |
| AET | 55686 | 57210 | 54999 | 20307693 |
| AFA | 4 | 4 | 4 | 197 |
| AFC | 5 | 6 | 6 | 1524 |
| AFE | 23158 | 24053 | 23029 | 8787204 |
| AFR | 30841 | 31571 | 30723 | 6664361 |
| AFT | 1 | 1 | 1 | 7 |
| AIC | 5 | 6 | 6 | 820 |
| AMC | 54216 | 55625 | 53999 | 13479093 |
| ANG | 103089 | 105397 | 102639 | 24784668 |
| AUN | 11 | 14 | 11 | 5095 |
| CAF | 19 | 19 | 19 | 3239 |
| CML | 2 | 2 | 2 | 45 |
| CMS | 16 | 18 | 13 | 7257 |
| CNT | 809 | 820 | 816 | 116924 |
| CON | 201 | 208 | 199 | 62061 |
| CSV | 42 | 42 | 42 | 6064 |
| DOD | 2 | 2 | 1 | 119 |
| ESC | 1 | 1 | 1 | 99 |
| FAA | 1 | 1 | 1 | 60 |
| GAF | 2 | 2 | 2 | 6 |
| HAF | 2 | 3 | 2 | 325 |
| ICT | 0 | 0 | 0 | 0 |
| ISC | 7 | 7 | 7 | 1211 |
| LCT | 1 | 1 | 1 | 28 |

FY98 Air Force MICAP Incidents (Continued)

| Command | Opening MICAP Incidents | Active MICAP Incidents | Closing MICAP Incidents | MICAP Period Hours |
|---|---|---|---|---|
| MAP | 1 | 1 | 1 | 119 |
| MEA | 167 | 179 | 170 | 48956 |
| MIF | 9 | 9 | 9 | 1500 |
| MPC | 6 | 6 | 6 | 1348 |
| MTC | 20029 | 21169 | 19109 | 15266533 |
| OAF | 24 | 28 | 26 | 5310 |
| OAR | 1 | 1 | 1 | 25 |
| OFG | 6 | 7 | 6 | 3773 |
| OSI | 1 | 1 | 1 | 46 |
| OTE | 9 | 9 | 9 | 448 |
| OUS | 10 | 10 | 10 | 411 |
| PAF | 32211 | 33209 | 32149 | 10200892 |
| RBO | 1 | 1 | 1 | 154 |
| RED | 54 | 67 | 65 | 47472 |
| SOC | 9797 | 10080 | 9805 | 2709830 |
| SPC | 2477 | 2578 | 2487 | 708844 |
| TAC | 0 | 1 | 0 | 8760 |
| TAP | 6 | 6 | 6 | 3001 |
| USS | 28 | 32 | 31 | 13675 |
| Total | 457319 | 470221 | 454369 | 140559191 |

FY98 MICAP Incidents for DLA Managed Items

DATE: 08/09/99 - 13.47.45 C.T. D165B-MIC : 08/08/99
AGGREGATE SUMMARY REPORT FOR D165B-MICAP HISTORY
SUBSETS SELECTED: MONTH: 97/10-98/09; SOURCE OF SUPPLY: S9E,S9F,S9G,S9I,S9T

| Command | Opening MICAP Incidents | Active MICAP Incidents | Closing MICAP Incidents | MICAP Period Hours |
|---|---|---|---|---|
| ACC | 31883 | 32885 | 31825 | 9304986 |
| ADC | 5 | 5 | 5 | 1385 |
| AET | 13673 | 14095 | 13421 | 5646480 |
| AFA | 1 | 1 | 1 | 49 |
| AFC | 2 | 2 | 2 | 661 |
| AFE | 7183 | 7401 | 6997 | 2850220 |
| AFR | 9728 | 9956 | 9660 | 2257406 |
| AIC | 2 | 2 | 2 | 133 |
| AMC | 14537 | 15168 | 14310 | 6093652 |
| ANG | 37042 | 37783 | 36812 | 8370856 |
| CAF | 7 | 7 | 7 | 661 |
| CMS | 8 | 9 | 6 | 3795 |
| CNT | 181 | 182 | 182 | 24117 |
| CON | 68 | 72 | 69 | 26703 |
| CSV | 15 | 15 | 15 | 3414 |
| HAF | 1 | 2 | 1 | 122 |
| ICT | 0 | 0 | 0 | 0 |
| ISC | 2 | 2 | 2 | 180 |
| MEA | 63 | 69 | 65 | 21348 |
| MIF | 3 | 3 | 3 | 436 |
| MPC | 2 | 2 | 2 | 252 |
| MTC | 5883 | 6231 | 5401 | 4844121 |
| OAF | 6 | 7 | 7 | 1368 |
| OFG | 2 | 2 | 1 | 287 |
| OTE | 3 | 3 | 3 | 176 |
| OUS | 3 | 3 | 3 | 153 |
| PAF | 8676 | 9019 | 8673 | 3074066 |
| RED | 23 | 31 | 30 | 32398 |
| SOC | 3187 | 3296 | 3199 | 917071 |
| SPC | 662 | 672 | 651 | 127682 |
| TAP | 1 | 1 | 1 | 2392 |
| USS | 4 | 4 | 4 | 6644 |
| Total | 132856 | 136930 | 131360 | 43613214 |

FY98 MICAP Incidents for Consumable Items

DATE: 08/09/99 - 13.42.14 C.T. D165B-MIC : 08/08/99
AGGREGATE SUMMARY REPORT FOR D165B-MICAP HISTORY
SUBSETS SELECTED: MONTH: 97/10-98/09; ERRC: N

| Command | Opening MICAP Incidents | Active MICAP Incidents | Closing MICAP Incidents | MICAP Period Hours |
|---|---|---|---|---|
| AAG | 1 | 1 | 0 | 735 |
| ACC | 50718 | 51933 | 50591 | 12970583 |
| ADC | 9 | 9 | 9 | 1875 |
| AET | 20412 | 20868 | 20232 | 6478621 |
| AFA | 1 | 1 | 1 | 49 |
| AFC | 2 | 2 | 2 | 245 |
| AFE | 10918 | 11231 | 10685 | 3936780 |
| AFR | 13693 | 13974 | 13637 | 2759961 |
| AFT | 1 | 1 | 1 | 7 |
| AIC | 2 | 2 | 2 | 191 |
| AMC | 21527 | 22297 | 21378 | 7731290 |
| ANG | 51961 | 52903 | 51712 | 11022425 |
| AUN | 0 | 1 | 0 | 4331 |
| CAF | 9 | 9 | 9 | 827 |
| CML | 0 | 0 | 0 | 0 |
| CMS | 9 | 10 | 7 | 4022 |
| CNT | 375 | 378 | 377 | 43366 |
| CON | 125 | 129 | 125 | 39309 |
| CSV | 16 | 16 | 16 | 1247 |
| GAF | 1 | 1 | 1 | 6 |
| HAF | 0 | 1 | 1 | 21 |
| ISC | 3 | 3 | 3 | 274 |
| MEA | 82 | 88 | 84 | 22652 |
| MIF | 5 | 5 | 5 | 1128 |
| MPC | 2 | 2 | 2 | 259 |
| MTC | 7641 | 8027 | 7147 | 5273318 |
| OAF | 11 | 12 | 12 | 2452 |
| OFG | 2 | 3 | 2 | 2293 |
| OSI | 1 | 1 | 1 | 46 |
| OTE | 4 | 4 | 4 | 176 |
| OUS | 4 | 4 | 4 | 183 |
| PAF | 15485 | 15938 | 15445 | 4358027 |
| RED | 31 | 40 | 39 | 42069 |

FY98 MICAP Incidents for Consumable Items (Continued)

| Command | Opening MICAP Incidents | Active MICAP Incidents | Closing MICAP Incidents | MICAP Period Hours |
|---|---|---|---|---|
| SOC | 5265 | 5412 | 5258 | 1331661 |
| SPC | 968 | 985 | 961 | 187049 |
| SPC | 968 | 985 | 961 | 187049 |
| TAC | 0 | 1 | 0 | 8760 |
| TAP | 4 | 4 | 4 | 2813 |
| USS | 6 | 6 | 6 | 7722 |
| Total | 199294 | 204302 | 197763 | 56236773 |

## Appendix C: List of Parts Used in Sample Data

| | Problem Parts |
|---|---|
| NSN | Nomenclature |
| 2840-01-146-9387 | SEAL, METALLIC, AIRCRAFT |
| 2840-01-178-0436 | NUT, LOCKING, TURBINE |
| 2840-01-198-4866 | LEVER AND LINK |
| 2995-01-200-7234 | MANIFOLD, FLUID, AIRCRAFT |
| 2995-01-324-2084 | MANIFOLD, FLUID, AIRCRAFT |
| 3110-01-147-4486 | BEARING, ROLLING, CYLINDRICAL |
| 4710-01-347-8084 | TUBE ASSEMBLY, METAL |
| 5305-01-319-6514 | SCREW, MACHINE |
| 5305-01-344-2126 | SCREW, MACHINE |
| 5306-01-312-8967 | BOLT, MACHINE |
| 5315-01-238-3341 | PIN, STRAIGHT, HEADED |
| 5315-01-272-0068 | PIN, STRAIGHT, HEADED |
| 5340-01-323-8442 | BRACKET, MOUNTING |
| 5365-01-218-0912 | RING, SEAL |
| | Non-problem Parts |
| 1680-01-213-8558 | CLAMP,TUBE,DOUBLE HINGED |
| 2840-01-198-4854 | GUTTER, AUGMENTOR, FLAMEHOLDER |
| 2840-01-322-4756 | CASE, TURBINE, AIRCRAFT GAS TURBINE |
| 2925-01-190-9352 | IGNITER, SPARK, GAS, TURBINE ENGINE |
| 4010-00-929-0041 | ROPE, WIRE |
| 5306-00-551-4845 | BOLT, MACHINE |
| 5306-01-173-9537 | BOLT, MACHINE |
| 5306-01-175-3619 | BOLT, MACHINE |
| 5306-01-323-5467 | BOLT, SHOULDER |
| 5310-01-177-4992 | NUT, SELF-LOCKING, EXTENDED WASHER |
| 5315-01-177-5964 | PIN, STRAIGHT, HEADED |
| 5315-01-269-2679 | PIN, STRAIGHT, HEADED |
| 5330-00-020-0203 | PACKING, PREFORMED |
| 5330-01-234-6378 | GASKET |
| 5331-00-166-0992 | O-RING |
| 5331-00-166-0993 | O-RING |
| 5331-00-166-1063 | O-RING |
| 5331-00-167-5110 | O-RING |
| 5331-00-167-5143 | O-RING |
| 5365-01-213-7700 | SPACER, SLEEVE |
| 5365-01-323-2790 | SPACER, SLEEVE |
| 5365-01-323-2794 | SPACER, SLEEVE |
| 6685-01-173-0502 | TUBE, SIGHT, PYROMETER |

Appendix D: Sample Data

Note: Numbers in bold represent National Stock Numbers

Problem Parts

| Recomm buy date | Award date | Receipt date | Actual ALT | Actual PLT | CLIN | DVD | Sys ALT | Sys PLT | Qty | ALT Differ-ence | PLT Differ-ence |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **4710013478084** | | | | | | | | | | | |
| 1997313 | 1998191 | 1999133 | 244 | 308 | 1 | N | 91 | 125 | 13 | 153 | 183 |
| 1998007 | 1998252 | 1999133 | 246 | | 2 | N | 91 | | 13 | 155 | |
| 1998196 | 1998252 | 1999134 | 57 | 248 | 1 | N | 91 | 125 | 17 | -34 | 123 |
| 1998281 | 1999055 | 0 | 140 | | 1 | N | 91 | | 0 | 49 | |
| 1999060 | 1999090 | 0 | 31 | | 1 | N | 230 | | 0 | -199 | |
| **2840011469387** | | | | | | | | | | | |
| 1997152 | 1998156 | 1999058 | 370 | 268 | 1 | N | 88.5 | 138 | 20 | 281.5 | 130 |
| 1997162 | 1997210 | 1997276 | 49 | 67 | 2 | N | 88.5 | 69 | 7 | -39.5 | -2 |
| 1997162 | 1997210 | 1997279 | | 70 | 1 | Y | | 69 | 1 | | 1 |
| 1998186 | 1999029 | 0 | 209 | | 0001AA | N | 177 | | 0 | 32 | |
| 1999067 | 1999067 | 0 | 1 | | 3 | N | 365 | | 0 | -364 | |
| 1999112 | 1999114 | 1999134 | 3 | 21 | 1 | Y | 365 | 434 | 1 | -362 | -413 |
| **2840011780436** | | | | | | | | | | | |
| 1995267 | 1995352 | 1996121 | 86 | 135 | | N | 240 | 63 | 63 | -154 | 72 |
| 1996221 | 1996327 | 1997112 | 107 | 152 | 2 | N | 229 | 260 | 29 | -122 | -108 |
| 1998165 | 1998219 | 1998315 | 55 | 97 | 2 | N | 106 | 148 | 40 | -51 | -51 |
| 1998213 | 1998324 | 1999120 | 112 | 162 | 1 | N | 106 | 148 | 100 | 6 | 14 |
| 1998225 | 1998230 | 1998253 | 6 | 24 | 2 | Y | 106 | 148 | 1 | -100 | -124 |
| 1999066 | 1999131 | 1999147 | 66 | 17 | 1 | N | 106 | 190 | 21 | -40 | -173 |

Sample Data (continued)

| Recomm buy date | Award date | Receipt date | Actual ALT | Actual PLT | CLIN | DVD | Sys ALT | Sys PLT | Qty | ALT Differ-ence | PLT Differ-ence |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **2840011984866** | | | | | | | | | | | |
| 1996122 | 1996345 | 1997304 | 224 | 326 | 1 | N | 229 | 411 | 1118 | -5 | -85 |
| 1997296 | 1997356 | 1999212 | 61 | 587 | 5001AA | N | 112.5 | 168 | 0 | -51.5 | 419 |
| 1999121 | 1999126 | 1999155 | 6 | 30 | 1 | Y | 300 | 380 | 17 | -294 | -350 |
| **2995012007234** | | | | | | | | | | | |
| 1995162 | 1995343 | 1996139 | 182 | 162 | 1 | N | 199 | 217 | 74 | -17 | -55 |
| 1995279 | 1996025 | 1996192 | 112 | 168 | 1 | N | 174 | 206 | 125 | -62 | -38 |
| 1996017 | 1996023 | 1996068 | 7 | 46 | 1 | Y | 149 | 206 | 1 | -142 | -160 |
| 1998060 | 1998183 | 0 | 124 | | 1 | N | 130 | | 0 | -6 | |
| 1998288 | 1999036 | 1999183 | 114 | 148 | 0001AA | N | 125 | 171 | 20 | -11 | -23 |
| 1999007 | 1999148 | 0 | 142 | | 1 | N | 125 | | 0 | 17 | |
| 1999096 | 1999096 | 1999110 | 1 | 15 | 0101AA | N | 260 | 182 | 0 | -259 | -167 |
| 1999112 | 1999123 | 1999180 | 12 | 58 | 2 | Y | 192.5 | 176.5 | 0 | -180.5 | -118.5 |
| 1999132 | 1999133 | 1999180 | 2 | 48 | 1 | Y | 192.5 | 176.5 | 0 | -190.5 | -128.5 |
| 1999141 | 1999154 | 1999180 | 14 | 27 | 6 | Y | 192.5 | 176.5 | 1 | -178.5 | -149.5 |
| **2995013242084** | | | | | | | | | | | |
| 1991037 | 1991256 | 1992231 | 220 | 341 | 0001AA | N | | 279.5 | 2 | | 61.5 |
| 1992110 | 1993033 | 1994040 | 290 | 373 | 0001AA | N | 222 | 430 | 2 | 68 | -57 |
| 1995158 | 1995252 | 0 | 95 | | 0001AA | N | 266 | | 0 | -171 | |
| 1997303 | 1998181 | 1999076 | 244 | 261 | 0001AA | N | 266 | 430 | 2 | -22 | -169 |
| 1998113 | 1998212 | 1999085 | 100 | 239 | 0001AA | N | 266 | 430 | 2 | -166 | -191 |
| **3110011474486** | | | | | | | | | | | |
| 1997254 | 1998071 | 1999112 | 183 | 407 | 0001AA | N | | 428 | 52 | | -21 |
| 1998106 | 1998349 | 0 | 244 | | 0001AA | N | 95 | | 0 | 149 | |
| 1999104 | 1999106 | 0 | 3 | | 1 | Y | 169 | | 0 | -166 | |

Sample Data (continued)

| Recomm buy date | Award date | Receipt date | Actual ALT | Actual PLT | CLIN | DVD | Sys ALT | Sys PLT | Qty | ALT Difference | PLT Difference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **5365012180912** | | | | | | | | | | | |
| 1992072 | 1992213 | 1992338 | 142 | 126 | 1 | N | 131 | 312 | 45 | 11 | -186 |
| 1998193 | 1998203 | 1999022 | 11 | 185 | 1 | N | 138 | 123 | 4 | -127 | 62 |
| 1998218 | 1999037 | 1999134 | 185 | 98 | 1 | N | 138 | 147 | 100 | 47 | -49 |
| **5305013196514** | | | | | | | | | | | |
| 1994249 | 1994279 | 1994311 | 31 | | 10 | Y | 68.5 | | 54 | -37.5 | |
| 1994280 | 1994298 | 1994332 | 19 | 35 | 1 | Y | 68.5 | 176.5 | 52 | -49.5 | -141.5 |
| 1995197 | 1995341 | 1997052 | 145 | 443 | 1 | N | 137 | 353 | 10460 | 8 | 90 |
| 1995295 | 1995341 | 1997241 | 47 | 632 | 1 | N | 126 | 353 | 12022 | -79 | 279 |
| 1995338 | 1996018 | 1996179 | 46 | 162 | 1 | Y | 126 | 250 | 593 | -80 | -88 |
| 1995353 | 1996019 | 1996180 | 32 | 162 | 1 | Y | 126 | 250 | 593 | -94 | -88 |
| 1996072 | 1996085 | 1996102 | 14 | 18 | 2 | N | 115 | 301.5 | 236 | -101 | -283.5 |
| 1996072 | 1996085 | 1996115 | 14 | 31 | 1 | Y | 126 | 301.5 | 94 | -112 | -270.5 |
| 1996095 | 1996242 | 1997154 | 148 | 279 | 1 | N | 118.5 | 233 | 24150 | 29.5 | 46 |
| 1997051 | 1997176 | 1998232 | 126 | 422 | 1 | N | 122 | 216 | 7000 | 4 | 206 |
| 1998113 | 1999050 | 0 | 303 | | 1 | N | 122 | | 0 | 181 | |
| 1998302 | 1999046 | 0 | 110 | | 1 | N | 122 | | 0 | -12 | |
| 1999007 | 1999046 | 0 | 40 | | 1 | N | 122 | | 0 | -82 | |
| 1999125 | 1999128 | 1999147 | 4 | 20 | 2 | Y | 122 | 236 | 90 | -118 | -216 |
| 1999128 | 1999133 | 1999165 | 6 | 33 | 5 | Y | 122 | 236 | 0 | -116 | -203 |
| 1999128 | 1999133 | 1999167 | | 35 | 15 | Y | | 236 | 54 | | -201 |
| 1999130 | 1999133 | 1999165 | 4 | | 1 | Y | 122 | | 159 | -118 | |
| 1999134 | 1999139 | 1999187 | 6 | 49 | 3 | Y | 122 | 236 | 200 | -116 | -187 |
| 1999139 | 1999140 | 0 | 2 | | 1 | Y | 122 | | 0 | -120 | |
| 1999140 | 1999144 | 0 | 5 | | 2 | Y | 122 | | 0 | -117 | |

Sample Data (continued)

| Recomm buy date | Award date | Receipt date | Actual ALT | Actual PLT | CLIN | DVD | Sys ALT | Sys PLT | Qty | ALT Differ-ence | PLT Differ-ence |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1999141 | 1999141 | 1999212 | 1 | 72 | 3 | N | 122 | 236 | 0 | -121 | -164 |
| 1999141 | 1999144 | 1999169 | 4 | 26 | 1 | Y | 122 | 236 | 54 | -118 | -210 |
| 1999145 | 1999147 | 1999169 | 3 | 23 | 1 | Y | 122 | 236 | 42 | -119 | -213 |
| 1999166 | 1999167 | 1999179 | 2 | 13 | 1 | Y | 122 | 236 | 54 | -120 | -223 |
| **5305013442126** | | | | | | | | | | | |
| 1992068 | 1992073 | 1993045 | 6 | 339 | 1 | N | 123 | 450 | 90 | -117 | -111 |
| 1993294 | 1994040 | 1995130 | 112 | 456 | 1 | N | 45 | 312 | 63 | 67 | 144 |
| 1994156 | 1994218 | 1995144 | 63 | 292 | 1 | N | 45 | 288.5 | 100 | 18 | 3.5 |
| 1994345 | 1995034 | 1995130 | 55 | 97 | 1 | N | 50.5 | 265 | 100 | 4.5 | -168 |
| 1995036 | 1995074 | 1995229 | 39 | 156 | 1 | N | 56 | 288.5 | 500 | -17 | -132.5 |
| 1995113 | 1995165 | 1995362 | 53 | 198 | 1 | N | 52.5 | 219.5 | 225 | 0.5 | -21.5 |
| 1995285 | 1995352 | 1996242 | 68 | 256 | 1 | N | 52.5 | 219.5 | 500 | 15.5 | 36.5 |
| 1995358 | 1996059 | 1996242 | 67 | 184 | 1 | N | 52.5 | 174 | 1000 | 14.5 | 10 |
| 1996189 | 1996202 | 1996242 | 14 | 41 | 1 | N | 49 | 151.5 | 600 | -35 | -110.5 |
| 1996315 | 1996319 | 1997274 | 5 | 322 | 1 | N | 44.5 | 151.5 | 500 | -39.5 | 170.5 |
| 1997019 | 1997059 | 1998042 | 41 | 349 | 1 | N | 40 | 129 | 950 | 1 | 220 |
| 1997100 | 1997106 | 1998049 | 7 | 309 | 1 | N | 40 | 114.5 | 1425 | -33 | 194.5 |
| 1997296 | 1998012 | 0 | 82 | | 2 | N | 40 | | 0 | 42 | |
| 1997296 | 1998037 | 1998056 | 107 | 20 | 1 | N | 40 | 114.5 | 950 | 67 | -94.5 |
| 1998022 | 1998024 | 0 | 3 | | 1 | N | 40 | | 0 | -37 | |
| 1998197 | 1998358 | 0 | 162 | | 1 | N | 40 | | 0 | 122 | |
| 1999014 | 1999051 | 1999187 | 38 | 137 | 2 | N | 75 | 132 | 2000 | -37 | 5 |
| 1999101 | 1999145 | 0 | 45 | | 1 | N | 75 | | 0 | -30 | |
| **5306013128967** | | | | | | | | | | | |
| 1995060 | 1995220 | 1996012 | 161 | 158 | 1 | N | 95 | 172.5 | 2000 | 66 | -14.5 |

Sample Data (continued)

| Recomm buy date | Award date | Receipt date | Actual ALT | Actual PLT | CLIN | DVD | Sys ALT | Sys PLT | Qty | ALT Difference | PLT Difference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1995113 | 1995301 | 1996089 | 189 | 154 | 1 | N | 122.5 | 172.5 | 20000 | 66.5 | -18.5 |
| 1995115 | 1995194 | 1996124 | 80 | 296 | 1 | Y | 122.5 | 202 | 1000 | -42.5 | 94 |
| 1995351 | 1996082 | 1996171 | 97 | 90 | 2 | N | 122.5 | 143 | 9400 | -25.5 | -53 |
| 1997096 | 1997135 | 1997267 | 40 | 133 | 1 | N | 40 | 128 | 24300 | 0 | 5 |
| 1997208 | 1998100 | 1998149 | 258 | 50 | 0001AB | N | 40 | 180 | 5225 | 218 | -130 |
| 1997299 | 1998220 | 0 | 287 | | 1 | N | 40 | | 0 | 247 | |
| 1998099 | 1998220 | 1998258 | 122 | 39 | 5 | N | 160 | 180 | 5000 | -38 | -141 |
| 1998228 | 1998267 | 1999147 | 40 | 246 | 2 | N | 160 | 180 | 19822 | -120 | 66 |
| 1998249 | 1999104 | 1999127 | 221 | 24 | 2 | N | 160 | 85 | 11732 | 61 | -61 |
| **5315012383341** | | | | | | | | | | | |
| 1990067 | 1990229 | 1991074 | 163 | 211 | 1 | N | 112 | 272 | 1430 | 51 | -61 |
| 1990214 | 1990239 | 0 | 26 | | 3 | Y | 137 | | 0 | -111 | |
| 1990223 | 1990337 | 1992128 | 115 | 522 | 1 | N | 137 | 247 | 1045 | -22 | 275 |
| 1990325 | 1990341 | 1991004 | 17 | 29 | 5 | Y | 137 | 247 | 20 | -120 | -218 |
| 1990359 | 1991030 | 1991063 | 37 | 34 | 3 | Y | 137 | 222 | 20 | -100 | -188 |
| 1991001 | 1991030 | 1991063 | 30 | 34 | 1 | Y | 162 | 222 | 30 | -132 | -188 |
| 1991038 | 1991050 | 1991070 | 13 | 21 | 3 | Y | 137 | 247 | 20 | -124 | -226 |
| 1991039 | 1991050 | 1991070 | 12 | | 4 | Y | 137 | | 20 | -125 | |
| 1991051 | 1991088 | 0 | 38 | | 1 | Y | 137 | | 0 | -99 | |
| 1991066 | 1991084 | 0 | 19 | | 1 | Y | 137 | | 0 | -118 | |
| 1991072 | 1991084 | 1991119 | 13 | 36 | 4 | Y | 137 | 247 | 20 | -124 | -211 |
| 1991077 | 1991088 | 1991126 | 12 | 39 | 1 | Y | 137 | 247 | 9 | -125 | -208 |
| 1991078 | 1991084 | 0 | 7 | | 2 | Y | 137 | | 0 | -130 | |
| 1991094 | 1991164 | 1992196 | 71 | 398 | 1 | N | 116.5 | 235.5 | 1900 | -45.5 | 162.5 |
| 1991110 | 1991122 | 1991155 | 13 | 34 | 1 | Y | 116.5 | 235.5 | 20 | -103.5 | -201.5 |

Sample Data (continued)

| Recomm buy date | Award date | Receipt date | Actual ALT | Actual PLT | CLIN | DVD | Sys ALT | Sys PLT | Qty | ALT Differ-ence | PLT Differ-ence |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1991122 | 1991136 | 1991155 | 15 | 20 | 6 | Y | 116.5 | 235.5 | 20 | -101.5 | -215.5 |
| 1991149 | 1991165 | 1991192 | 17 | 28 | 6 | Y | 116.5 | 235.5 | 3 | -99.5 | -207.5 |
| 1991160 | 1991221 | 1992198 | 62 | 343 | 1 | N | 116.5 | 235.5 | 1400 | -54.5 | 107.5 |
| 1992037 | 1992045 | 1992065 | 9 | 21 | 1 | Y | 71 | 249 | 1 | -62 | -228 |
| 1992055 | 1992073 | 1992086 | 19 | 14 | 3 | Y | 116.5 | 235.5 | 20 | -97.5 | -221.5 |
| 1992099 | 1992121 | 1992171 | 23 | | 2 | Y | 71 | | 20 | -48 | |
| 1992100 | 1992121 | 1992171 | 22 | | 1 | Y | 71 | | 20 | -49 | |
| 1992105 | 1992121 | 1992171 | 17 | 51 | 3 | Y | 71 | 288.5 | 20 | -54 | -237.5 |
| 1992107 | 1992358 | 0 | 252 | | 2 | N | 71 | | 0 | 181 | |
| 1992183 | 1992353 | 0 | 171 | | 1 | N | 71 | | 0 | 100 | |
| 1992184 | 1992199 | 1992216 | 16 | 18 | 3 | Y | 71 | 288.5 | 20 | -55 | -270.5 |
| 1992306 | 1993090 | 0 | 151 | | 1 | N | 71 | | 0 | 80 | |
| 1993089 | 1993103 | 1993118 | 15 | 16 | 1 | Y | 71 | 210.5 | 11 | -56 | -194.5 |
| 1993098 | 1993112 | 1993132 | 15 | 21 | 1 | Y | 79.5 | 210.5 | 6 | -64.5 | -189.5 |
| 1993103 | 1993112 | 1993132 | 10 | | 3 | Y | 79.5 | | 20 | -69.5 | |
| 1993104 | 1993112 | 1993132 | 9 | | 4 | Y | 79.5 | | 20 | -70.5 | |
| 1993115 | 1993171 | 1993287 | 57 | 117 | 1 | N | 79.5 | 210.5 | 11899 | -22.5 | -93.5 |
| 1993118 | 1993146 | 1993159 | 29 | 14 | 1 | Y | 79.5 | 210.5 | 20 | -50.5 | -196.5 |
| 1993131 | 1993158 | 1993176 | 28 | 19 | 1 | Y | 79.5 | 210.5 | 17 | -51.5 | -191.5 |
| 1993213 | 1993296 | 1994006 | 84 | 76 | 1 | N | 79.5 | 210.5 | 4753 | 4.5 | -134.5 |
| 1993217 | 1993222 | 1993267 | 6 | 46 | 2 | Y | 79.5 | 210.5 | 1 | -73.5 | -164.5 |
| 1993261 | 1993293 | 1993316 | 33 | 24 | 1 | Y | 79.5 | 210.5 | 18 | -46.5 | -186.5 |
| 1993298 | 1993301 | 0 | 4 | | 2 | Y | 79.5 | | 0 | -75.5 | |
| 1993311 | 1993346 | 1994090 | 36 | 110 | 1 | N | 79.5 | 210.5 | 4200 | -43.5 | -100.5 |
| 1994055 | 1994121 | 1996102 | 67 | 712 | 1 | N | 88 | 93 | 3700 | -21 | 619 |

Sample Data (continued)

| Recomm buy date | Award date | Receipt date | Actual ALT | Actual PLT | CLIN | DVD | Sys ALT | Sys PLT | Qty | ALT Differ-ence | PLT Differ-ence |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1994317 | 1994348 | 1995069 | 32 | 87 | 1 | N | 80 | 96 | 4300 | -48 | -9 |
| 1995253 | 1996062 | 1996144 | 175 | 83 | 1 | N | 72 | 88 | 6405 | 103 | -5 |
| 1996070 | 1996153 | 1996242 | 84 | 90 | 1 | N | 45 | 85 | 8175 | 39 | 5 |
| 1997096 | 1997178 | 1998033 | 83 | 221 | 1 | N | 133 | 82 | 10400 | -50 | 139 |
| 1997274 | 1997330 | 1998097 | 57 | 133 | 1 | N | 133 | 90 | 3000 | -76 | 43 |
| 1997352 | 1998180 | 0 | 194 | | 1 | N | 133 | | 6825 | 61 | |
| 1998182 | 1998280 | 0 | 99 | | 1 | N | 101 | | 0 | -2 | |
| 1998260 | 1999011 | 0 | 117 | | 1 | N | 101 | | 0 | 16 | |
| 1998340 | 1999042 | 1999146 | 68 | 105 | 1 | N | 116 | 133 | 0 | -48 | -28 |
| 1999119 | 1999127 | 1999209 | 9 | 83 | 1 | N | 120 | 122 | 0 | -111 | -39 |
| **5315012720068** | | | | | | | | | | | |
| 1995267 | 1995317 | 1996185 | 51 | 234 | 2 | N | 151 | 119 | 1787 | -100 | 115 |
| 1995358 | 1996090 | 1996220 | 98 | 131 | 1 | N | 147.5 | 116 | 3000 | -49.5 | 15 |
| 1996046 | 1996050 | 1996072 | 5 | 23 | 2 | Y | 144 | 113 | 15 | -139 | -90 |
| 1996102 | 1996305 | 1997130 | 204 | 192 | 1 | N | 134 | 129 | 5000 | 70 | 63 |
| 1996310 | 1997042 | 1997228 | 99 | 187 | 1 | N | 134 | 145 | 2180 | -35 | 42 |
| 1998071 | 1998174 | 0 | 104 | | 2 | N | 78 | | 0 | 26 | |
| 1998172 | 1998211 | 0 | 40 | | 1 | N | 78 | | 0 | -38 | |
| 1998309 | 1999069 | 1999146 | 126 | 78 | 1 | N | 86 | 153 | 2590 | 40 | -75 |
| 1999052 | 1999097 | 1999174 | 46 | 78 | 2 | N | 70 | 153 | 2000 | -24 | -75 |
| **5340013238442** | | | | | | | | | | | |
| 1990223 | 1991128 | 1991275 | 271 | 148 | 1 | N | | 360 | 34 | | -212 |
| 1993248 | 1994153 | 1995047 | 271 | 260 | 1 | N | 270 | 257.5 | 29 | 1 | 2.5 |
| 1994124 | 1994144 | 1994160 | 21 | 17 | 1 | Y | 270 | 276 | 11 | -249 | -259 |
| 1994188 | 1994315 | 1995349 | 128 | 400 | 1 | N | 270 | 257.5 | 192 | -142 | 142.5 |

Sample Data (continued)

| Recomm buy date | Award date | Receipt date | Actual ALT | Actual PLT | CLIN | DVD | Sys ALT | Sys PLT | Qty | ALT Difference | PLT Difference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1994189 | 1994213 | 1994227 | 25 | 15 | 3 | Y | 270 | 257.5 | 1 | -245 | -242.5 |
| 1994190 | 1994213 | 1994227 | 24 | | 1 | Y | 270 | | 1 | -246 | |
| 1994194 | 1994213 | 1994242 | 20 | 30 | 4 | Y | 270 | 257.5 | 3 | -250 | -227.5 |
| 1994262 | 1994286 | 1994297 | 25 | 12 | 1 | Y | 270 | 257.5 | 10 | -245 | -245.5 |
| 1994296 | 1995202 | 1997113 | 272 | 643 | 1 | N | 270 | 245 | 504 | 2 | 398 |
| 1995162 | 1995172 | 1995195 | 11 | 24 | 1 | Y | 270 | 239 | 1 | -259 | -215 |
| 1995169 | 1995232 | 1995311 | 64 | 80 | 0001AC | N | 212 | 245 | 120 | -148 | -165 |
| 1995194 | 1995198 | 1995223 | 5 | 26 | 1 | Y | 212 | 245 | 10 | -207 | -219 |
| 1996014 | 1996048 | 1996145 | 35 | 98 | 1 | N | 154 | 251 | 225 | -119 | -153 |
| 1996042 | 1996088 | 1996326 | 47 | 239 | 0001AB | N | 212 | 245 | 302 | -165 | -6 |
| 1996066 | 1996131 | 1996281 | 66 | 151 | 0001AA | Y | 212 | 175.5 | 250 | -146 | -24.5 |
| 1996066 | 1996131 | 1996335 | | 205 | 0001AB | Y | | 175.5 | 216 | | 29.5 |
| 1996183 | 1996229 | 1996353 | 47 | 125 | 1 | N | 97 | 175.5 | 267 | -50 | -50.5 |
| 1996298 | 1996312 | 1997043 | 15 | 98 | 1 | N | 97 | 175.5 | 300 | -82 | -77.5 |
| 1996326 | 1997036 | 1997127 | 77 | 92 | 0001AA | Y | 97 | 100 | 210 | -20 | -8 |
| 1996333 | 1996353 | 1997064 | 21 | 78 | 1 | N | 97 | 175.5 | 300 | -76 | -97.5 |
| 1997019 | 1997166 | 1997197 | 148 | 32 | 0001AA | N | 40 | 83.5 | 200 | 108 | -51.5 |
| 1997083 | 1997222 | 0 | 140 | | 1 | Y | 97 | | 0 | 43 | |
| 1997166 | 1997183 | 1997281 | 18 | 99 | 1 | N | 41 | 83.5 | 350 | -23 | 15.5 |
| 1997182 | 1997206 | 1997309 | 25 | 104 | 1 | N | 41 | 83.5 | 234 | -16 | 20.5 |
| 1997201 | 1997222 | 1997303 | 22 | 82 | 0001AC | N | 41 | 83.5 | 100 | -19 | -1.5 |
| 1998060 | 1998134 | 1998289 | 75 | 156 | 0001AC | N | 42 | 93 | 300 | 33 | 63 |
| 1998162 | 1998280 | 1998321 | 119 | 42 | 1 | N | 42 | 72 | 195 | 77 | -30 |
| 1998273 | 1999008 | 1999022 | 101 | 15 | 0002AC | N | 53 | 69 | 100 | 48 | -54 |
| 1998273 | 1999008 | 1999025 | | 18 | 0001AA | Y | | 69 | 100 | | -51 |

Sample data (continued)

| Recomm buy date | Award date | Receipt date | Actual ALT | Actual PLT | CLIN | DVD | Sys ALT | Sys PLT | Qty | ALT Differ-ence | PLT Differ-ence |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1998273 | 1999008 | 1999070 | | 63 | 0002AD | N | | 69 | 422 | | -6 |
| 1998273 | 1999008 | 1999105 | | 98 | 0001AB | Y | | 69 | 314 | | 29 |
| 1999129 | 1999160 | 1999175 | 32 | 16 | 0001AA | N | 74 | 51 | 350 | -42 | -35 |
| 1999161 | 1999170 | 1999203 | 10 | 34 | 0001AB | N | 63.5 | 60 | 300 | -53.5 | -26 |

Non-problem Parts

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1680012138558** | | | | | | | | | | | |
| 1990238 | 1991039 | 1991265 | 167 | 227 | 3 | N | 113 | 259 | 175 | 54 | -32 |
| 1990350 | 1991039 | 1993170 | 55 | 863 | 3 | N | 113 | 259 | 805 | -58 | 604 |
| 1992198 | 1992327 | 1993324 | 130 | 364 | 2 | N | 113 | 259 | 417 | 17 | 105 |
| 1993057 | 1993063 | 1993351 | 7 | 289 | 1 | Y | 68 | 365 | 2 | -61 | -76 |
| 1993090 | 1993103 | 1993328 | 14 | 226 | 4 | Y | 90.5 | 347.5 | 1 | -76.5 | -121.5 |
| 1993096 | 1993103 | 1993328 | 8 | | 3 | Y | 68 | | 5 | -60 | |
| 1993097 | 1993103 | 1993328 | 7 | | 2 | Y | 68 | | 1 | -61 | |
| 1994006 | 1994119 | 1994278 | 114 | 160 | 3 | N | 68 | 330 | 225 | 46 | -170 |
| 1995239 | 1995335 | 1996209 | 97 | 240 | 1 | N | 68 | 301 | 176 | 29 | -61 |
| 1996214 | 1996325 | 1997077 | 112 | 119 | 1 | N | 68 | 206 | 150 | 44 | -87 |
| 1996319 | 1997237 | 1998338 | 285 | 467 | 1 | N | 77.5 | 223 | 30 | 207.5 | 244 |
| 1997261 | 1997309 | 1998125 | 49 | 182 | 1 | N | 87 | 186.5 | 390 | -38 | -4.5 |
| 1998244 | 1999092 | 0 | 214 | | 1 | N | 106 | | 0 | 108 | |
| **2840011984854** | | | | | | | | | | | |
| 1997159 | 1998135 | 1999177 | 342 | 408 | 1 | N | | 304 | 255 | | 104 |
| **2840013224756** | | | | | | | | | | | |
| 1998315 | 1999043 | 0 | 94 | | 0001AA | N | 177 | | 0 | -83 | |
| 1999066 | 1999113 | 0 | 48 | | 1 | N | 177 | | 0 | -129 | |

Sample Data (continued)

| Recomm buy date | Award date | Receipt date | Actual ALT | Actual PLT | CLIN | DVD | Sys ALT | Sys PLT | Qty | ALT Differ-ence | PLT Differ-ence |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **2925011909352** | | | | | | | | | | | |
| 1995064 | 1995233 | 1996058 | 170 | 191 | 0001AA | N | 250 | 240 | 325 | -80 | -49 |
| 1995197 | 1995293 | 1996118 | 97 | 191 | 1 | N | 215.5 | 225.5 | 141 | -118.5 | -34.5 |
| 1996049 | 1996214 | 1997094 | 166 | 247 | 0001AA | N | 181 | 211 | 500 | -15 | 36 |
| 1996222 | 1996274 | 1996295 | 53 | 22 | 4 | Y | 181 | 198 | 2 | -128 | -176 |
| 1996245 | 1996297 | 1997155 | 53 | 225 | 1 | N | 181 | 198 | 109 | -128 | 27 |
| 1996255 | 1996274 | 1996295 | 20 | 22 | 2 | Y | 181 | 198 | 1 | -161 | -176 |
| 1996302 | 1996320 | 1997036 | 19 | 83 | 1 | Y | 181 | 198 | 1 | -162 | -115 |
| 1996326 | 1996328 | 1996362 | 3 | 35 | 1 | Y | 181 | 198 | 2 | -178 | -163 |
| 1997100 | 1998028 | 1998155 | 294 | 128 | 0001AA | N | 181 | 168 | 150 | 113 | -40 |
| 1997348 | 1998071 | 1999051 | 89 | 346 | 5001AB | N | 120.5 | 176.5 | 150 | -31.5 | 169.5 |
| 1998067 | 1999085 | 0 | 384 | | 0001AA | N | 60 | | 0 | 324 | |
| 1999066 | 1999139 | 0 | 74 | | 5001AA | N | 293 | | 0 | -219 | |
| **6685011730502** | | | | | | | | | | | |
| 1994006 | 1994172 | 1994299 | 167 | 128 | 2 | N | 90 | 365 | 49 | 77 | -237 |
| 1995121 | 1995332 | 1996144 | 212 | 178 | 0001AA | N | 141 | 122 | 50 | 71 | 56 |
| 1996025 | 1996089 | 1997030 | 65 | 308 | 6 | N | 141 | 152 | 63 | -76 | 156 |
| 1996189 | 1996239 | 1997036 | 51 | 164 | 5001AA | N | 141 | 159 | 50 | -90 | 5 |
| 1996242 | 1997227 | 1998160 | 352 | 299 | 1 | N | 141 | 166 | 40 | 211 | 133 |
| 1997225 | 1997227 | 1998069 | 3 | 208 | 0003AB | N | 141 | 166 | 50 | -138 | 42 |
| 1999136 | 1999147 | 1999190 | 12 | 44 | 1 | N | 180 | 277 | 0 | -168 | -233 |
| **4010009290041** | | | | | | | | | | | |
| 1991041 | 1991100 | 1991268 | 60 | 169 | 2 | N | 210 | 90 | 40000 | -150 | 79 |
| 1991077 | 1991118 | 1991165 | 42 | 48 | 1 | Y | 139.5 | 132.5 | 2997 | -97.5 | -84.5 |
| 1991218 | 1992009 | 1992046 | 157 | 38 | 2 | N | 134.5 | 175 | 38000 | 22.5 | -137 |

Sample Data (continued)

| Recomm buy date | Award date | Receipt date | Actual ALT | Actual PLT | CLIN | DVD | Sys ALT | Sys PLT | Qty | ALT Differ-ence | PLT Differ-ence |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1992030 | 1992057 | 1992182 | 28 | 126 | 0021AA | N | 59 | 132.5 | 20000 | -31 | -6.5 |
| 1992212 | 1992283 | 1993096 | 72 | 180 | 0021AA | N | 49.5 | 146.5 | 30000 | 22.5 | 33.5 |
| 1992250 | 1992280 | 1993096 | 31 | 183 | 0021AB | N | 49.5 | 146.5 | 18000 | -18.5 | 36.5 |
| 1993152 | 1993224 | 1994095 | 73 | 237 | 0021AA | N | 40 | 118 | 80000 | 33 | 119 |
| 1994005 | 1994040 | 1994140 | 36 | 101 | 0021AA | N | 40 | 162 | 105000 | -4 | -61 |
| 1994182 | 1994224 | 1995068 | 43 | 210 | 0021AA | N | 40 | 150 | 100000 | 3 | 60 |
| 1995265 | 1996088 | 1996161 | 189 | 74 | 2 | N | 40 | 137 | 75000 | 149 | -63 |
| 1996133 | 1996197 | 1996299 | 65 | 103 | 1 | N | 40 | 123 | 72000 | 25 | -20 |
| 1996350 | 1997080 | 1997233 | 97 | 154 | 1 | N | 80 | 109 | 62000 | 17 | 45 |
| 1997187 | 1997309 | 1997364 | 123 | 56 | 2 | N | 120 | 105.5 | 61000 | 3 | -49.5 |
| 1998116 | 1998243 | 1998316 | 128 | 74 | 1 | N | 116 | 94 | 170000 | 12 | -20 |
| **5365012137700** | | | | | | | | | | | |
| 1989279 | 1990081 | 1990272 | 168 | 192 | 2 | N | | 250 | 2100 | | -58 |
| 1990056 | 1990117 | 0 | 62 | | 1 | N | 94 | | 0 | -32 | |
| 1990133 | 1990194 | 1992022 | 62 | 559 | 2 | N | 79.5 | 241.5 | 1000 | -17.5 | 317.5 |
| 1990164 | 1990172 | 1990193 | 9 | 22 | 1 | Y | 79.5 | 241.5 | 75 | -70.5 | -219.5 |
| 1990166 | 1990172 | 1990193 | 7 | | 2 | Y | 79.5 | | 125 | -72.5 | |
| 1990171 | 1990177 | 1990213 | 7 | 37 | 3 | Y | 79.5 | 241.5 | 4 | -72.5 | -204.5 |
| 1990180 | 1990200 | 1990227 | 21 | 28 | 1 | Y | 79.5 | 241.5 | 24 | -58.5 | -213.5 |
| 1990187 | 1990200 | 1990227 | 14 | | 1 | Y | 79.5 | | 24 | -65.5 | |
| 1990194 | 1990206 | 1990233 | 13 | 28 | 1 | Y | 79.5 | 241.5 | 2 | -66.5 | -213.5 |
| 1990200 | 1990233 | 1990262 | 34 | 30 | 1 | Y | 79.5 | 241.5 | 9 | -45.5 | -211.5 |
| 1990202 | 1990233 | 1990262 | 32 | | 2 | Y | 79.5 | | 24 | -47.5 | |
| 1990205 | 1990233 | 1990262 | 29 | | 2 | Y | 79.5 | | 24 | -50.5 | |
| 1990207 | 1990226 | 1990253 | 20 | 28 | 3 | Y | 79.5 | 241.5 | 6 | -59.5 | -213.5 |

Sample Data (continued)

| Recomm buy date | Award date | Receipt date | Actual ALT | Actual PLT | CLIN | DVD | Sys ALT | Sys PLT | Qty | ALT Difference | PLT Difference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1990219 | 1990232 | 1990262 | 14 | 31 | 3 | Y | 79.5 | 241.5 | 1 | -65.5 | -210.5 |
| 1990220 | 1990232 | 1990262 | 13 | | 6 | Y | 79.5 | | 4 | -66.5 | |
| 1990221 | 1990233 | 1990262 | 13 | 30 | 1 | Y | 79.5 | 241.5 | 3 | -66.5 | -211.5 |
| 1990222 | 1990233 | 1990262 | 12 | | 4 | Y | 79.5 | | 12 | -67.5 | |
| 1990226 | 1990233 | 1990262 | 8 | | 6 | Y | 79.5 | | 24 | -71.5 | |
| 1990228 | 1990242 | 1990269 | 15 | 28 | 2 | Y | 79.5 | 241.5 | 1 | -64.5 | -213.5 |
| 1990234 | 1990249 | 0 | 16 | | 2 | Y | 79.5 | | 0 | -63.5 | |
| 1990236 | 1990249 | 0 | 14 | | 4 | Y | 79.5 | | 0 | -65.5 | |
| 1990237 | 1990249 | 0 | 13 | | 5 | Y | 79.5 | | 0 | -66.5 | |
| 1990238 | 1990332 | 0 | 95 | | 1 | N | 79.5 | | 0 | 15.5 | |
| 1990242 | 1990254 | 0 | 13 | | 2 | Y | 79.5 | | 0 | -66.5 | |
| 1990249 | 1990267 | 0 | 19 | | 2 | Y | 79.5 | | 0 | -60.5 | |
| 1990251 | 1990267 | 0 | 17 | | 3 | Y | 79.5 | | 0 | -62.5 | |
| 1990255 | 1990270 | 0 | 16 | | 1 | Y | 79.5 | | 0 | -63.5 | |
| 1990261 | 1990269 | 0 | 9 | | 1 | Y | 79.5 | | 0 | -70.5 | |
| 1990263 | 1990269 | 0 | 7 | | 2 | Y | 79.5 | | 0 | -72.5 | |
| 1990308 | 1991033 | 1991273 | 91 | 241 | 3 | N | 79.5 | 233 | 1640 | 11.5 | 8 |
| 1991027 | 1991132 | 1991256 | 106 | 125 | 1 | N | 65 | 170.5 | 3418 | 41 | -45.5 |
| 1991094 | 1991184 | 1991271 | 91 | 88 | 0001AB | N | 80.5 | 170.5 | 4000 | 10.5 | -82.5 |
| 1991096 | 1991112 | 1991126 | 17 | 15 | 1 | Y | 80.5 | 170.5 | 24 | -63.5 | -155.5 |
| 1991150 | 1991348 | 1992184 | 199 | 202 | 1 | N | 80.5 | 170.5 | 7035 | 118.5 | 31.5 |
| 1991171 | 1991184 | 1991214 | 14 | 31 | 5 | Y | 80.5 | 170.5 | 23 | -66.5 | -139.5 |
| 1991179 | 1991196 | 1991214 | 18 | 19 | 2 | Y | 80.5 | 170.5 | 24 | -62.5 | -151.5 |
| 1991184 | 1991270 | 1991310 | 87 | 41 | 4 | Y | 80.5 | 170.5 | 14 | 6.5 | -129.5 |
| 1991197 | 1991206 | 1991241 | 10 | 36 | 5 | Y | 80.5 | 170.5 | 24 | -70.5 | -134.5 |

Sample Data (continued)

| Recomm buy date | Award date | Receipt date | Actual ALT | Actual PLT | CLIN | DVD | Sys ALT | Sys PLT | Qty | ALT Differ-ence | PLT Differ-ence |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1991199 | 1991207 | 1991218 | 9 | 12 | 1 | Y | 80.5 | 170.5 | 24 | -71.5 | -158.5 |
| 1991200 | 1991212 | 1991241 | 13 | 30 | 2 | Y | 80.5 | 170.5 | 24 | -67.5 | -140.5 |
| 1991206 | 1991224 | 1991239 | 19 | 16 | 1 | Y | 80.5 | 170.5 | 24 | -61.5 | -154.5 |
| 1991214 | 1991227 | 1991239 | 14 | 13 | 1 | Y | 80.5 | 170.5 | 24 | -66.5 | -157.5 |
| 1991226 | 1991235 | 1991259 | 10 | 25 | 1 | Y | 80.5 | 170.5 | 14 | -70.5 | -145.5 |
| 1991253 | 1991266 | 1991283 | 14 | 18 | 2 | Y | 80.5 | 170.5 | 24 | -66.5 | -152.5 |
| 1996095 | 1996138 | 0 | 44 | | 1 | N | 92 | | 0 | -48 | |
| 1996179 | 1996281 | 1997036 | 103 | 122 | 1 | N | 82.5 | 111.5 | 1565 | 20.5 | 10.5 |
| 1997219 | 1997297 | 1998049 | 79 | 118 | 1 | N | 73 | 121 | 1710 | 6 | -3 |
| 1997331 | 1998009 | 0 | 44 | | 1 | N | 78 | | 0 | -34 | |
| 1998214 | 1998299 | 0 | 86 | | 1 | N | 68 | | 0 | 18 | |
| 1999010 | 1999056 | 0 | 47 | | 1 | N | 68 | | 0 | -21 | |
| **5365013232790** | | | | | | | | | | | |
| 1990223 | 1991122 | 1992009 | 265 | 253 | 1 | N | | 360 | 26 | | -107 |
| 1991206 | 1991235 | 1991259 | 30 | 25 | 1 | Y | 95 | 323 | 1 | -65 | -298 |
| 1996340 | 1997283 | 1998099 | 310 | 182 | 1 | N | 95 | 263 | 31 | 215 | -81 |
| 1997320 | 1998029 | 1998189 | 75 | 161 | 1 | N | 95 | 250 | 42 | -20 | -89 |
| 1998025 | 1998120 | 1998356 | 96 | 237 | 1 | N | 95 | 263 | 53 | 1 | -26 |
| 1998031 | 1998035 | 1998056 | 5 | 22 | 1 | Y | 95 | 256.5 | 1 | -90 | -234.5 |
| **5365013232794** | | | | | | | | | | | |
| 1991069 | 1991312 | 1991362 | 244 | 51 | 1 | N | 95 | 270 | 135 | 149 | -219 |
| 1995348 | 1995354 | 1996064 | 7 | 76 | 1 | Y | 194 | 143 | 1 | -187 | -67 |
| 1996108 | 1996110 | 1996166 | 3 | 57 | 1 | Y | 194 | 143 | 41 | -191 | -86 |
| 1996112 | 1996281 | 1997063 | 170 | 149 | 2 | N | 147 | 143 | 57 | 23 | 6 |
| 1996189 | 1996281 | 1997071 | 93 | 157 | 1 | N | 147 | 143 | 110 | -54 | 14 |

Sample Data (continued)

| Recomm buy date | Award date | Receipt date | Actual ALT | Actual PLT | CLIN | DVD | Sys ALT | Sys PLT | Qty | ALT Differ-ence | PLT Differ-ence |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1996305 | 1997013 | 1997226 | 75 | 214 | 1 | N | 147 | 143 | 204 | -72 | 71 |
| 1996322 | 1997074 | 1997155 | 119 | 82 | 1 | N | 147 | 143 | 750 | -28 | -61 |
| 1997219 | 1997269 | 1998093 | 51 | 190 | 1 | N | 100 | 153.5 | 2500 | -49 | 36.5 |
| 1998039 | 1998087 | 1998274 | 49 | 188 | 1 | N | 75 | 164 | 3150 | -26 | 24 |
| **5306005514845** | | | | | | | | | | | |
| 1991027 | 1991088 | 1991347 | 62 | 260 | 2 | N | 171 | 243 | 10500 | -109 | 17 |
| 1996139 | 1996144 | 1996207 | 6 | 64 | 1 | Y | 100 | 228 | 49 | -94 | -164 |
| **5306011739537** | | | | | | | | | | | |
| 1998155 | 1998318 | 1999084 | 164 | 132 | 1 | N | 124 | 124 | 6669 | 40 | 8 |
| 1998260 | 1998348 | 1999093 | 89 | 111 | 2 | N | 124 | 124 | 3022 | -35 | -13 |
| 1998323 | 1998348 | 1999093 | 26 | | 1 | N | 124 | | 1819 | -98 | |
| **5306011753619** | | | | | | | | | | | |
| 1995229 | 1995319 | 1996101 | 91 | 148 | 0001AB | N | 95 | 202 | 10940 | -4 | -54 |
| 1996067 | 1996124 | 1997004 | 58 | 247 | 1 | N | 130 | 289 | 5000 | -72 | -42 |
| 1996165 | 1996185 | 1997065 | 21 | 247 | 1 | N | 97 | 203.5 | 5240 | -76 | 43.5 |
| 1996284 | 1996359 | 1997073 | 76 | 81 | 1 | N | 97 | 203.5 | 4620 | -21 | -122.5 |
| 1996357 | 1997004 | 1997065 | 14 | 62 | 1 | N | 97 | 118 | 9154 | -83 | -56 |
| 1997264 | 1997268 | 0 | 5 | | 1 | N | 64 | | 0 | -59 | |
| 1998081 | 1998217 | 1998245 | 137 | 29 | 2 | N | 28 | 104 | 4515 | 109 | -75 |
| 1998137 | 1998217 | 1998240 | 81 | 24 | 1 | N | 28 | 104 | 8400 | 53 | -80 |
| 1998221 | 1998295 | 1998343 | 75 | 49 | 1 | N | 28 | 104 | 5300 | 47 | -55 |
| 1998281 | 1999101 | 1999163 | 186 | 63 | 2 | N | 60 | 61 | 5250 | 126 | 2 |
| **5306013235467** | | | | | | | | | | | |
| 1991069 | 1992017 | 1992351 | 314 | 335 | 1 | N | 118 | 200 | 105 | 196 | 135 |
| 1991283 | 1991297 | 1991322 | 15 | 26 | 1 | Y | 118 | 300 | 1 | -103 | -274 |

Sample Data (continued)

| Recomm buy date | Award date | Receipt date | Actual ALT | Actual PLT | CLIN | DVD | Sys ALT | Sys PLT | Qty | ALT Differ-ence | PLT Differ-ence |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1992019 | 1992166 | 1993192 | 148 | 393 | 1 | N | 118 | 200 | 100 | 30 | 193 |
| 1993185 | 1994117 | 1994200 | 298 | 84 | 1 | N | 137 | 297 | 100 | 161 | -213 |
| 1994005 | 1994117 | 1994200 | 113 |  | 2 | N | 137 |  | 77 | -24 |  |
| 1995244 | 1995278 | 1996115 | 35 | 203 | 1 | N | 239 | 162 | 174 | -204 | 41 |
| 1997278 | 1998016 | 1998086 | 104 | 71 | 1 | N | 94 | 172 | 298 | 10 | -101 |
| **5310011774992** |  |  |  |  |  |  |  |  |  |  |  |
| 1996091 | 1996138 | 1996291 | 48 | 154 | 1 | N | 129 | 136 | 19440 | -81 | 18 |
| 1996109 | 1996291 | 1997037 | 183 | 113 | 0001AD | N | 96.5 | 109.5 | 15000 | 86.5 | 3.5 |
| 1996142 | 1996159 | 1996169 | 18 | 11 | 1 | Y | 96.5 | 109.5 | 68 | -78.5 | -98.5 |
| 1996158 | 1996173 | 1996258 | 16 | 86 | 1 | N | 96.5 | 109.5 | 2100 | -80.5 | -23.5 |
| 1996221 | 1996262 | 1996268 | 42 | 7 | 2 | N | 96.5 | 109.5 | 2393 | -54.5 | -102.5 |
| 1996221 | 1996272 | 1996346 | 52 | 75 | 1 | N | 96.5 | 109.5 | 4441 | -44.5 | -34.5 |
| 1996350 | 1997231 | 1997331 | 248 | 101 | 1 | N | 96.5 | 83 | 61770 | 151.5 | 18 |
| 1997331 | 1998222 | 1999013 | 257 | 157 | 3 | N | 64 | 83 | 16648 | 193 | 74 |
| 1998029 | 1998222 | 1999013 | 194 |  | 2 | N | 64 |  | 15000 | 130 |  |
| 1998183 | 1998189 | 1998219 | 7 | 31 | 0001AA | N | 64 | 83 | 7500 | -57 | -52 |
| 1998225 | 1998322 | 1999005 | 98 | 49 | 0001AB | N | 64 | 83 | 2553 | 34 | -34 |
| 1999017 | 1999085 | 1999198 | 69 | 114 | 1 | N | 45 | 68.5 | 33000 | 24 | 45.5 |
| 1999049 | 1999068 | 1999080 | 20 | 13 | 1 | N | 54.5 | 54 | 19000 | -34.5 | -41 |
| **5315011775964** |  |  |  |  |  |  |  |  |  |  |  |
| 1995288 | 1996241 | 1997191 | 319 | 317 | 1 | N | 95 | 82 | 6000 | 224 | 235 |
| 1996242 | 1996356 | 0 | 115 |  | 1 | N | 144 |  | 0 | -29 |  |
| 1997047 | 1997100 | 1997218 | 54 | 119 | 1 | N | 197 | 233.5 | 8400 | -143 | -114.5 |
| 1997056 | 1997063 | 1997083 | 8 | 21 | 6 | Y | 170.5 | 265 | 18 | -162.5 | -244 |
| 1997056 | 1997063 | 1997091 |  | 29 | 4 | Y |  | 265 | 20 |  | -236 |

Sample Data (continued)

| Recomm buy date | Award date | Receipt date | Actual ALT | Actual PLT | CLIN | DVD | Sys ALT | Sys PLT | Qty | ALT Differ-ence | PLT Differ-ence |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1997285 | 1998020 | 1998114 | 101 | 95 | 1 | N | 164 | 202 | 6300 | -63 | -107 |
| 1998281 | 1998325 | 1999140 | 45 | 181 | 1 | N | 121 | 134 | 1650 | -76 | 47 |
| **5315012692679** | | | | | | | | | | | |
| 1990098 | 1990241 | 1991060 | 144 | 185 | 1 | N | 156 | 217 | 1995 | -12 | -32 |
| 1990191 | 1990200 | 1990227 | 10 | 28 | 1 | Y | 151.5 | 154 | 18 | -141.5 | -126 |
| 1990249 | 1991073 | 1991177 | 190 | 105 | 1 | N | 151.5 | 280 | 1635 | 38.5 | -175 |
| 1991241 | 1992039 | 1992171 | 164 | 133 | 1 | N | 147 | 137 | 2310 | 17 | -4 |
| 1992173 | 1992263 | 1993015 | 91 | 119 | 1 | N | 175 | 133.5 | 1900 | -84 | -14.5 |
| 1993168 | 1993298 | 1994053 | 131 | 121 | 1 | N | 167 | 130 | 2900 | -36 | -9 |
| 1993297 | 1993353 | 1994138 | 57 | 151 | 1 | N | 141 | 125.5 | 3700 | -84 | 25.5 |
| 1994027 | 1994102 | 1994246 | 76 | 145 | 1 | N | 115 | 121 | 3400 | -39 | 24 |
| 1994170 | 1994347 | 1995054 | 178 | 73 | 1 | N | 95.5 | 132.5 | 3900 | 82.5 | -59.5 |
| 1994356 | 1995094 | 1995251 | 104 | 158 | 1 | N | 95.5 | 144 | 5300 | 8.5 | 14 |
| 1996102 | 1996163 | 1996214 | 62 | 52 | 1 | N | 96 | 119 | 4787 | -34 | -67 |
| 1997142 | 1997253 | 1997315 | 112 | 63 | 1 | N | 75 | 73 | 5292 | 37 | -10 |
| 1997296 | 1997351 | 1998085 | 56 | 100 | 1 | N | 72 | 75 | 8403 | -16 | 25 |
| 1998274 | 1998348 | 1999041 | 75 | 59 | 1 | N | 64 | 90 | 6820 | 11 | -31 |
| 1999098 | 1999144 | 1999210 | 47 | 67 | 1 | N | 93 | 85 | 0 | -46 | -18 |
| **5330000200203** | | | | | | | | | | | |
| 1990112 | 1990179 | 0 | 68 | | 1 | N | 114 | | 0 | -46 | |
| 1990238 | 1990358 | 1991239 | 121 | 247 | 2 | N | 91.5 | 179 | 144473 | 29.5 | 68 |
| 1990308 | 1991037 | 1991354 | 95 | 318 | 1 | N | 91.5 | 152 | 75143 | 3.5 | 166 |
| 1991060 | 1991298 | 0 | 239 | | 4 | N | 69 | | 0 | 170 | |
| 1991069 | 1991298 | 0 | 230 | | 9 | N | 91.5 | | 0 | 138.5 | |
| 1993346 | 1994090 | 1994253 | 110 | 164 | 1 | N | 216 | 177 | 66300 | -106 | -13 |

Sample Data (continued)

| Recomm buy date | Award date | Receipt date | Actual ALT | Actual PLT | CLIN | DVD | Sys ALT | Sys PLT | Qty | ALT Differ-ence | PLT Differ-ence |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1995005 | 1995087 | 1995203 | 83 | 117 | 1 | N | 144 | 134 | 57150 | -61 | -17 |
| 1995330 | 1995362 | 1996069 | 33 | 73 | 1 | N | 121 | 108.5 | 57906 | -88 | -35.5 |
| 1996343 | 1997024 | 1997144 | 48 | 121 | 1 | N | 98 | 89 | 54111 | -50 | 32 |
| 1997096 | 1997136 | 1997220 | 41 | 85 | 1 | N | 54 | 90.5 | 73330 | -13 | -5.5 |
| 1997180 | 1997364 | 1998183 | 185 | 185 | 1 | N | 50.5 | 90.5 | 73175 | 134.5 | 94.5 |
| 1998035 | 1998037 | 1998156 | 3 | 120 | 1 | Y | 47 | 92 | 610 | -44 | 28 |
| 1998036 | 1998038 | 1998156 | 3 | 119 | 1 | Y | 50.5 | 92 | 56 | -47.5 | 27 |
| 1998042 | 1998044 | 1998202 | 3 | 159 | 1 | Y | 50.5 | 90.5 | 33 | -47.5 | 68.5 |
| 1998051 | 1998055 | 1998195 | 5 | 141 | 1 | Y | 50.5 | 90.5 | 57 | -45.5 | 50.5 |
| 1998056 | 1998058 | 1998159 | 3 | 102 | 1 | Y | 50.5 | 90.5 | 78 | -47.5 | 11.5 |
| 1998060 | 1998064 | 1998159 | 5 | 96 | 1 | Y | 50.5 | 90.5 | 48 | -45.5 | 5.5 |
| 1998061 | 1998064 | 1998159 | 4 | 96 | 1 | Y | 50.5 | 90.5 | 521 | -46.5 | 5.5 |
| 1998063 | 1998065 | 1998160 | 3 | 96 | 1 | Y | 50.5 | 90.5 | 60 | -47.5 | 5.5 |
| 1998066 | 1998069 | 1998159 | 4 | 91 | 1 | Y | 50.5 | 90.5 | 171 | -46.5 | 0.5 |
| 1998071 | 1998073 | 1998159 | 3 | 87 | 1 | Y | 50.5 | 90.5 | 169 | -47.5 | -3.5 |
| 1998077 | 1998079 | 1998160 | 3 | 82 | 1 | Y | 50.5 | 90.5 | 4 | -47.5 | -8.5 |
| 1998082 | 1998203 | 1998337 | 122 | 135 | 1 | Y | 50.5 | 92.5 | 100 | 71.5 | 42.5 |
| 1998104 | 1998106 | 1998160 | 3 | 55 | 1 | Y | 47 | 92 | 5 | -44 | -37 |
| 1998120 | 1998125 | 1998160 | 6 | 36 | 1 | Y | 47 | 92 | 4 | -41 | -56 |
| 1998122 | 1998125 | 1998160 | 4 | 36 | 1 | Y | 47 | 92 | 3 | -43 | -56 |
| 1998122 | 1998125 | 1998161 | 4 | 37 | 1 | Y | 47 | 92 | 382 | -43 | -55 |
| 1998126 | 1998128 | 1998202 | 3 | 75 | 1 | Y | 47 | 92 | 26 | -44 | -17 |
| 1998128 | 1998132 | 1998202 | 5 | 71 | 1 | Y | 47 | 92 | 93 | -42 | -21 |
| 1998129 | 1998132 | 1998202 | 4 | 71 | 1 | Y | 47 | 92 | 34 | -43 | -21 |
| 1998130 | 1998133 | 1998216 | 4 | 84 | 1 | Y | 47 | 92 | 138 | -43 | -8 |

Sample Data (continued)

| Recomm buy date | Award date | Receipt date | Actual ALT | Actual PLT | CLIN | DVD | Sys ALT | Sys PLT | Qty | ALT Differ-ence | PLT Differ-ence |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1998132 | 1998134 | 1998229 | 3 | 96 | 1 | Y | 47 | 92 | 90 | -44 | 4 |
| 1998133 | 1998135 | 1998173 | 3 | 39 | 1 | Y | 47 | 92 | 2 | -44 | -53 |
| 1998134 | 1998136 | 1998225 | 3 | 90 | 1 | Y | 47 | 92 | 29 | -44 | -2 |
| 1998135 | 1998139 | 1998226 | 5 | 88 | 1 | Y | 47 | 92 | 81 | -42 | -4 |
| 1998135 | 1998139 | 1998226 | 5 | 88 | 1 | Y | 47 | 92 | 585 | -42 | -4 |
| 1998137 | 1998140 | 1998226 | 4 | 87 | 1 | Y | 47 | 92 | 33 | -43 | -5 |
| 1998138 | 1998140 | 1998226 | 3 | 87 | 1 | Y | 47 | 92 | 295 | -44 | -5 |
| 1998140 | 1998142 | 1998226 | 3 | 85 | 1 | Y | 47 | 92 | 58 | -44 | -7 |
| 1998142 | 1998147 | 1998226 | 6 | 80 | 1 | Y | 47 | 92 | 75 | -41 | -12 |
| 1998144 | 1998148 | 1998225 | 5 | 78 | 1 | Y | 47 | 92 | 8 | -42 | -14 |
| 1998149 | 1998152 | 1998226 | 4 | 75 | 1 | Y | 47 | 92 | 52 | -43 | -17 |
| 1998164 | 1998167 | 1998226 | 4 | 60 | 1 | Y | 47 | 92 | 149 | -43 | -32 |
| 1998167 | 1998169 | 1998226 | 3 | 58 | 1 | Y | 47 | 92 | 29 | -44 | -34 |
| 1998170 | 1998174 | 1998225 | 5 | 52 | 1 | Y | 47 | 92 | 8 | -42 | -40 |
| 1998170 | 1998174 | 1998226 | 5 | 53 | 1 | Y | 47 | 92 | 245 | -42 | -39 |
| 1998171 | 1998174 | 1998225 | 4 | 52 | 1 | Y | 47 | 92 | 4 | -43 | -40 |
| 1998174 | 1998176 | 1998229 | 3 | 54 | 1 | Y | 47 | 92 | 50 | -44 | -38 |
| 1998176 | 1998178 | 1998226 | 3 | 49 | 1 | Y | 47 | 92 | 2 | -44 | -43 |
| 1998178 | 1998181 | 1998260 | 4 | 80 | 1 | Y | 47 | 92 | 16 | -43 | -12 |
| 1998180 | 1998182 | 1998260 | 3 | 79 | 1 | Y | 47 | 92.5 | 2 | -44 | -13.5 |
| 1998180 | 1998182 | 1998261 | 3 | 80 | 1 | Y | 47 | 92.5 | 25 | -44 | -12.5 |
| 1998182 | 1998188 | 1998229 | 7 | 42 | 1 | Y | 47 | 93 | 41 | -40 | -51 |
| 1998183 | 1998188 | 1998226 | 6 | 39 | 1 | Y | 47 | 93 | 3 | -41 | -54 |
| 1998192 | 1998195 | 1998232 | 4 | 38 | 1 | Y | 47 | 92.5 | 45 | -43 | -54.5 |
| 1998197 | 1998199 | 1998218 | 3 | 20 | 1 | Y | 47 | 92.5 | 49 | -44 | -72.5 |

Sample Data (continued)

| Recomm buy date | Award date | Receipt date | Actual ALT | Actual PLT | CLIN | DVD | Sys ALT | Sys PLT | Qty | ALT Differ-ence | PLT Differ-ence |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1998199 | 1998203 | 1998230 | 5 | 28 | 1 | Y | 47 | 92.5 | 15 | -42 | -64.5 |
| 1998201 | 1998203 | 1998279 | 3 | 77 | 1 | Y | 47 | 92.5 | 33 | -44 | -15.5 |
| 1998202 | 1998204 | 1998231 | 3 | 28 | 1 | Y | 47 | 92.5 | 253 | -44 | -64.5 |
| 1998203 | 1998205 | 1998231 | 3 | 27 | 1 | Y | 47 | 92.5 | 9 | -44 | -65.5 |
| 1998204 | 1998206 | 1998265 | 3 | 60 | 1 | Y | 47 | 92.5 | 439 | -44 | -32.5 |
| 1998206 | 1998209 | 1998246 | 4 | 38 | 1 | Y | 47 | 92.5 | 25 | -43 | -54.5 |
| 1998209 | 1998211 | 1998244 | 3 | 34 | 1 | Y | 47 | 92.5 | 2 | -44 | -58.5 |
| 1998225 | 1998254 | 1999042 | 30 | 154 | 0001AB | N | 47 | 92.5 | 59165 | -17 | 61.5 |
| 1999129 | 1999179 | 0 | 51 | | 1 | N | 41 | | 0 | 10 | |
| **5330012346378** | | | | | | | | | | | |
| 1991290 | 1992059 | 1992105 | 135 | 47 | 3 | N | | 94 | 500 | | -47 |
| 1992008 | 1992024 | 1992050 | 17 | 27 | 1 | Y | 146 | 188 | 31 | -129 | -161 |
| 1992055 | 1992073 | 1992094 | 19 | 22 | 2 | Y | 73 | 94 | 40 | -54 | -72 |
| 1992064 | 1992085 | 1992118 | 22 | 34 | 1 | Y | 73 | 94 | 40 | -51 | -60 |
| 1992084 | 1992101 | 1992125 | 18 | | 1 | Y | 73 | | 4 | -55 | |
| 1992098 | 1992101 | 1992125 | 4 | 25 | 2 | Y | 134.5 | 155.5 | 4 | -130.5 | -130.5 |
| 1992099 | 1992105 | 1992118 | 7 | 14 | 1 | Y | 134.5 | 155.5 | 40 | -127.5 | -141.5 |
| 1992110 | 1992339 | 1993089 | 230 | 117 | 1 | N | 134.5 | 155.5 | 3845 | 95.5 | -38.5 |
| 1992140 | 1992162 | 1992171 | 23 | 10 | 1 | Y | 134.5 | 155.5 | 1 | -111.5 | -145.5 |
| 1992156 | 1992178 | 1992213 | 23 | 36 | 1 | Y | 134.5 | 155.5 | 40 | -111.5 | -119.5 |
| 1992245 | 1993038 | 1993167 | 160 | 130 | 1 | Y | 134.5 | 155.5 | 3313 | 25.5 | -25.5 |
| 1992311 | 1992325 | 1992343 | 15 | 19 | 1 | Y | 134.5 | 155.5 | 40 | -119.5 | -136.5 |
| 1992317 | 1992321 | 1992343 | 5 | 23 | 1 | Y | 134.5 | 155.5 | 40 | -129.5 | -132.5 |
| 1992343 | 1992363 | 1993057 | 21 | 61 | 2 | Y | 134.5 | 155.5 | 40 | -113.5 | -94.5 |

Sample Data (continued)

| Recomm buy date | Award date | Receipt date | Actual ALT | Actual PLT | CLIN | DVD | Sys ALT | Sys PLT | Qty | ALT Differ-ence | PLT Differ-ence |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1992350 | 1992363 | 1993061 | 14 | 65 | 4 | Y | 134.5 | 155.5 | 40 | -120.5 | -90.5 |
| 1993008 | 1993039 | 1993050 | 32 | 12 | 1 | Y | 134.5 | 123 | 2 | -102.5 | -111 |
| 1993024 | 1993315 | 1994049 | 292 | 100 | 2 | N | 134.5 | 103.5 | 8930 | 157.5 | -3.5 |
| 1993026 | 1993043 | 1993061 | 18 | 19 | 1 | Y | 134.5 | 155.5 | 40 | -116.5 | -136.5 |
| 1993036 | 1993071 | 1993083 | 36 | 13 | 2 | Y | 134.5 | 155.5 | 40 | -98.5 | -142.5 |
| 1993047 | 1993071 | 1993083 | 25 | | 3 | Y | 134.5 | | 40 | -109.5 | |
| 1993056 | 1993071 | 1993083 | 16 | | 1 | Y | 134.5 | | 40 | -118.5 | |
| 1993065 | 1993078 | 1993090 | 14 | 13 | 1 | Y | 134.5 | 155.5 | 40 | -120.5 | -142.5 |
| 1993069 | 1993085 | 1993095 | 17 | 11 | 1 | Y | 134.5 | 155.5 | 40 | -117.5 | -144.5 |
| 1993098 | 1993105 | 1993110 | 8 | 6 | 1 | Y | 123 | 103.5 | 38 | -115 | -97.5 |
| 1993159 | 1993190 | 1993231 | 32 | 42 | 2 | Y | 123 | 103.5 | 1414 | -91 | -61.5 |
| 1993166 | 1993315 | 1994053 | 150 | 104 | 1 | Y | 123 | 103.5 | 5586 | 27 | 0.5 |
| 1993182 | 1993190 | 1993230 | 9 | 41 | 1 | Y | 123 | 103.5 | 40 | -114 | -62.5 |
| 1993204 | 1993210 | 1993231 | 7 | 22 | 1 | Y | 123 | 103.5 | 40 | -116 | -81.5 |
| 1993210 | 1993260 | 1993342 | 51 | 83 | 1 | N | 123 | 103.5 | 4975 | -72 | -20.5 |
| 1993267 | 1993294 | 1993323 | 28 | 30 | 2 | Y | 123 | 103.5 | 25 | -95 | -73.5 |
| 1993287 | 1993295 | 1993312 | 9 | 18 | 1 | Y | 123 | 103.5 | 40 | -114 | -85.5 |
| 1993287 | 1993295 | 1994011 | | 82 | 3 | Y | | 103.5 | 30 | | -21.5 |
| 1993339 | 1994069 | 1994161 | 96 | 93 | 1 | N | 123 | 84 | 5885 | -27 | 9 |
| 1994139 | 1994180 | 1994264 | 42 | 85 | 0051AA | N | 123 | 88 | 3925 | -81 | -3 |
| 1995047 | 1995073 | 1995130 | 27 | 58 | 0051AA | N | 115 | 92 | 2940 | -88 | -34 |
| 1995260 | 1995276 | 1995341 | 17 | 66 | 51 | N | 102.5 | 91 | 2339 | -85.5 | -25 |
| 1995320 | 1996018 | 1996065 | 64 | 48 | 2 | N | 102.5 | 90 | 2656 | -38.5 | -42 |
| 1997194 | 1997258 | 1997310 | 65 | 53 | 1 | N | 72 | 58 | 3300 | -7 | -5 |
| 1997236 | 1997282 | 1997358 | 47 | 77 | 1 | N | 57.5 | 62.5 | 3600 | -10.5 | 14.5 |

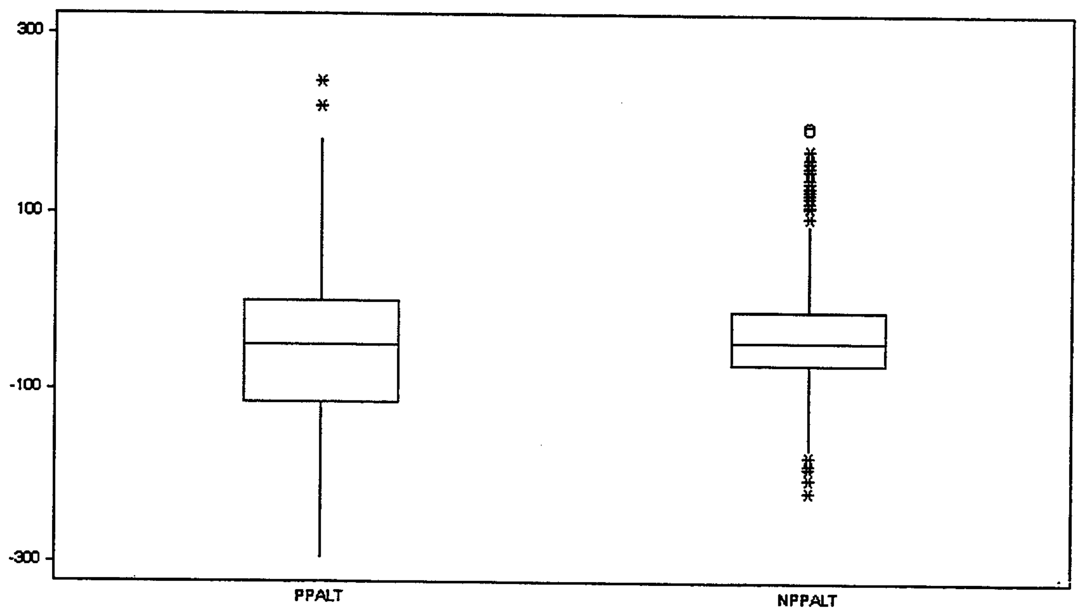
Sample Data (continued)

| Recomm buy date | Award date | Receipt date | Actual ALT | Actual PLT | CLIN | DVD | Sys ALT | Sys PLT | Qty | ALT Differ-ence | PLT Differ-ence |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1997289 | 1997307 | 1998009 | 19 | 68 | 1 | N | 57.5 | 62.5 | 3500 | -38.5 | 5.5 |
| 1997355 | 1998023 | 1998058 | 34 | 36 | 1 | N | 57.5 | 67 | 3000 | -23.5 | -31 |
| 1998064 | 1998096 | 1998161 | 33 | 66 | 1 | N | 43 | 73 | 4700 | -10 | -7 |
| 1998127 | 1998152 | 1998218 | 26 | 67 | 1 | N | 35 | 70 | 4000 | -9 | -3 |
| 1998225 | 1999015 | 1999063 | 156 | 49 | 1 | N | 34 | 67 | 6150 | 122 | -18 |
| 1999038 | 1999103 | 1999169 | 66 | 67 | 1 | N | 30 | 67 | 0 | 36 | 0 |
| **5331001660992** | | | | | | | | | | | |
| 1998116 | 1998154 | 1999007 | 39 | 219 | 1 | N | 58 | 83 | 95693 | -19 | 136 |
| **5331001660993** | | | | | | | | | | | |
| 1998152 | 1998180 | 1998272 | 29 | 93 | 1 | N | 39 | 105 | 35000 | -10 | -12 |
| **5331001661063** | | | | | | | | | | | |
| 1998081 | 1998132 | 1998317 | 52 | 186 | 1 | N | | 125 | 26444 | | 61 |
| 1998305 | 1998336 | 1999006 | 32 | 36 | 1 | N | 43 | 118 | 31000 | -11 | -82 |
| **5331001675110** | | | | | | | | | | | |
| 1998095 | 1998112 | 1998266 | 18 | 155 | 1 | N | 60 | 129 | 14662 | -42 | 26 |
| **5331001675143** | | | | | | | | | | | |
| 1998116 | 1998157 | 1998276 | 42 | 120 | 1 | N | 19 | 69 | 10382 | 23 | 51 |
| 1999073 | 1999109 | 1999161 | 37 | 53 | 2 | N | 26 | 95 | 3129 | 11 | -42 |

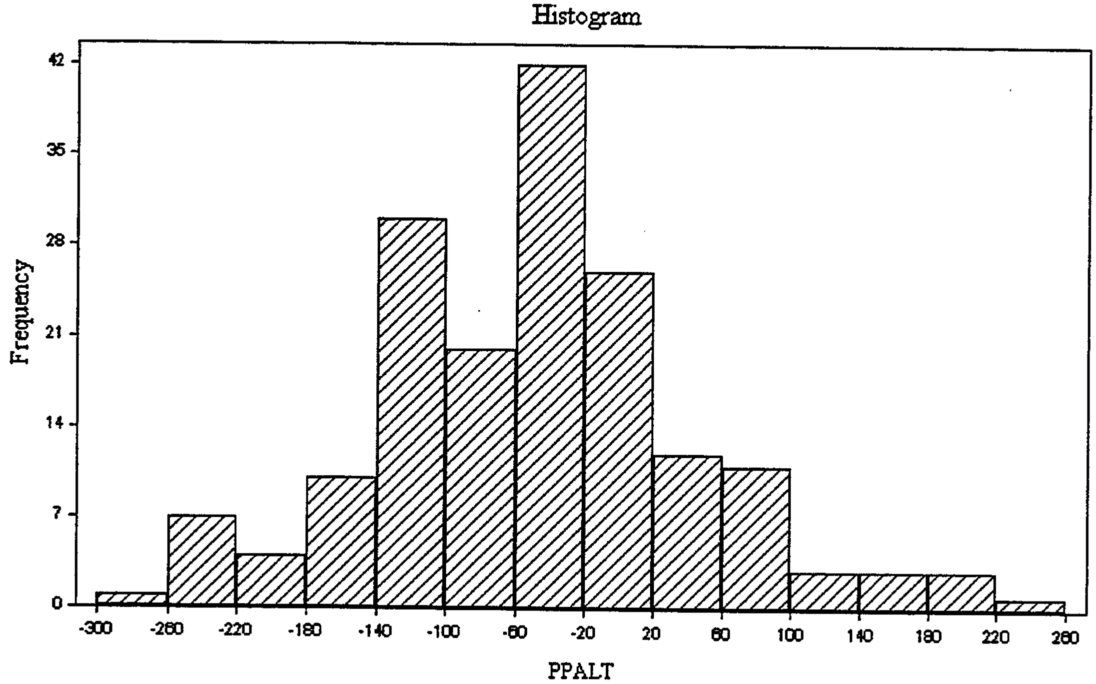
## Appendix E: Graphical Summaries of Sample Sets

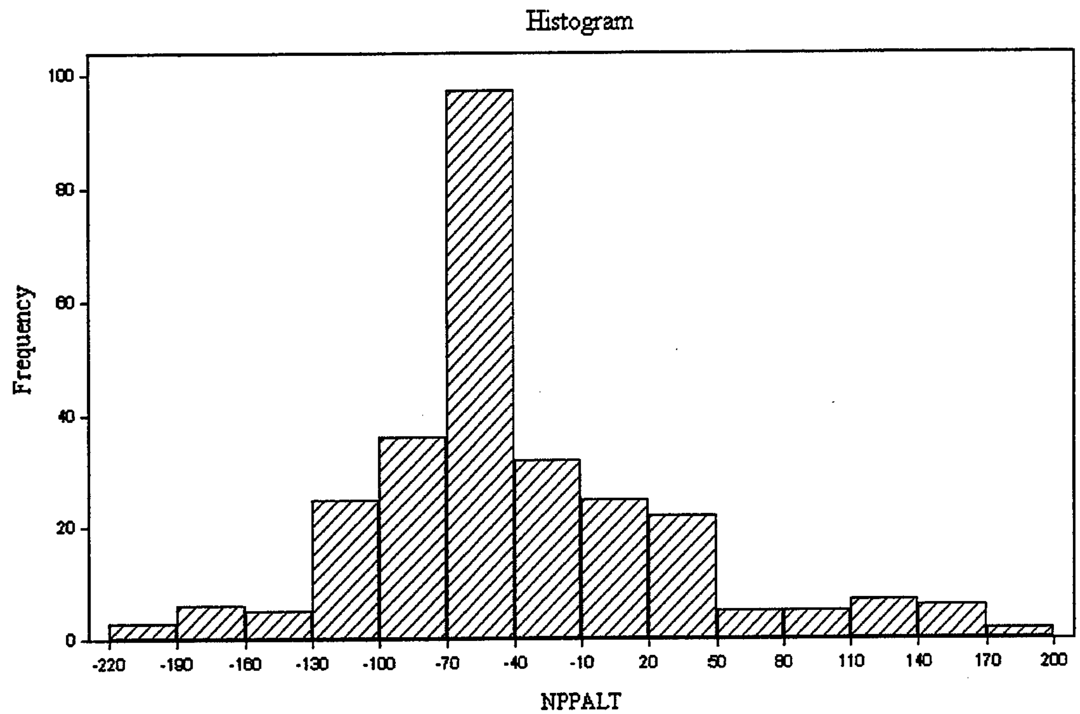
Case 1: Administrative Lead Time

Box and Whisker Plot

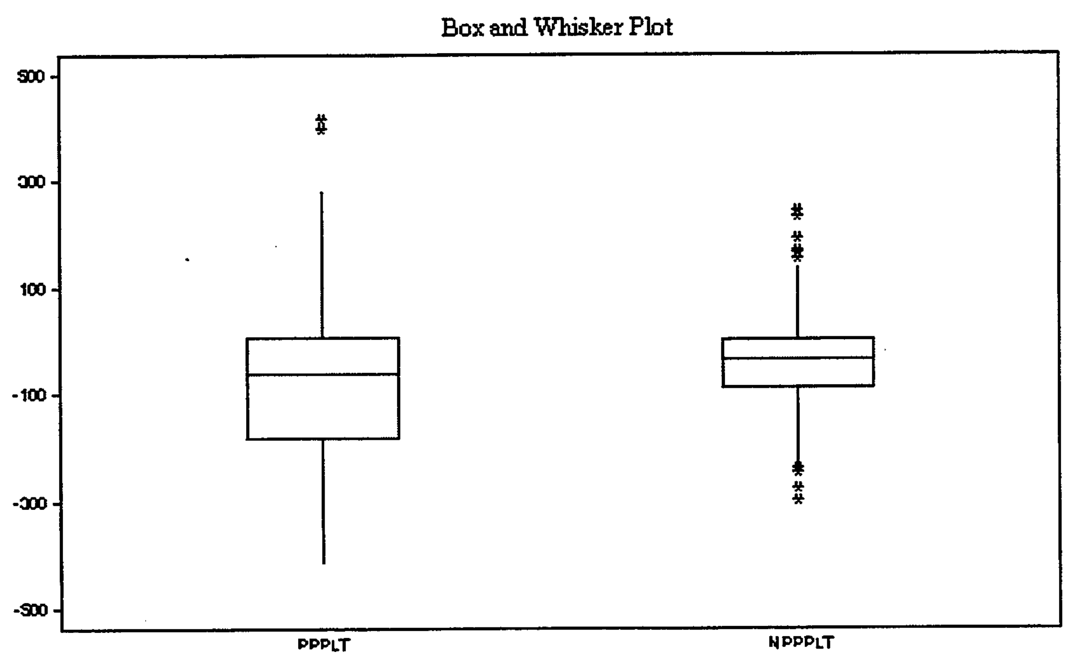



Histogram

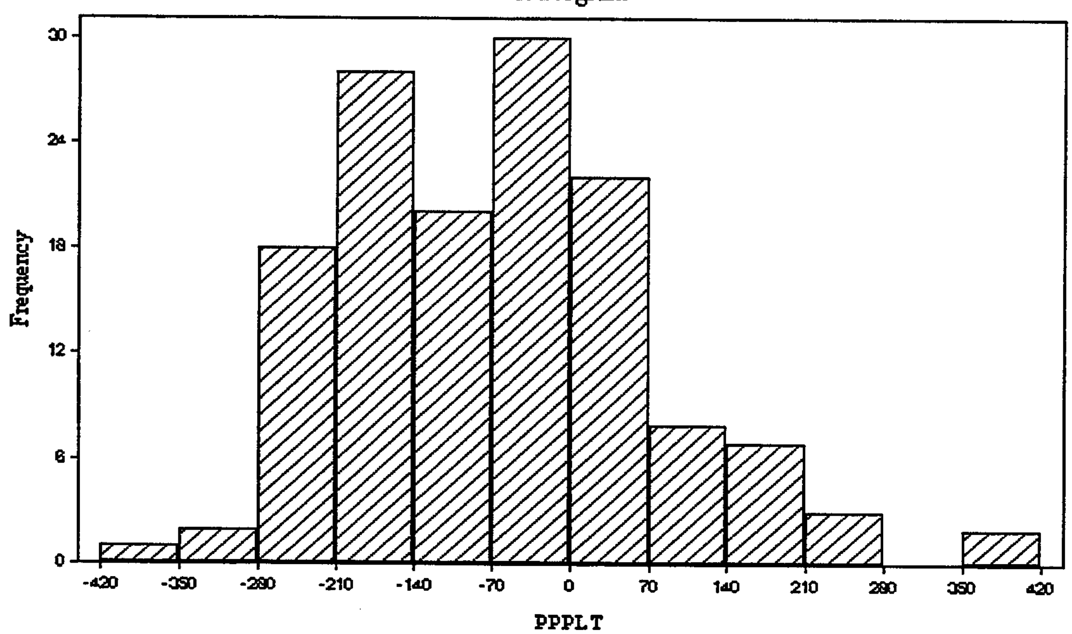




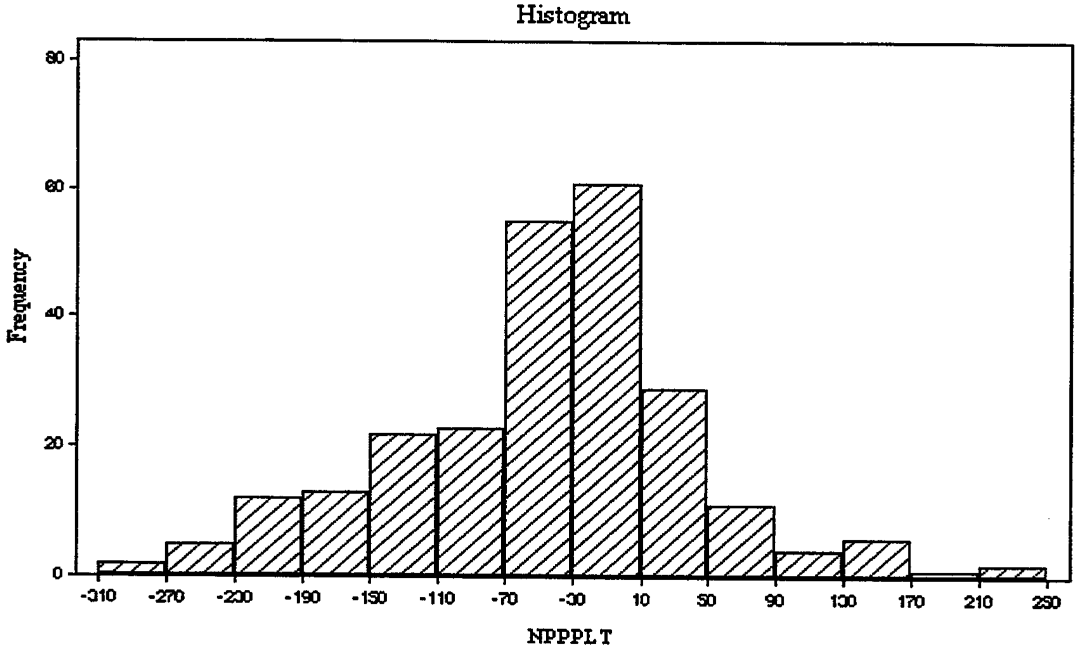

Case 1: Production Lead Time



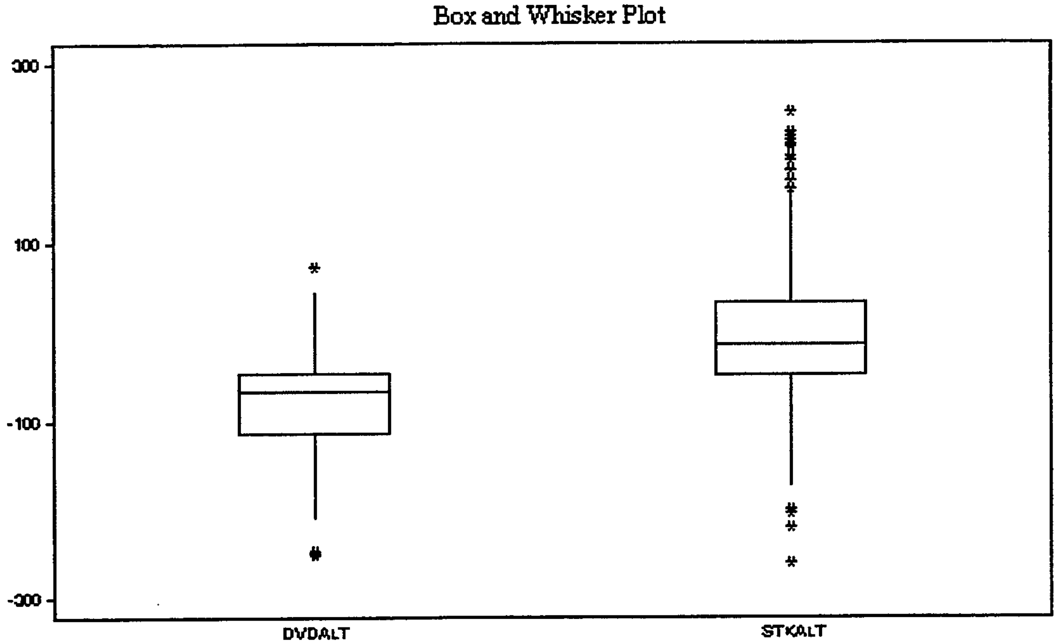
Histogram

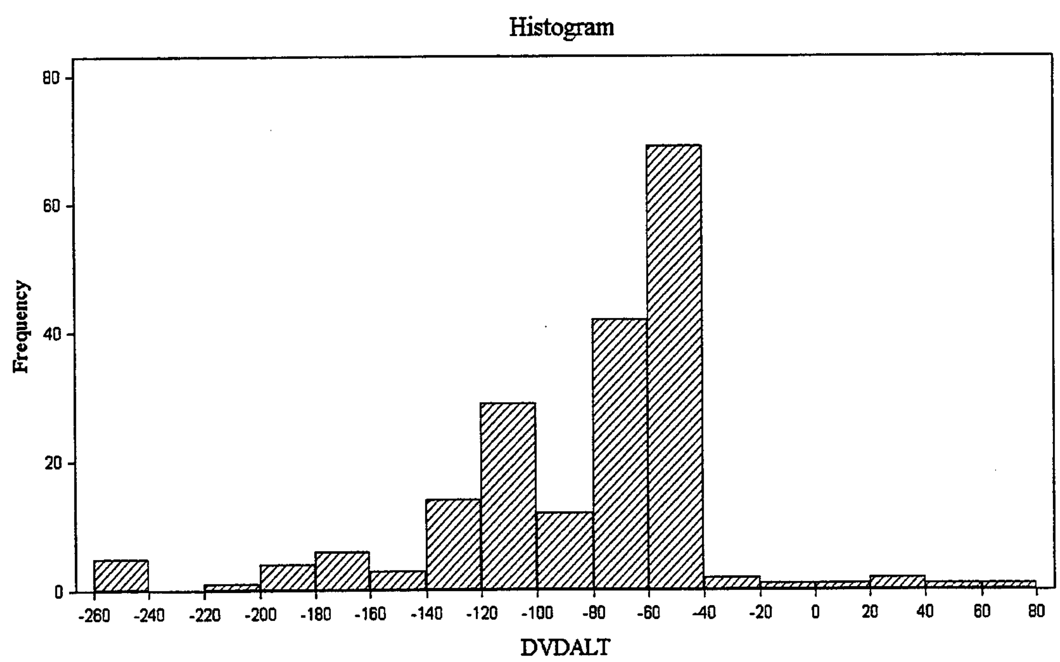


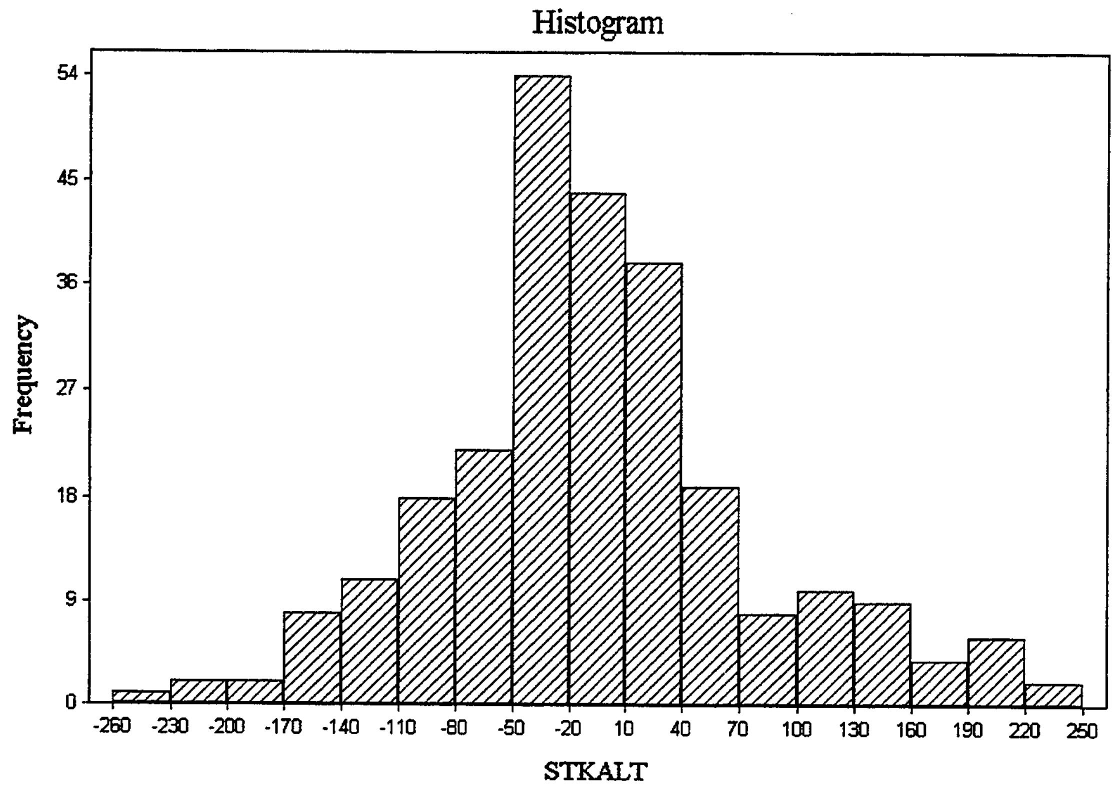

Histogram



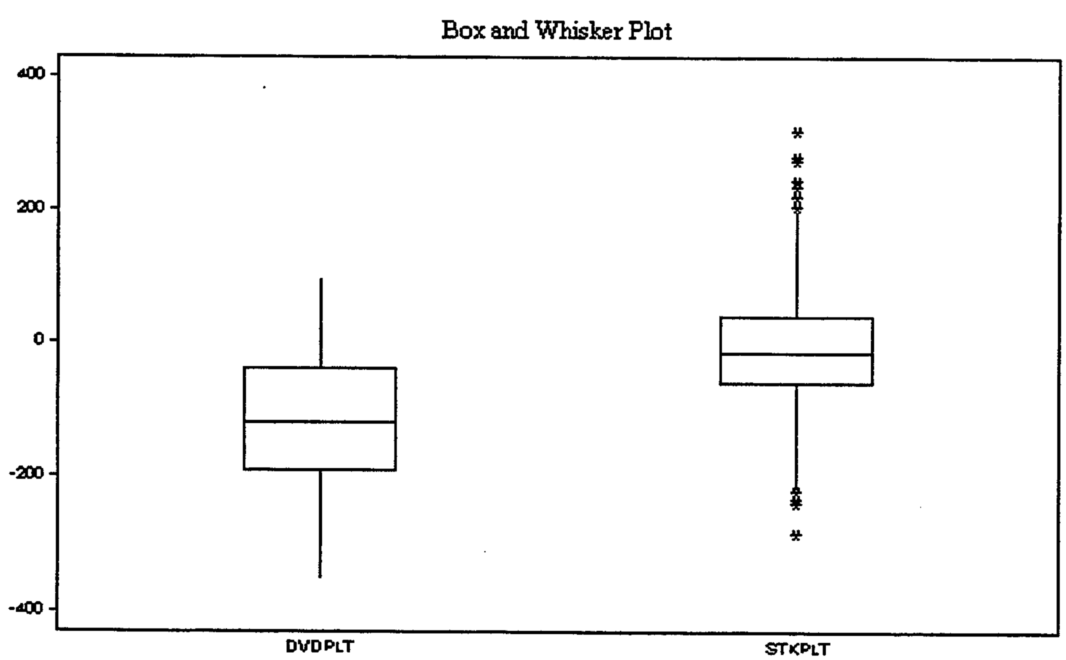
Case 2: Administrative Lead Time

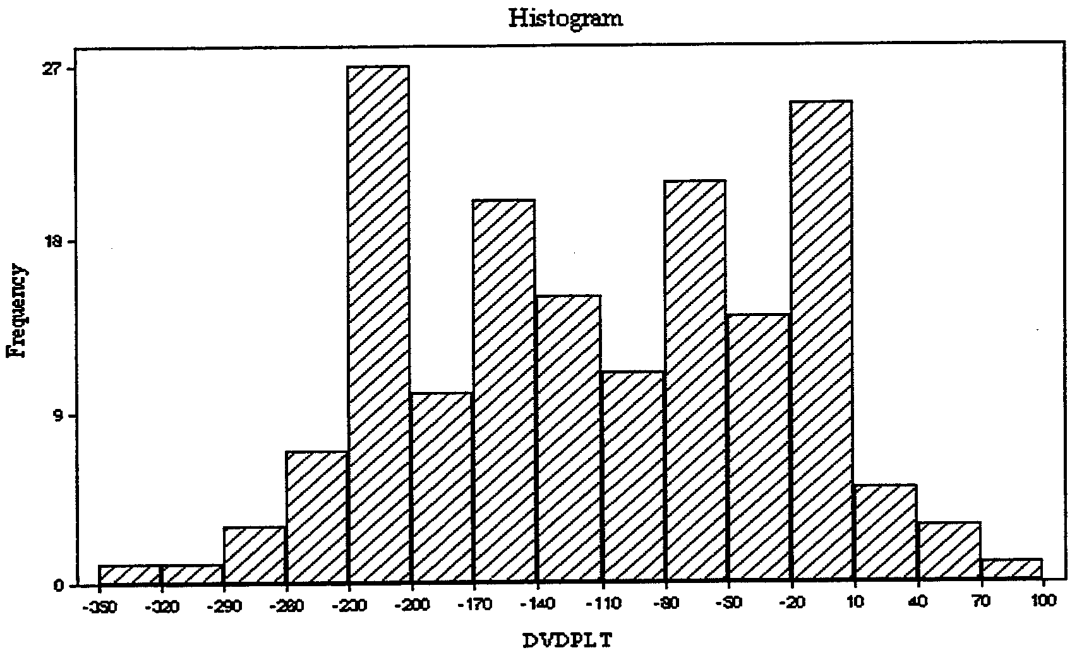


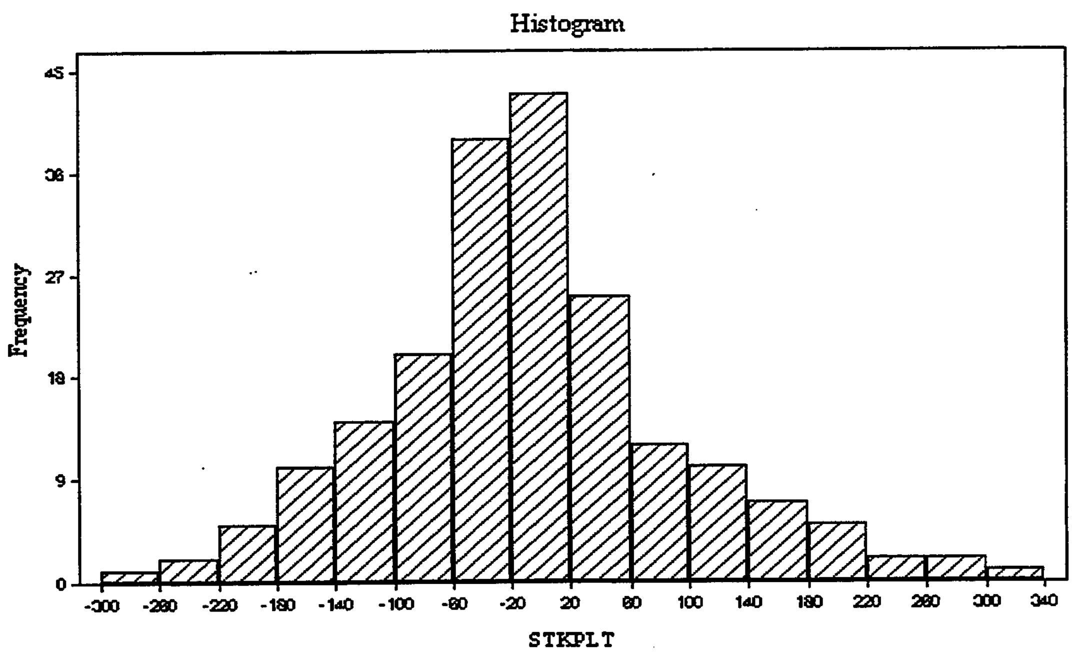





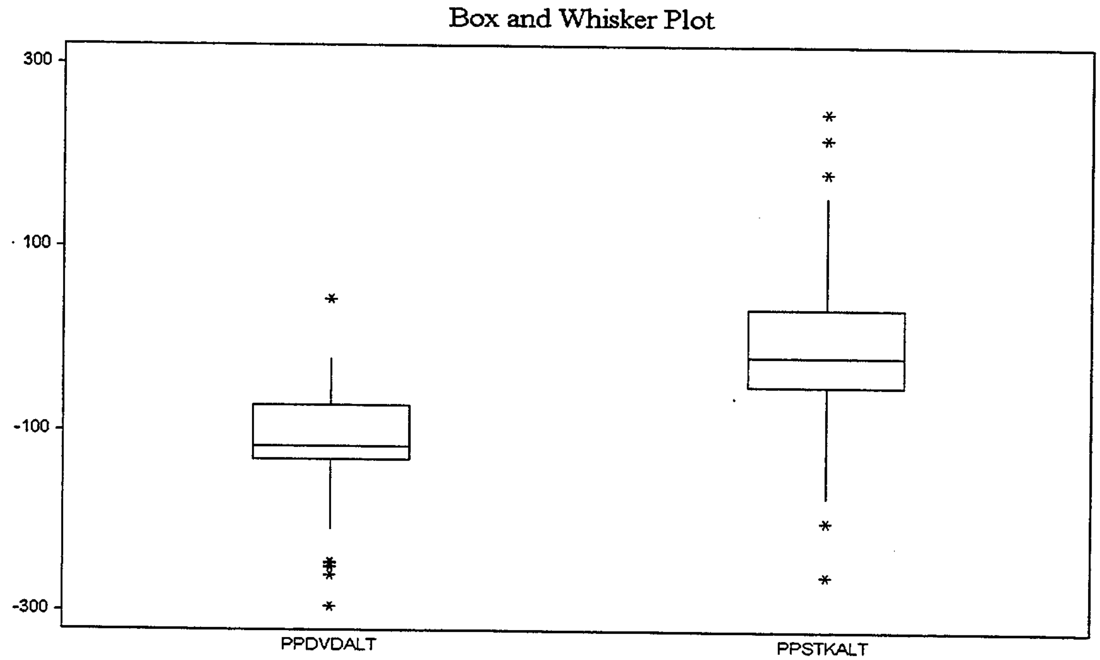

Case 2: Production Lead Time

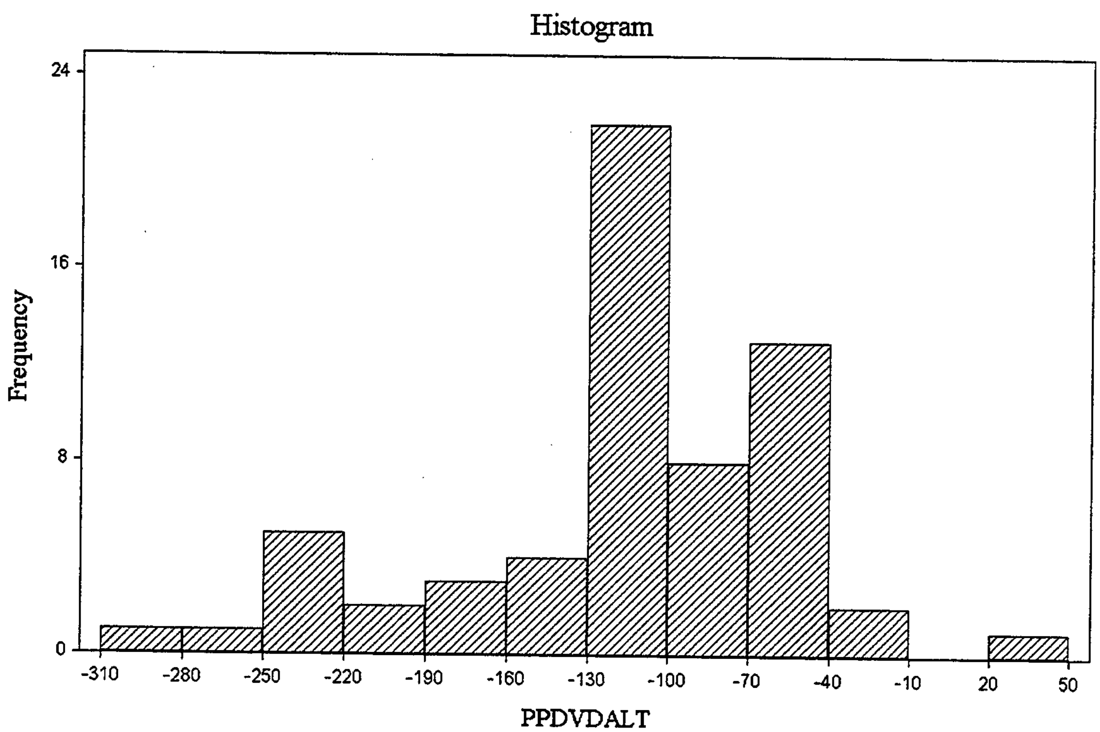


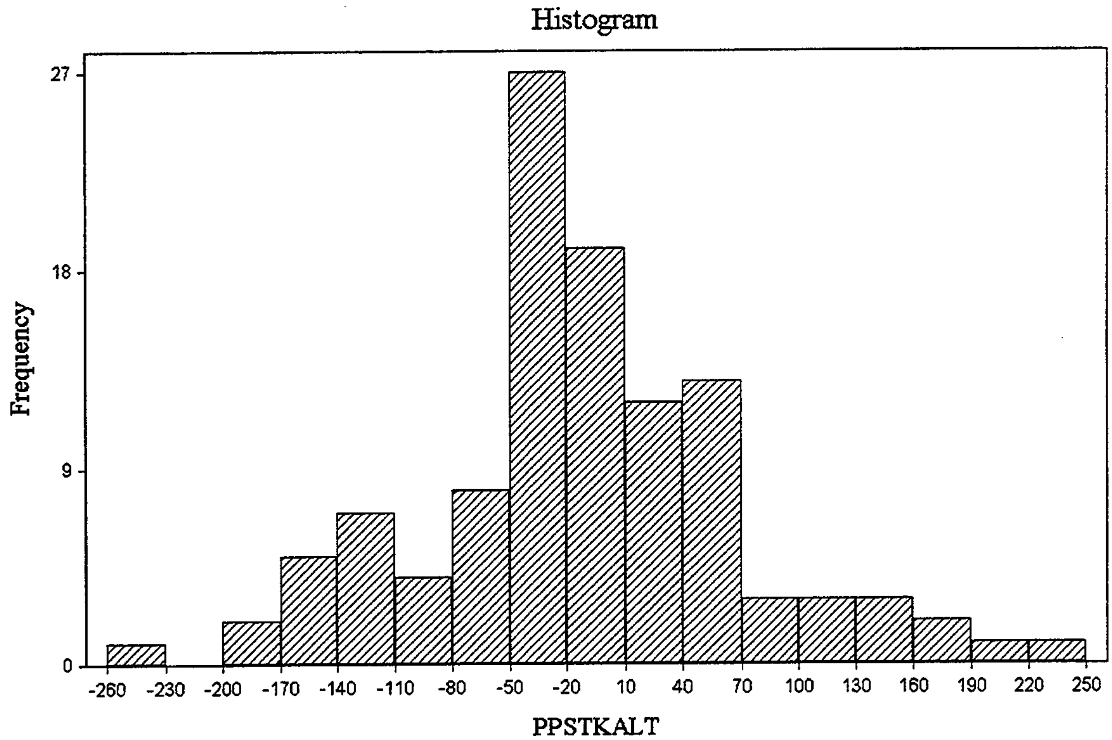

Histogram
Frequency
27
18
9
0
-350
-320
-290
-260
-230
-200
-170
-140
-110
-80
-50
-20
10
40
70
100
DVDPLT


Histogram
Frequency
45
36
27
18
9
0
-300
-260
-220
-180
-140
-100
-60
-20
20
60
100
140
180
220
260
300
340
STKPLT

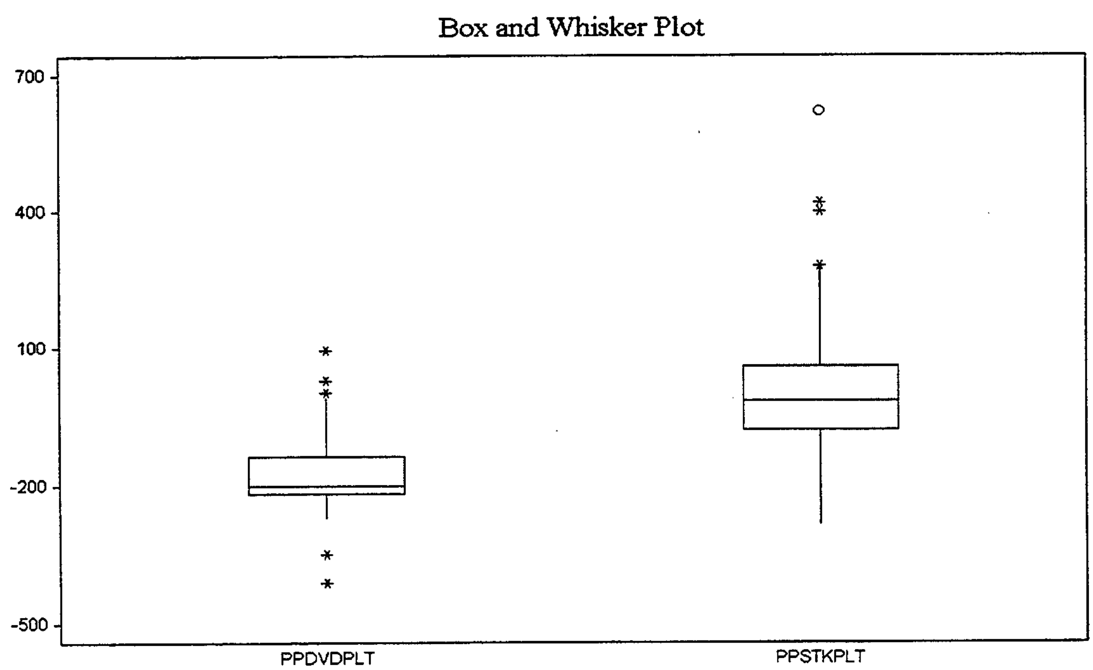
Case 3: Administrative Lead Time

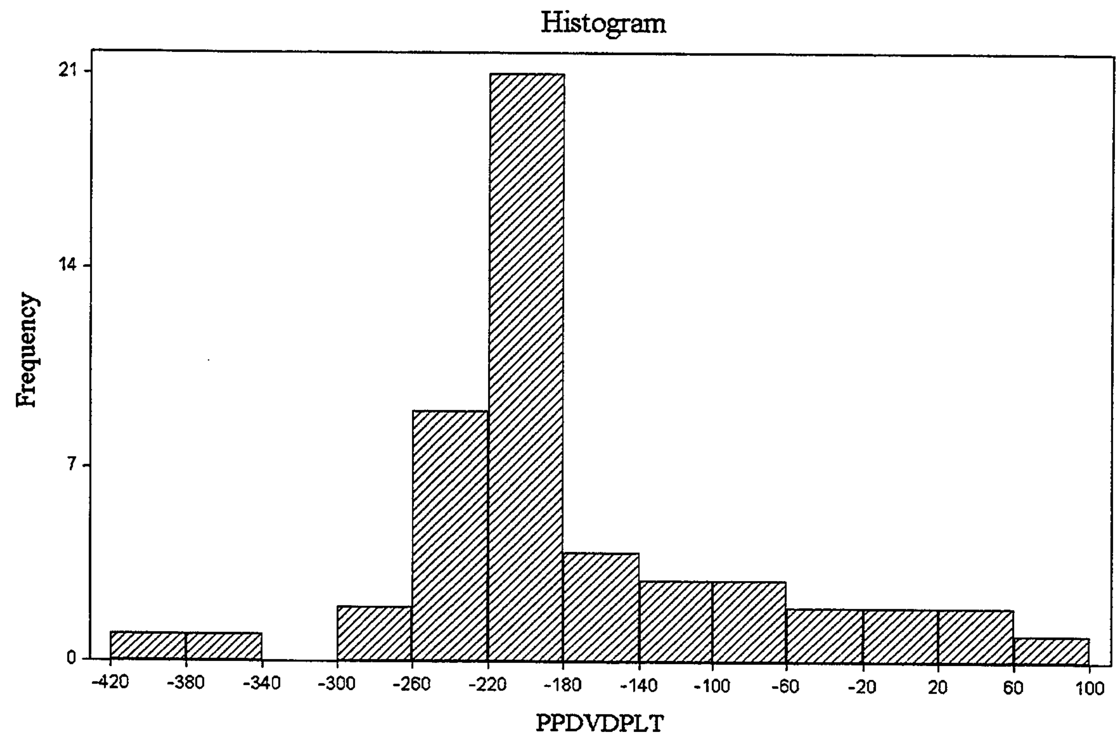





Case 3: Production Lead Time




Histogram
Frequency
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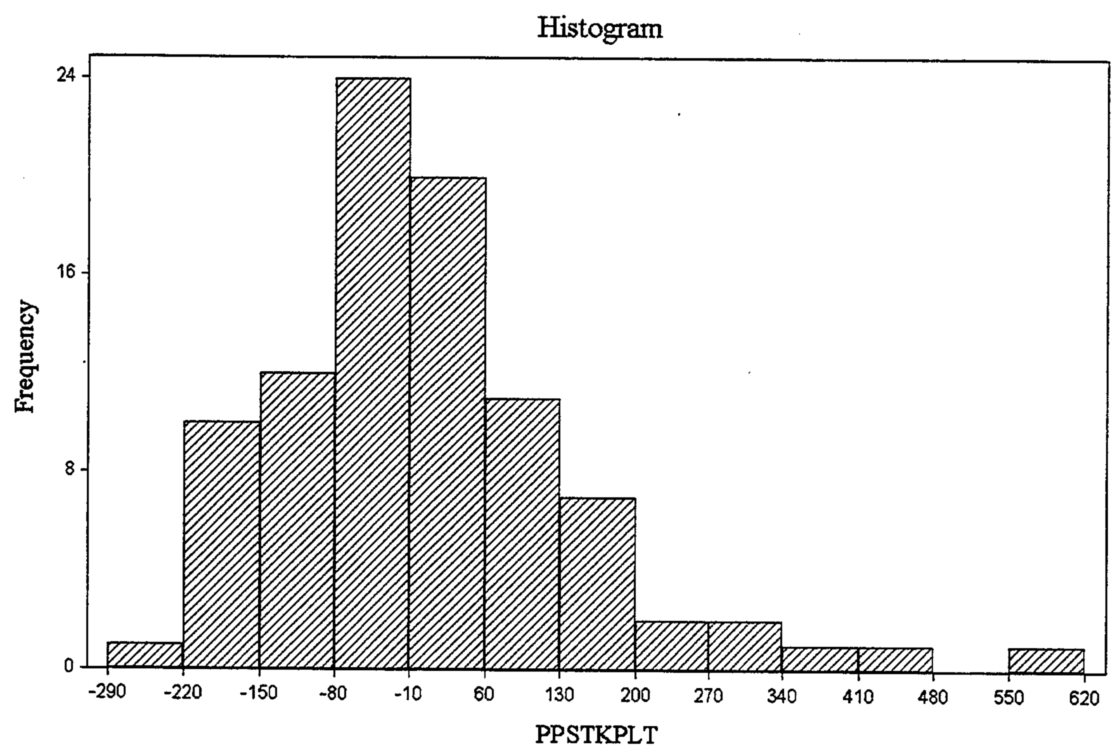
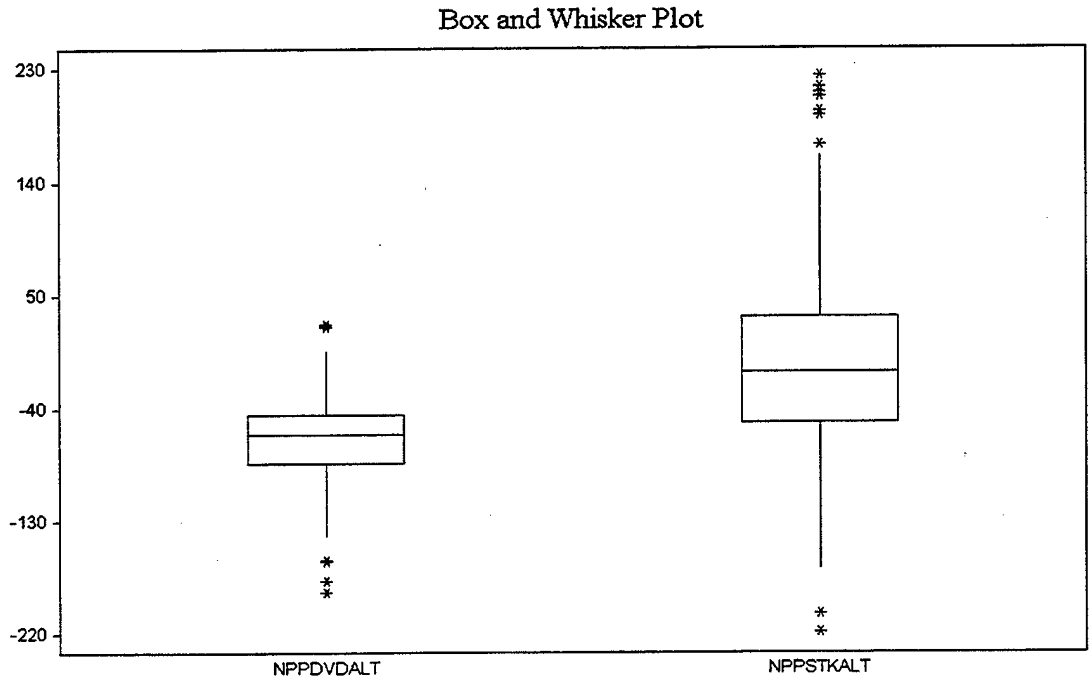
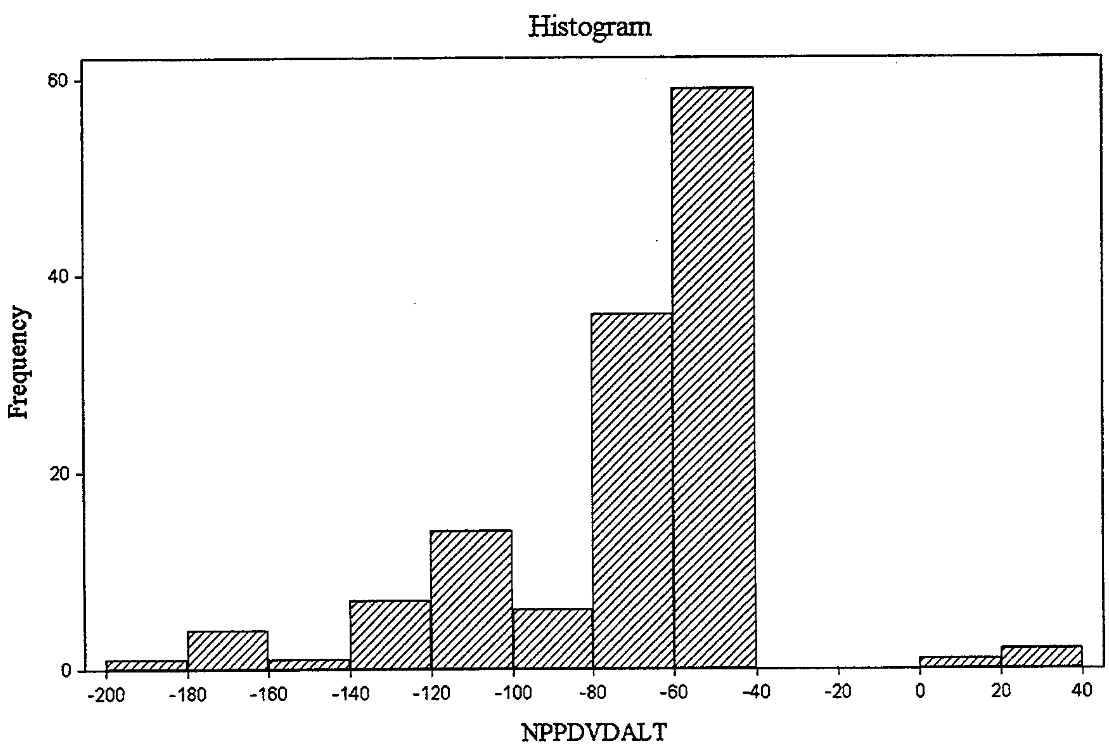
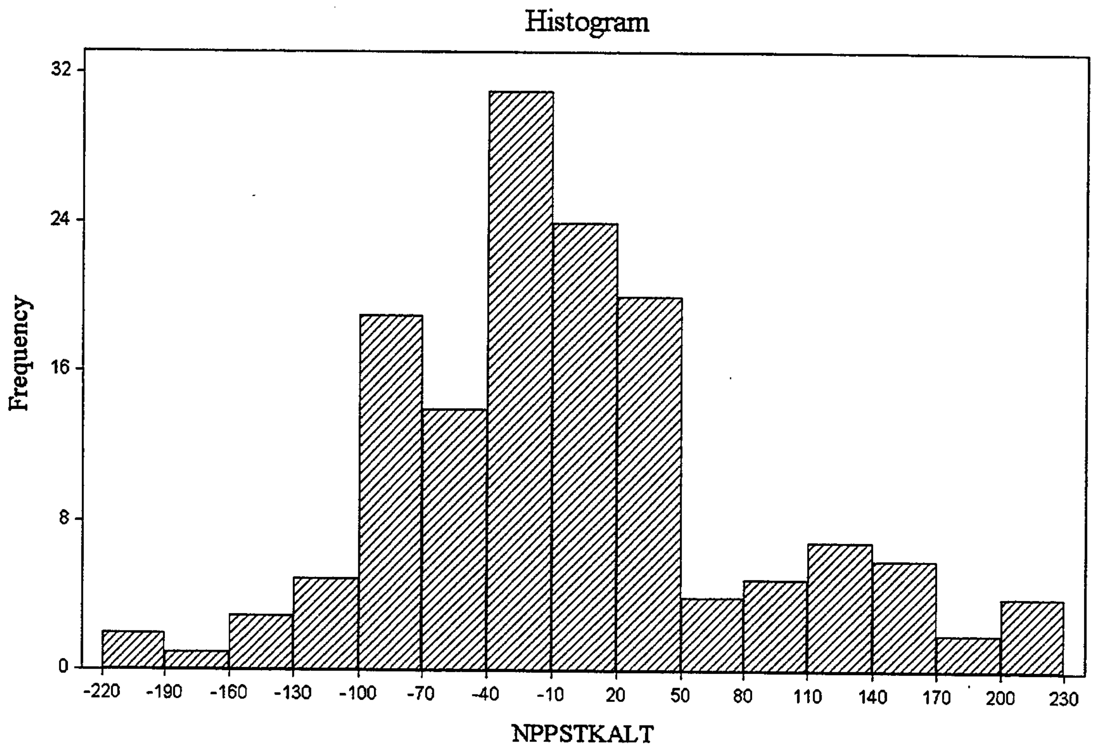
7
14
21
-420 -380 -340 -300 -260 -220 -180 -140 -100 -60 -20 20 60 100
PPDVDPLT


Histogram
Frequency
0
8
16
24
-290 -220 -150 -80 -10 60 130 200 270 340 410 480 550 620
PPSTKPLT

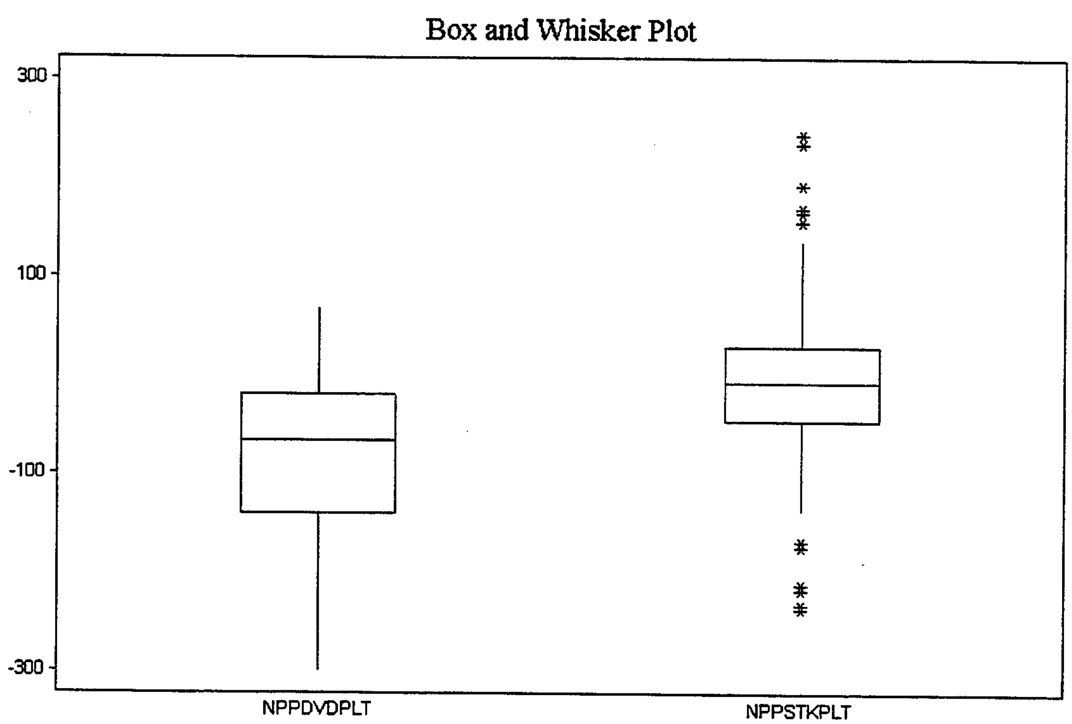
Case 4: Administrative Lead Time

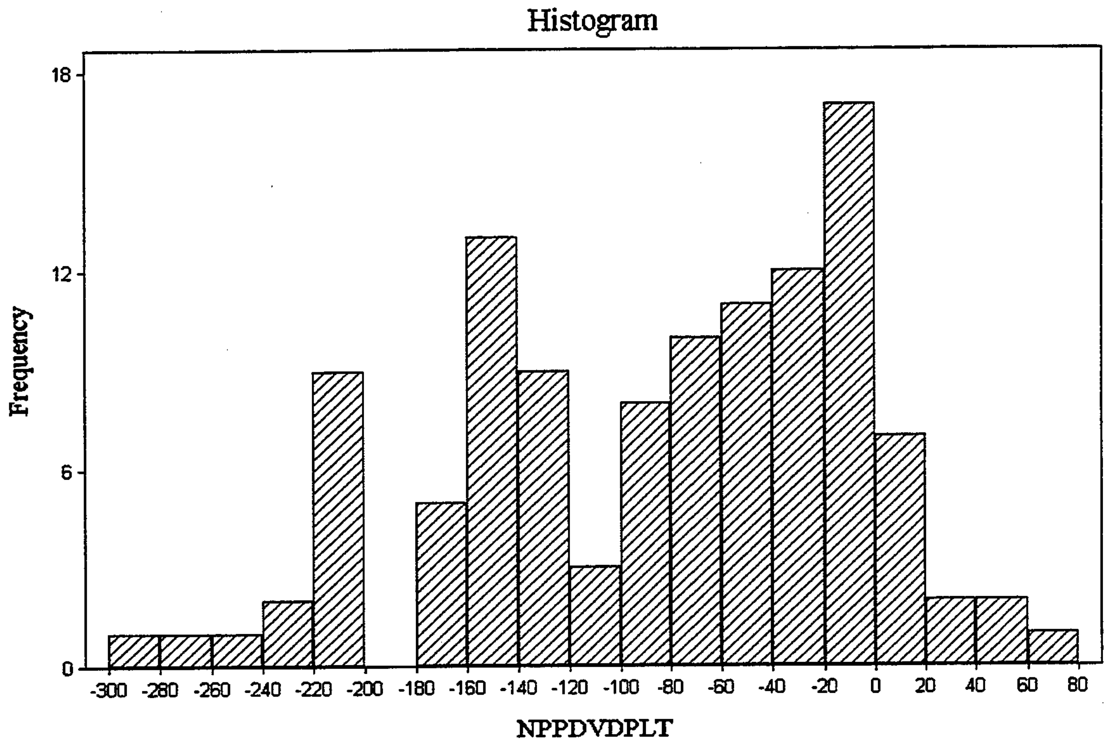


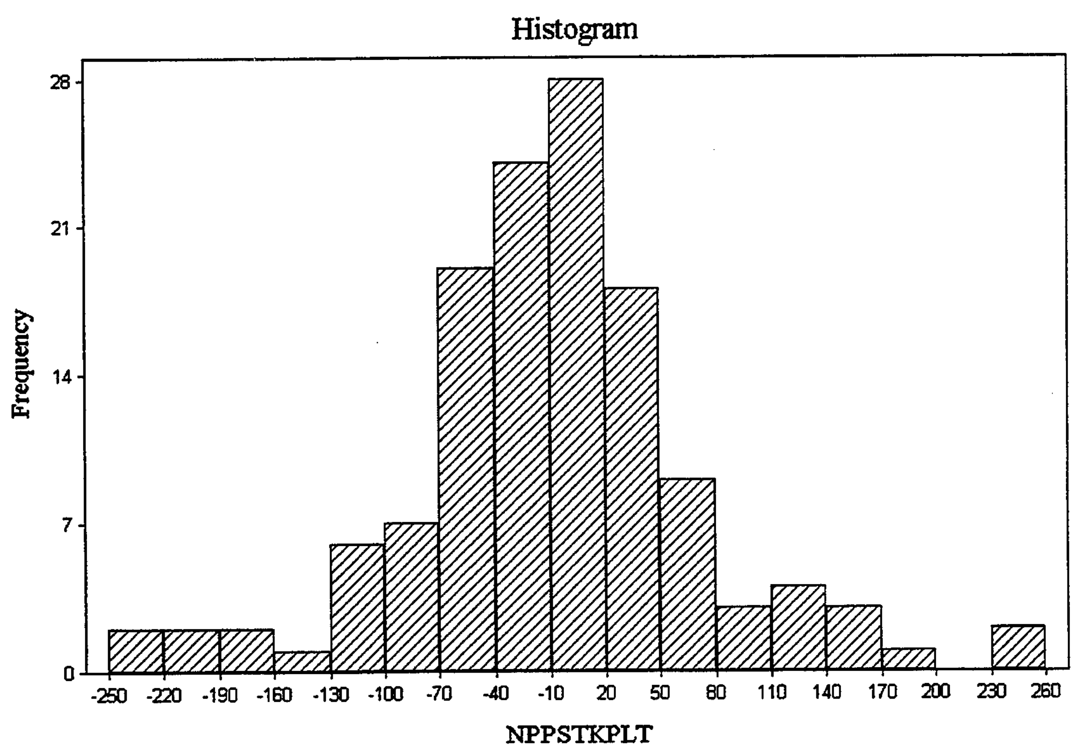






Case 4: Production Lead Time

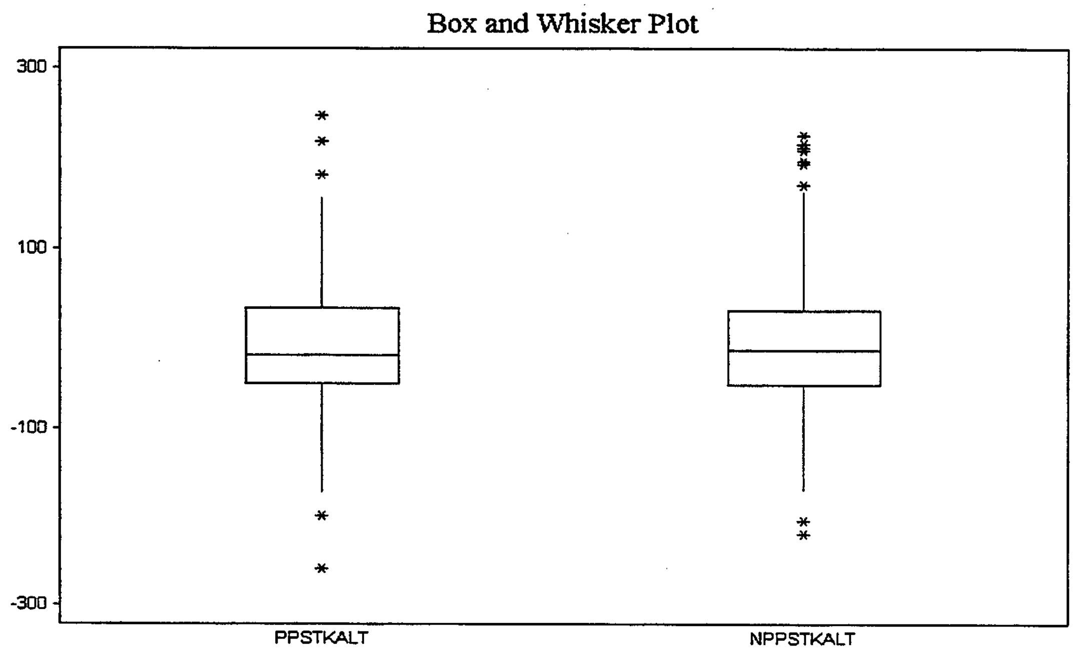



Histogram
Frequency
18
12
6
0
-300 -280 -260 -240 -220 -200 -180 -160 -140 -120 -100 -80 -60 -40 -20 0 20 40 60 80
NPPDVDPLT

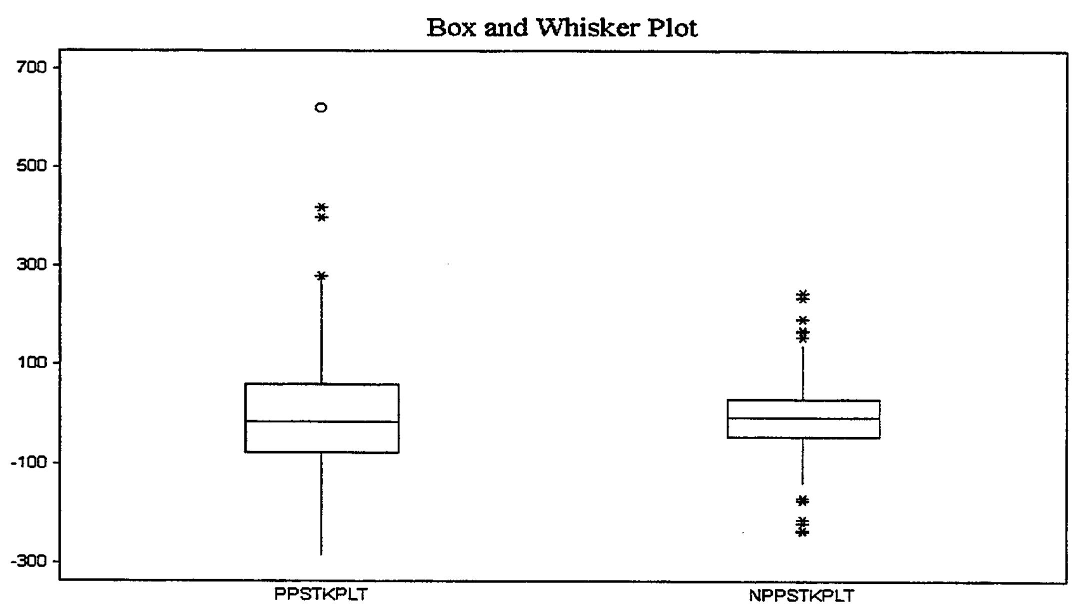

Histogram
Frequency
28
21
14
7
0
-250 -220 -190 -160 -130 -100 -70 -40 -10 20 50 80 110 140 170 200 230 260
NPPSTKPLT

Case 5: Administrative Lead Time

Note: Histograms are shown in Cases 3 and 4 above.



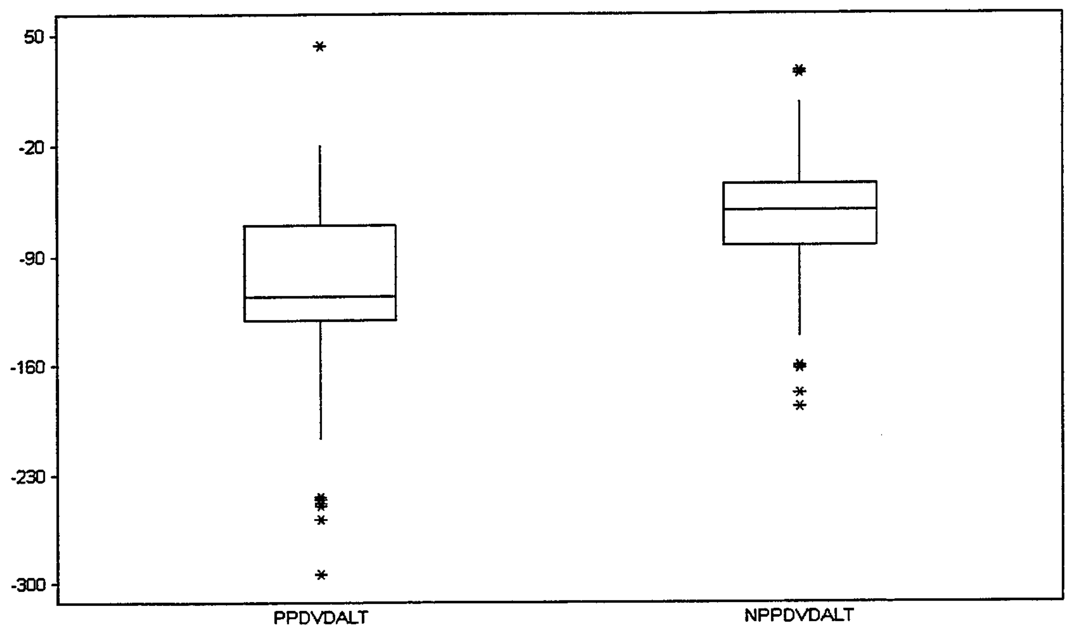

Case 5: Production Lead Time



Case 6: Administrative Lead Time

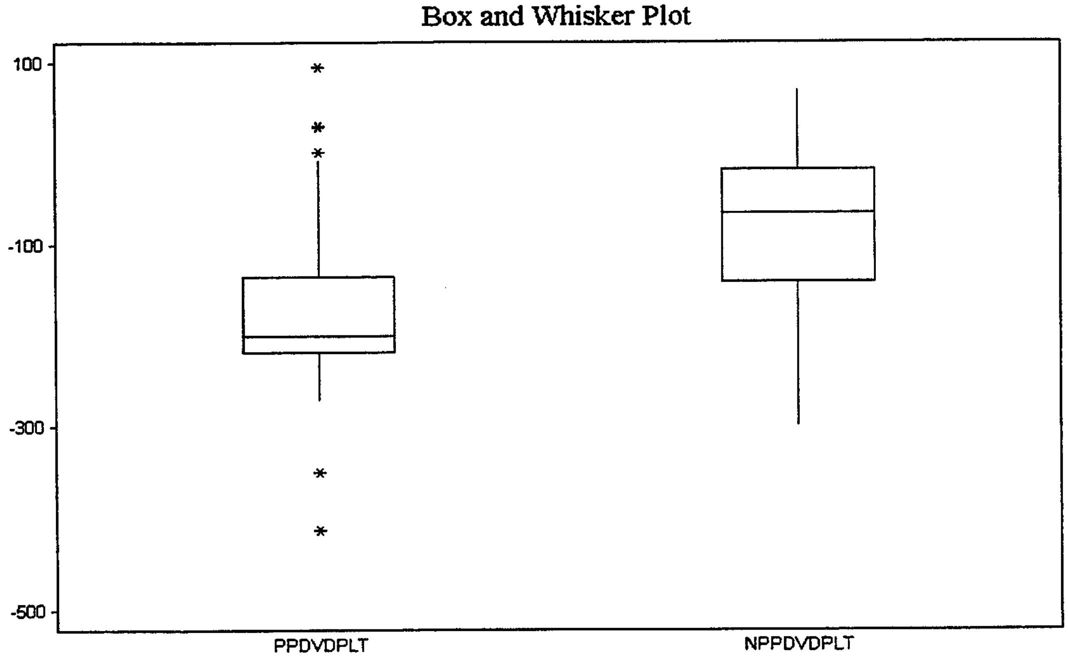
Note: Histograms are shown in Cases 3 and 4 above.

Box and Whisker Plot




Case 6: Production Lead Time

Box and Whisker Plot



Appendix F: Results of Hypothesis Tests

CASE 1: TWO-SAMPLE T TESTS FOR PPALT VS NPPALT

| VARIABLE | MEAN | SAMPLE SIZE | S.D. | S.E. |
|---|---|---|---|---|
| PPALT | -48.931 | 173 | 93.892 | 7.1385 |
| NPPALT | -36.717 | 276 | 69.603 | 4.1896 |
| DIFFERENCE | -12.213 | | | |

NULL HYPOTHESIS: DIFFERENCE = 0
ALTERNATIVE HYP: DIFFERENCE <> 0

| ASSUMPTION | T | DF | P | 95% CI FOR DIFFERENCE |
|---|---|---|---|---|
| EQUAL VARIANCES | -1.58 | 447 | 0.1153 | (-27.427, 3.0003) |
| UNEQUAL VARIANCES | -1.48 | 289.4 | 0.1369 | (-28.504, 4.0777) |

| | F | NUM DF | DEN DF | P |
|---|---|---|---|---|
| TESTS FOR EQUALITY OF VARIANCES | 1.82 | 172 | 275 | 0.0000 |

CASE 1: TWO-SAMPLE T TESTS FOR PPPLT VS NPPPLT

| VARIABLE | MEAN | SAMPLE SIZE | S.D. | S.E. |
|---|---|---|---|---|
| PPPLT | -63.631 | 141 | 142.23 | 11.978 |
| NPPPLT | -44.646 | 246 | 89.594 | 5.7123 |
| DIFFERENCE | -18.985 | | | |

NULL HYPOTHESIS: DIFFERENCE = 0
ALTERNATIVE HYP: DIFFERENCE <> 0

| ASSUMPTION | T | DF | P | 95% CI FOR DIFFERENCE |
|---|---|---|---|---|
| EQUAL VARIANCES | -1.61 | 385 | 0.1082 | (-42.171, 4.2015) |
| UNEQUAL VARIANCES | -1.43 | 204.9 | 0.1500 | (-45.149, 7.1794) |

| | F | NUM DF | DEN DF | P |
|---|---|---|---|---|
| TESTS FOR EQUALITY OF VARIANCES | 2.52 | 140 | 245 | 0.0000 |

CASE 2: TWO-SAMPLE T TESTS FOR DVDALT VS STKALT

| VARIABLE | MEAN | SAMPLE SIZE | S.D. | S.E. |
|---|---|---|---|---|
| DVDALT | -82.218 | 193 | 50.672 | 3.6474 |
| STKALT | -5.1163 | 258 | 85.099 | 5.2980 |
| DIFFERENCE | -77.101 | | | |

NULL HYPOTHESIS: DIFFERENCE = 0
ALTERNATIVE HYP: DIFFERENCE <> 0

| ASSUMPTION | T | DF | P | 95% CI FOR DIFFERENCE |
|---|---|---|---|---|
| EQUAL VARIANCES | -11.19 | 449 | 0.0000 | (-90.644, -63.558) |
| UNEQUAL VARIANCES | -11.99 | 429.3 | 0.0000 | (-89.744, -64.459) |

| | F | NUM DF | DEN DF | P |
|---|---|---|---|---|
| TESTS FOR EQUALITY OF VARIANCES | 2.82 | 257 | 192 | 0.0000 |

CASE 2: TWO-SAMPLE T TESTS FOR DVDPLT VS STKPLT

| VARIABLE | MEAN | SAMPLE SIZE | S.D. | S.E. |
|---|---|---|---|---|
| DVDPLT | -111.38 | 164 | 90.043 | 7.0312 |
| STKPLT | -8.6667 | 198 | 101.83 | 7.2364 |
| DIFFERENCE | -102.72 | | | |

NULL HYPOTHESIS: DIFFERENCE = 0
ALTERNATIVE HYP: DIFFERENCE <> 0

| ASSUMPTION | T | DF | P | 95% CI FOR DIFFERENCE |
|---|---|---|---|---|
| EQUAL VARIANCES | -10.06 | 360 | 0.0000 | (-122.79, -82.645) |
| UNEQUAL VARIANCES | -10.18 | 358.4 | 0.0000 | (-122.56, -82.875) |

| | F | NUM DF | DEN DF | P |
|---|---|---|---|---|
| TESTS FOR EQUALITY OF VARIANCES | 1.28 | 197 | 163 | 0.0518 |

CASE 3: TWO-SAMPLE T TESTS FOR PPDVDALT VS PPSTKALT

| VARIABLE | MEAN | SAMPLE SIZE | S.D. | S.E. |
|---|---|---|---|---|
| PPDVDALT | -116.58 | 62 | 66.054 | 8.3889 |
| PPSTKALT | -11.050 | 111 | 85.600 | 8.1248 |
| DIFFERENCE | -105.53 | | | |

NULL HYPOTHESIS: DIFFERENCE = 0
ALTERNATIVE HYP: DIFFERENCE <> 0

| ASSUMPTION | T | DF | P | 95% CI FOR DIFFERENCE |
|---|---|---|---|---|
| EQUAL VARIANCES | -8.41 | 171 | 0.0000 | (-130.31, -80.749) |
| UNEQUAL VARIANCES | -9.04 | 154.0 | 0.0000 | (-128.60, -82.461) |

| | F | NUM DF | DEN DF | P |
|---|---|---|---|---|
| TESTS FOR EQUALITY OF VARIANCES | 1.68 | 110 | 61 | 0.0139 |

CASE 3: TWO-SAMPLE T TESTS FOR PPDVDPLT VS PPSTKPLT

| VARIABLE | MEAN | SAMPLE SIZE | S.D. | S.E. |
|---|---|---|---|---|
| PPDVDPLT | -173.67 | 51 | 94.082 | 13.174 |
| PPSTKPLT | 3.3043 | 92 | 142.32 | 14.838 |
| DIFFERENCE | -176.97 | | | |

NULL HYPOTHESIS: DIFFERENCE = 0
ALTERNATIVE HYP: DIFFERENCE <> 0

| ASSUMPTION | T | DF | P | 95% CI FOR DIFFERENCE |
|---|---|---|---|---|
| EQUAL VARIANCES | -7.96 | 141 | 0.0000 | (-220.91, -133.03) |
| UNEQUAL VARIANCES | -8.92 | 136.6 | 0.0000 | (-216.21, -137.73) |

| | F | NUM DF | DEN DF | P |
|---|---|---|---|---|
| TESTS FOR EQUALITY OF VARIANCES | 2.29 | 91 | 50 | 0.0009 |

CASE 4: TWO-SAMPLE T TESTS FOR NPPDVDALT VS NPPSTKALT

| VARIABLE | MEAN | SAMPLE SIZE | S.D. | S.E. |
|---|---|---|---|---|
| --------- | --------- | ------ | --------- | ------- |
| NPPDVDALT | -68.958 | 131 | 36.275 | 3.1693 |
| NPPSTKALT | -0.6463 | 147 | 84.633 | 6.9804 |
| DIFFERENCE | -68.312 | | | |

NULL HYPOTHESIS: DIFFERENCE = 0
ALTERNATIVE HYP: DIFFERENCE <> 0

| ASSUMPTION | T | DF | P | 95% CI FOR DIFFERENCE |
|---|---|---|---|---|
| ----------------- | ------ | ------ | ------ | ---------------------------------- |
| EQUAL VARIANCES | -8.56 | 276 | 0.0000 | (-84.017, -52.607) |
| UNEQUAL VARIANCES | -8.91 | 202.7 | 0.0000 | (-83.427, -53.196) |

| | F | NUM DF | DEN DF | P |
|---|---|---|---|---|
| TESTS FOR EQUALITY | ------- | ------ | ------ | ------ |
| OF VARIANCES | 5.44 | 146 | 130 | 0.0000 |

CASE 4: TWO-SAMPLE T TESTS FOR NPPDVDPLT VS NPPSTKPLT

| VARIABLE | MEAN | SAMPLE SIZE | S.D. | S.E. |
|---|---|---|---|---|
| --------- | --------- | ------ | --------- | ------- |
| NPPDVDPLT | -85.868 | 114 | 78.399 | 7.3428 |
| NPPSTKPLT | -7.2977 | 131 | 81.415 | 7.1132 |
| DIFFERENCE | -78.571 | | | |

NULL HYPOTHESIS: DIFFERENCE = 0
ALTERNATIVE HYP: DIFFERENCE <> 0

| ASSUMPTION | T | DF | P | 95% CI FOR DIFFERENCE |
|---|---|---|---|---|
| ----------------- | ------ | ------ | ------ | ---------------------------------- |
| EQUAL VARIANCES | -7.67 | 243 | 0.0000 | (-98.761, -58.380) |
| UNEQUAL VARIANCES | -7.69 | 240.5 | 0.0000 | (-98.709, -58.432) |

| | F | NUM DF | DEN DF | P |
|---|---|---|---|---|
| TESTS FOR EQUALITY | ------- | ------ | ------ | ------ |
| OF VARIANCES | 1.08 | 130 | 113 | 0.3410 |

CASE 5: TWO-SAMPLE T TESTS FOR PPSTKALT VS NPPSTKALT

| VARIABLE | MEAN | SAMPLE SIZE | S.D. | S.E. |
|---|---|---|---|---|
| PPSTKALT | -11.050 | 111 | 85.600 | 8.1248 |
| NPPSTKALT | -0.6463 | 147 | 84.633 | 6.9804 |
| DIFFERENCE | -10.403 | | | |

NULL HYPOTHESIS: DIFFERENCE = 0
ALTERNATIVE HYP: DIFFERENCE <> 0

| ASSUMPTION | T | DF | P | 95% CI FOR DIFFERENCE |
|---|---|---|---|---|
| EQUAL VARIANCES | -0.97 | 256 | 0.3316 | (-31.464, 10.657) |
| UNEQUAL VARIANCES | -0.97 | 235.6 | 0.3344 | (-31.506, 10.699) |

| | F | NUM DF | DEN DF | P |
|---|---|---|---|---|
| TESTS FOR EQUALITY OF VARIANCES | 1.02 | 110 | 146 | 0.4461 |

CASE 5: TWO-SAMPLE T TESTS FOR PPSTKPLT VS NPPSTKPLT

| VARIABLE | MEAN | SAMPLE SIZE | S.D. | S.E. |
|---|---|---|---|---|
| PPSTKPLT | 3.3043 | 92 | 142.32 | 14.838 |
| NPPSTKPLT | -7.2977 | 131 | 81.415 | 7.1132 |
| DIFFERENCE | 10.602 | | | |

NULL HYPOTHESIS: DIFFERENCE = 0
ALTERNATIVE HYP: DIFFERENCE <> 0

| ASSUMPTION | T | DF | P | 95% CI FOR DIFFERENCE |
|---|---|---|---|---|
| EQUAL VARIANCES | 0.70 | 221 | 0.4819 | (-19.055, 40.260) |
| UNEQUAL VARIANCES | 0.64 | 132.7 | 0.5279 | (-21.946, 43.150) |

| | F | NUM DF | DEN DF | P |
|---|---|---|---|---|
| TESTS FOR EQUALITY OF VARIANCES | 3.06 | 91 | 130 | 0.0000 |

CASE 6: TWO-SAMPLE T TESTS FOR PPDVDALT VS NPPDVDALT

| VARIABLE | MEAN | SAMPLE SIZE | S.D. | S.E. |
|---|---|---|---|---|
| --------- | --------- | ------ | --------- | ------- |
| PPDVDALT | -116.58 | 62 | 66.054 | 8.3889 |
| NPPDVDALT | -68.958 | 131 | 36.275 | 3.1693 |
| DIFFERENCE | -47.623 | | | |

NULL HYPOTHESIS: DIFFERENCE = 0
ALTERNATIVE HYP: DIFFERENCE <> 0

| ASSUMPTION | T | DF | P | 95% CI FOR DIFFERENCE |
|---|---|---|---|---|
| ----------------- | ------ | ------ | ------ | ---------------------------------- |
| EQUAL VARIANCES | -6.46 | 191 | 0.0000 | (-62.170, -33.075) |
| UNEQUAL VARIANCES | -5.31 | 78.9 | 0.0000 | (-65.472, -29.773) |

| | F | NUM DF | DEN DF | P |
|---|---|---|---|---|
| TESTS FOR EQUALITY | ------- | ------ | ------ | ------ |
| OF VARIANCES | 3.32 | 61 | 130 | 0.0000 |

CASE 6: TWO-SAMPLE T TESTS FOR PPDVDPLT VS NPPDVDPLT

| VARIABLE | MEAN | SAMPLE SIZE | S.D. | S.E. |
|---|---|---|---|---|
| --------- | --------- | ------ | --------- | ------- |
| PPDVDPLT | -173.67 | 51 | 94.082 | 13.174 |
| NPPDVDPLT | -85.868 | 114 | 78.399 | 7.3428 |
| DIFFERENCE | -87.798 | | | |

NULL HYPOTHESIS: DIFFERENCE = 0
ALTERNATIVE HYP: DIFFERENCE <> 0

| ASSUMPTION | T | DF | P | 95% CI FOR DIFFERENCE |
|---|---|---|---|---|
| ----------------- | ------ | ------ | ------ | ---------------------------------- |
| EQUAL VARIANCES | -6.24 | 163 | 0.0000 | (-115.58, -60.014) |
| UNEQUAL VARIANCES | -5.82 | 82.4 | 0.0000 | (-117.80, -57.797) |

| | F | NUM DF | DEN DF | P |
|---|---|---|---|---|
| TESTS FOR EQUALITY | ------- | ------ | ------ | ------ |
| OF VARIANCES | 1.44 | 50 | 113 | 0.0574 |

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Vita

Captain Kieran F. Keelty was born on 13 August 1966 in the borough of the Bronx, New York City, New York. He was raised in New City, New York and graduated Clarkstown South Senior High School in 1984. He earned a Bachelor of Arts degree in Political Science in 1990 from the University of North Carolina at Wilmington. He enlisted in the United States Army in 1994, and received the Distinguished Graduate honor from the U.S. Army School of Computer Science at Fort Gordon, Georgia. He received his Air Force commission from OTS in June of 1995.

Following graduation, Captain Keelty was assigned to the 20th Supply Squadron at Shaw AFB. While there, he served as Flight Commander of Materiel Storage and Distribution, Combat Operations Support, and Fuels Management. In 1997, he received the Air Combat Command Outstanding Junior Supply Officer Award. In 1998 he deployed as Chief of Supply for the 347th Air Expeditionary Wing at Shaikh Isa Air Base, Bahrain in support of OPERATION SOUTHERN WATCH.

In May 1998 Captain Keelty was reassigned to AFIT to pursue a Master of Science in Logistics Management. Upon graduation he will proceed to Item Management branch of the Logistics Group at Air Force Materiel Command at Wright-Patterson AFB, Ohio.

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**13. ABSTRACT (*Maximum 200 Words*)**

This study examined the variability experienced in the administrative and production lead times of consumable items managed by the Defense Logistics Agency (DLA). Assets were categorized based on an item manager's determination that an asset was a problem part, and whether the asset was purchased for stock replenishment or direct vendor delivery. The methodology was a two-sample t-test of aggregated data to determine if significant differences existed between the mean deviations from the system lead times of various combinations of categories. The study produced results indicating that a significant difference did not exist between the mean deviations of problem parts and non-problem parts, but substantial variability did exist for all categories of consumable items. The degree of variability was such that the author suspected this as a possible cause for individual assets entering problem part status. The study also confirmed that while the DLA methodology used for forecasting lead times of stock replenishment purchases was accurate over aggregated data, the variability present is, to some extent, contributing to excess inventory levels..

**14. Subject Terms**
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