FORECASTING READINESS:

USING REGRESSION TO PREDICT THE MISSION CAPABILITY OF

AIR FORCE F-16 FIGHTER AIRCRAFT

THESIS

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AFIT/GLM/ENS/01M-18

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Wright-Patterson Air Force Base, Ohio

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THESIS

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Steven A. Oliver

Table of Contents

List of Figures

List of Tables

AFIT/GLM/ENS/01M-18

Abstract

According to many experts, the readiness of America's armed forces has deteriorated throughout the 1990s. In the Air Force, the combat readiness of its fighter aircraft has declined in varying degrees. One of the Air Force's indicators of combat readiness for its aircraft, the mission capable rate, is a rate primarily used to identify the percentage of aircraft that are able to perform their primary missions. From FY94 through FY98, the aggregate Air Force aircraft total not mission capable rate for maintenance (TNMCM) for all aircraft has steadily increased from 14 percent to 18.2 percent while total not mission capable rate for supply (TNMCS) increased from 5.5 percent in FY86 to 17.5 percent in FY00. The Air Force currently uses the Funding/Availability Multi-Method Allocator for Spares (FAMMAS) forecasting model to predict overall mission capable rates for each type of aircraft it has in its inventory. While the FAMMAS model does an excellent job of predicting mission capable rates based on funding data and other associated planning factors, it is does not explain the key drivers that influence mission capable rates, which limits its effectiveness as a management and decision-making tool. Recent studies have identified other variables, such as manning and experience levels, retention, fix rates, operations tempo, spare parts issues, and aircraft systems reliability and maintainability as being related to mission capable rates. The research used these and other variables, using the F-16 and its support structure as a representative example, to develop explanatory and predictive models that provide more insightful forecasts. Results are obtained from analyzing over 600 variables and 10 years of quarterly data, from the Reliability and Maintainability

Information System (REMIS), the Recoverable Consumption Items Requirements System (D041), the Personnel Data System, and the Manpower Data System. This research will help the Air Force make better readiness-based operational, funding, and management decisions.

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I. Introduction

Chapter Overview

This chapter begins with a discussion of two views prevalent in today's Air Force as they pertain to logistics management. From this discussion, a problem statement is derived. Next, a brief background is presented on inventory reduction efforts the Air Force has been executing since 1991. Following the background discussion, the scope of the study is then established. The resulting research objective and research questions follow. Finally, an overview of the remaining chapters is provided.

Background

According to many experts, the readiness of America's armed forces has deteriorated throughout the 1990s. Chairman of the House National Security Committee, Rep. Floyd D. Spence, stated that the readiness of the armed forces has already been jeopardized and that there is "a real danger of the Defense Department will return to the hollow forces of the 1970s" (Williams, 1997). In the Air Force, the combat readiness of its fighter aircraft has declined in varying degrees. One of the Air Force's indicators of combat readiness for its aircraft, the mission capable rate, is a rate primarily used to identify the percentage of aircraft that are able to perform their primary missions. From FY94 through FY98, the aggregate Air Force aircraft total not mission capable rate for maintenance (TNMCM) for all aircraft has steadily increased from 14 percent to 18.2

percent while total not mission capable rate for supply TNMCS increased from 5.5 percent in FY86 to 17.5 percent in FY00 (Hallin, 1998 and Merry, 2000). The erosion of mission capable rates still continues today and concern continues to mount. To illustrate the level of concern, in a 5 January 2000 memorandum to HQ USAF/IL, the Air Force Chief of Staff, General Michael Ryan asked *"what are the main causes for increasing TNMCM rates over the last few years?"* (Hall, 2000).

As just stated, mission capable rates are used by the Air Force as one of its primary readiness indicators and serve as one of its indicators of logistics efficiency. Currently, the Air Force uses the Funding/Availability Multi-Method Allocator for Spares (FAMMAS) forecasting model to predict overall mission capable rates for each mission design series (MDS) aircraft it has in its inventory. To make its predictions, FAMMAS uses an exponential smoothing algorithm to predict overall mission capable rates for each Air Force MDS. The model uses past, present and future spares funding levels (reparable support division – buy and repair funding, initial spares funding and system support {consumables} funding) and the last 3 years of historical total not mission capable for supply (TNMCS) and total not mission capable for maintenance (TNMCM) rates for the respective MDS (DRC, 1997). Each year, numerous operational and funding decisions are made based, in part, on the predictions of this model.

While the FAMMAS model does an excellent job of predicting mission capable rates for each MDS based on funding data and planning factors (inflation, carryover and lead time), it is does not adequately consider additional variables that could impact mission capable rates. Furthermore, the FAMMAS model does not incorporate any logistics-related variables into its prediction computations of mission capable rates other than historical TNMCM and TNMCS data that act as adjustment factors in the model. Recent studies, such as Dynamics Research Corporation's (DRC) NMCM Escalation and Erosion of Mission Capable Rates Study, have identified several variables related to mission capable rates. In particular, DRC identified maintenance manning and skill levels, retention, break rates, fix rates, operations tempo, spare parts issues and reliability and maintainability of aircraft systems among many other variables as being related to mission capable rates (Humphrey, 1999). Another factor related to readiness and mission capable rates is that of funding, particularly operations and maintenance (O&M) and spare parts funding (Sherbo, 1998). While not an exhaustive list, a review of the literature indicates that the majority of these variables can be grouped into one of the following categories: personnel, environment, aircraft reliability and maintainability, funding and operations.

Because FAMMAS does not incorporate any of these types of variables (other than spares funding), the model cannot assess what the impact to mission capable rates will be when changes in any one of these areas occurs. This shortcoming of the FAMMAS model limits its effectiveness as a management and decision-making tool. It is believed that by using correlation analysis to identify significant relationships among the independent variables and mission capable rates and subsequently constructing a multiple linear regression model based on the variables, more accurate and useful forecasts can be made. If successful, the model may help the Air Force make better operational, funding and management decisions. Additionally, for significant relationships identified between the logistics variables and mission capable rates, further analysis into their cause and effect relationships can be explored in an attempt to better understand what the primary causes are so potential corrective actions can be initiated.

Problem Statement

The overall problem is the reduced readiness of Air Force combat aircraft. As earlier stated, several studies performed both within and outside of the Air Force have linked factors in the areas of reliability and maintainability, management, funding, and personnel with the erosion of mission capable rates. Unfortunately, none of these efforts have used all of these factors in the construction of a forecasting model to predict mission capable rates. While the Air Force does have an effective forecasting tool (FAMMAS) for predicting overall mission capable rates, FAMMAS lacks the sensitivity needed to account for changes that take place with other related logistics variables of mission capable rates.

It is this deficiency in forecasting capability that this thesis research attempts to satisfy. With fewer resources available to the Air Force and the continued emphasis by senior leadership to use resources more efficiently, the Air Force can not afford to indiscriminately use its resources with little knowledge as to how their use will impact mission needs and goals. As such, the Air Force needs to develop analytical tools to identify the key variables to take into account when allocating its resources. These tools will assist the Air Force in forecasting what results might arise from the allocation of its resources in pursuit of mission needs and goals. The research problem in this thesis project addresses the suitability of using correlation analysis to identify key variables associated with mission capable rates throughout the 1990s. Additionally, it investigates the use of multiple linear regression, using the key variables identified through correlation analysis, to forecast mission capable rates and the combat readiness of Air Force aircraft, specifically the combat readiness of the F-16C/D aircraft.

Research Objectives

The primary objectives of this research are to identify and demonstrate how different variables in the Air Force have impacted F-16C/D aircraft readiness as related to mission capable rates. Once those variables are identified, they will be used to develop a forecasting model that can be used to predict mission capable rates so that better operations and funding decisions can be made.

Investigative Questions

In order to meet the goals of the research, objective data must be collected and the following research questions need to be addressed:

> What changes have taken place since 1990 that have affected the five areas (reliability and maintainability, aircraft and logistics operations, personnel, funding and the environment) that are believed to influence mission capable rates?
>
> What is the cost of lower mission capable rates to the Air Force?
>
> Which variables are related to mission capable rates and what are the associated relationships?
>
> What model best predicts mission capable rates and how helpful are they in demonstrating relationships among the variables and what is the result?

Data Sources and Analysis

Aircraft reliability and maintainability and operations data will be extracted from the Air Force's Reliability and Maintainability Information System (REMIS) for the years 1990-2000. Other data pertaining to supply-related aircraft reliability issues and maintenance operations will retrieved from the Recoverable Consumption Item Requirements System (D041) while personnel data is gathered from the Personnel Data System and the Headquarters Air Force Manpower Data System. Once each data set is obtained, it will be thoroughly analyzed so each can be used in the overall analysis.

Since the independent variables are measured rather than fixed by an intervention, longitudinal correlational methods, more specifically regression, will be used to analyze the data (Dooley, 1995). Regression is a mathematical predictive tool used to show a mathematical relationship among a certain set of variables in order to provide a predictive response. Multiple linear regression is used for analysis when higher order terms are believed to be present or when combinations of more than one independent variable are included (McClave, Benson, & Sincich, 1998). Since this study will include numerous independent variables, multiple linear regression will be used to analyze the data to develop a noncausal, mathematical association among the variables.

Population and Sampling Information

Specifically, this study will be used to analyze quarterly (fiscal) mission capable rates for all Air Force F-16C/D aircraft from 1990-2000 to examine how they relate to the independent variables of interest (Table 1). The F-16C/D aircraft was selected so that an in-depth analysis could be conducted on a single aircraft type as opposed to conducting a superficial analysis of multiple aircraft types. If the results of this analysis prove to be meaningful, they could potentially be used to analyze other aircraft mission capable rates.

An initial review of the literature identified several independent variables potentially related to mission capable rates were identified, as shown below. The variables tended to fall into five areas: personnel, environment, aircraft reliability and maintainability, funding and operations.

Table 1. Potential Variables Affecting Mission Capable Rates

Personnel	Environment	Reliability And Maintainability	Funding	Aircraft and Logistics Operations
Personnel Assigned or Authorized	OPSTEMPO Factors	Mission Capable Hours	Spares Funding	Aircraft Utilization Rates
Number Personnel in Each Skill Level (1, 3, 5, 7, 9 and 0)	PERSTEMPO Factors	TNMCM Hours	Repair Funding	Possessed Hours
Number of Personnel in Each Grade (E1-E9)	Number of Deployments	Maintenance Downtime	General Support Funding	Average Sortie Duration
Total Number of F-16 Maintenance Personnel in various AFSCs	Policy Changes	Maintenance Reliability	Contractor Logistics Support Funding	Flying Hours
Total Number of F-16 Maintenance Personnel in various Skill Levels per AFSC		Supply Reliability	Mission Support Funding	Sorties
Total Number of F-16 Maintenance Personnel in various Grades per AFSC		Supply Downtime		Repair Cycle Time
Reenlistment Rates for F-16 Maintenance Personnel		Code 3 Breaks		Order and Ship Time
Personnel to Aircraft Ratios		TNMCS Hours		

Overview of the Remaining Chapters

Chapter II begins with a discussion of Air Force readiness in terms of mission capable rates and how it has changed from the 1970s to 2000. Chapter II also discusses what mission capable rates measure and why they are important and goes on to discuss the variables that affect mission capable rates (TNMCM and TNMCS variables as well as other underlying factors). Next, a discussion of the models the Air Force uses to forecast mission capable rates is conducted. The data needs, collection, and preparation are presented in Chapter III. Additionally, regression analysis is discussed both from an explanatory and forecasting perspective. The regression models are then developed and tested in Chapter IV. Finally, the results of the analysis and their implications as well as recommendations for future research are discussed in Chapter V.

II. Literature Review

"From levels of training, to equipment availability to personnel resourcing, units throughout the force are doing whatever they can to meet today's operational requirement – and barely getting by; however, high personnel and operational tempos have all by obscured the reality that the nation's ability to deploy and sustain large military forces during war has been placed in jeopardy, or in some cases, has clearly been lost…the proof of readiness will not be determined by the next peacekeeping mission, forest fire, or hurricane, but by how U.S. Army, Navy, Air Force, and Marine Corps units perform in the next war."

Rep. Floyd D. Spence, Chairman, House National Security Committee (Readiness Pledge by Pentagon Prompts Challenge from Congressional Leader, National Defense, 1997)

Logistical Readiness

Definition. To properly address the concept of readiness, it is essential that the term be defined to establish the context to discuss the subject. Joint Publication 1-02, *DoD Dictionary of Military and Associated Terms*, defines readiness as:

> *The ability of US military forces to fight and meet the demands of the national military strategy. Readiness is the synthesis of two distinct but interrelated levels: a. unit readiness--The ability to provide capabilities required by the combatant commanders to execute their assigned missions. This is derived from the ability of each unit to deliver the outputs for which it was designed. b. joint readiness--The combatant commander's ability to integrate and synchronize ready combat and support forces to execute his or her assigned missions* (JP 1-02, 2000).

Unfortunately, for the purpose of this thesis, the DoD definition is too broad and a more narrowly defined definition needs to be used in its place.

After reviewing several other definitions of readiness, Colonel Walter L. Siep's definition of readiness, specifically logistical readiness, provided the best definition. Colonel Siep defines logistical readiness in the following manner:

> *…the ability of forces, units, weapons systems, or material to carry out the movement, services, or maintenance planned for them or to deliver the outputs for which they were designed* (Siep, 1994).

His definition encompasses the four categories of readiness the Department of Defense measures to evaluate its overall readiness position. These four categories consist of personnel, equipment and supplies on hand, equipment condition and training (CJCSM 3150.02, 2000). For this thesis, Colonel Siep's definition of logistical readiness will serve as the baseline definition; however, the readiness categories of personnel and training will be combined into one and funding will be added as a new category.

Measuring Readiness. Several laws require the Department of Defense to measure its readiness. The Goldwater-Nichols DoD Reorganization Act of 1986 and Title 10, Section 482 of the United States Code are two of the main legislative directives that impose this requirement upon the DoD. The Goldwater-Nichols Act calls for the establishment and maintenance of a system to measure the preparedness of each unified and specified command to carry out its designated missions (USC, 2000a). Section 153 of Title 10 requires the DoD to provide quarterly reports that describe *…each readiness problem and deficiency identified and the key indicators and other relevant information related to each* (USC, 2000b).

The system the Department of Defense uses to gather the information it needs from each of the services to assess its readiness is the Global Status of Resources and

Training System (GSORTS). The operational units of each service determine their category level (C-level) rating, the degree to which a unit meets standards (Table 2), within each of the aforementioned categories as well as an overall C-level rating. The individual services may use their own reporting systems to gather information for their own units and report it to GSORTS or input it directly into the system (CJCSM 3150.02, 2000). One of the key systems the Air Force obtains data from to develop its inputs for GSORTS is the Reliability Maintainability Information System (REMIS) (AFPD 21-1, 1993; AFI 21-103, 1998) which will be discussed in more detail in Chapter III. The Air Force uses this system to provide GSORTS with mission capable rate data for all of its aircraft as one indicator of the readiness of its forces. Furthermore, the Air Force uses a wide variety of data from this system as an internal measure of its overall readiness.

Table 2. C-Level Definitions of Readiness (CJCSM 3150.02, 2000)

Category Level	Definition
C-1	The unit possesses the required resources and is trained to undertake the full wartime mission(s) for which it is organized or designed. The resource and training area status does not limit flexibility in methods for mission accomplishment nor increase vulnerability of unit personnel and equipment. The unit does not require any compensation for deficiencies.
C-2	The unit possesses the required resources and is trained to undertake most of the wartime mission(s) for which it is organized or designed. The unit's resource and training condition may cause isolated decreases in the flexibility of choices for mission accomplishment. However, it will not increase the vulnerability of the unit under most envisioned operational scenarios. The unit would require little, if any, compensation for deficiencies.
C-3	The unit possesses the required resources and is trained to undertake many, but not all, portions of the wartime mission(s) for which it is organized or designed. The resource and training area status will result in significant decreases in flexibility for mission accomplishment and will increase vulnerability of unit under many, but not all, envisioned operational scenarios. Unit would require significant compensation for deficiencies.
C-4	The unit requires additional resources or training to undertake its wartime mission(s), but it may be directed to undertake portions of its wartime mission(s) with resources on hand.
C-5	The unit is undergoing a Service-directed resource action and is not prepared, at this time, to undertake the wartime mission(s) for which it is organized or designed.

Now that readiness has been defined, the armed forces need to know what to be ready for. The bottom-up review and our nation's defense plans spell out the primary mission of our armed forces, which is to fight and win two near simultaneous major regional conflicts (MRC). In addition to the two MRC scenario, there are the implied missions that require the armed forces to meet unexpected threats in the future and support a wide variety of military operations other than war (MOOTW).

Readiness Through the Years

Air Force readiness has existed at different levels over the last three decades. To gain an overall understanding of how readiness has evolved over this period of time and the role the categories played; the categories used to measure readiness (personnel and training, equipment condition, supplies and equipment on hand and funding) will be examined over three distinct periods of time – the 1970s, 1980s and the 1990s.

The Hollow Force – The 1970s. In 1980, Army Chief of Staff General Edward C. Meyer coined the phrase "hollow force" as a term to describe the dismal state of the armed forces. General Meyer stated *…the combination of people, material and sustainability aspects caused him to say we had a hollow Army at the time…* he went on to say that *…it turns out we had hollowness in all the services* (Tirpak, 1994). The beginning of the 1970s saw the United States withdrawing its forces from Vietnam and by 1974; it had just experienced its first year without armed conflict. During this period, many experts considered the U.S. military to be deficient and lacking a robust ability to fight or dissuade war. All levels of command were uncertain as to whether the United States was prepared to fight the Soviet Union or anyone else. In the Air Force, the primary indicators of its "hollowness" were a lack of spare parts, insufficient flying hours and poor morale. Furthermore, the continuous departure of highly skilled personnel and the inability to attract high quality recruits compounded the problem further (Cuda, 1994; Tirpak, 1994 and Grier, 1998).

One area that was significantly impacted by the "hollowness" of the 1970s was the readiness of combat aircraft. Mission capable rates, a rate that represents the percent of time an aircraft/system is partially or fully capable of performing its designated mission, of fighter aircraft declined sharply. Aircraft are judged to be not mission capable (NMC) on the basis of maintenance needing to be completed, a lack of spare parts or a combination of both (DoD 3110.5, 1990). The components of NMC time are defined in ACCI 21-118, Logistics Quality Performance Measures Reporting Procedures, in the following manner:

> *Total Not Mission Capable Maintenance (TNMCM) Rate – The percent of time that an aircraft/system is not mission capable due to maintenance (NMCM) plus not mission capable for both maintenance and supply (NMCB).*
>
> *Total Not Mission Capable Supply (TNMCS) Rate – The percent of time that an aircraft/system is not mission capable due to supply (NMCS) plus not mission capable for both maintenance and supply (NMCB).*

Each percent of TNMCM and TNMCS is subtracted from a fully mission capable rate of 100 percent to arrive at an overall mission capable rate for the system being evaluated. Prior to 1981, only overall NMC rates were tracked; however, after 1981, the NMC rate measurement was broken out into TNMCM and TNMCS (and by default, NMCB) to refine the measurement (Merry, 2000a).

As shown in Figure 1, mission capable rates for operational fighters sharply declined during the 1970s. This plunge in mission capable rates (1971-1978) was known as the *Slippery Slope* and was a time when maintenance personnel struggled to support flying schedules and cannibalized aircraft were plentiful (Bell, 2000a). Personnel reductions and a poorly skilled workforce are often cited as the major factors closely associated with the decline as well as a lack of test equipment, dwindling spare parts stocks, the decreased reliability of older weapons systems and the technological complexities associated with the activation of new weapons systems such as the F-15, F-

16 and A-10. Each of these factors played a role in delaying the return of aircraft to fully mission capable status after breaking (Cuda, 1994).

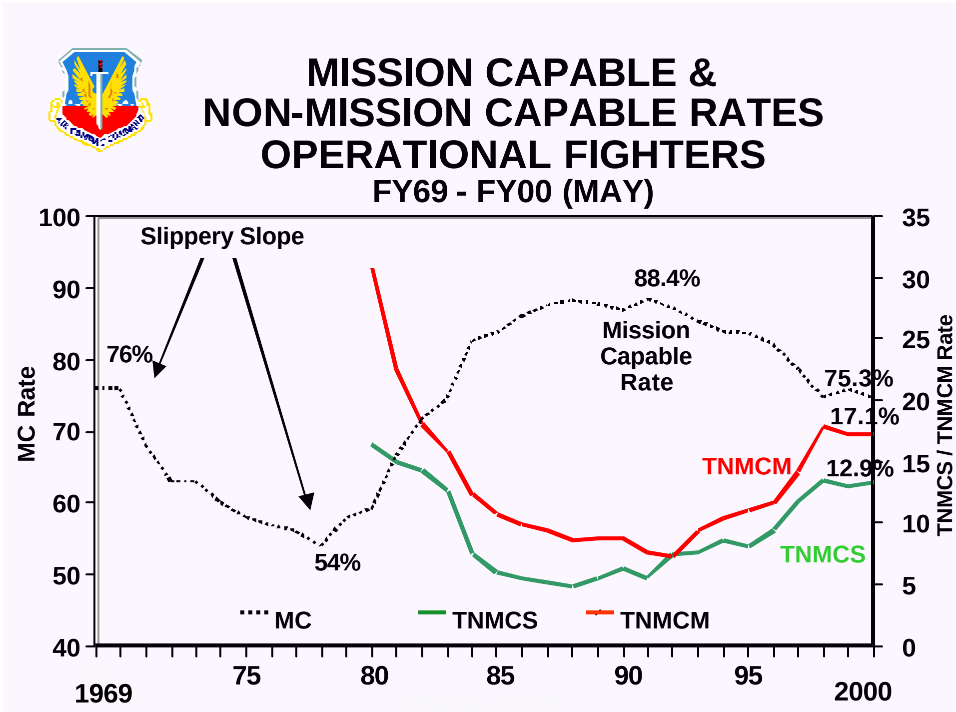


Figure 1. Mission Capable Trends (Merry, 2000)

Another reason for decreased mission capable rates that serves as a common denominator for many of the other reasons is the level of financial resources made available to the Air Force to conduct its operations and purchase the resources it needs. From 1970 to 1979, total obligation authority for the Air Force was reduced 28.2 percent (from $112B to $80.6B) as measured in constant 2001 dollars. Additionally, funding for both operations and maintenance (O&M) and procurement funding fell 24.9 percent (DoD, 2000) (Figure 2).

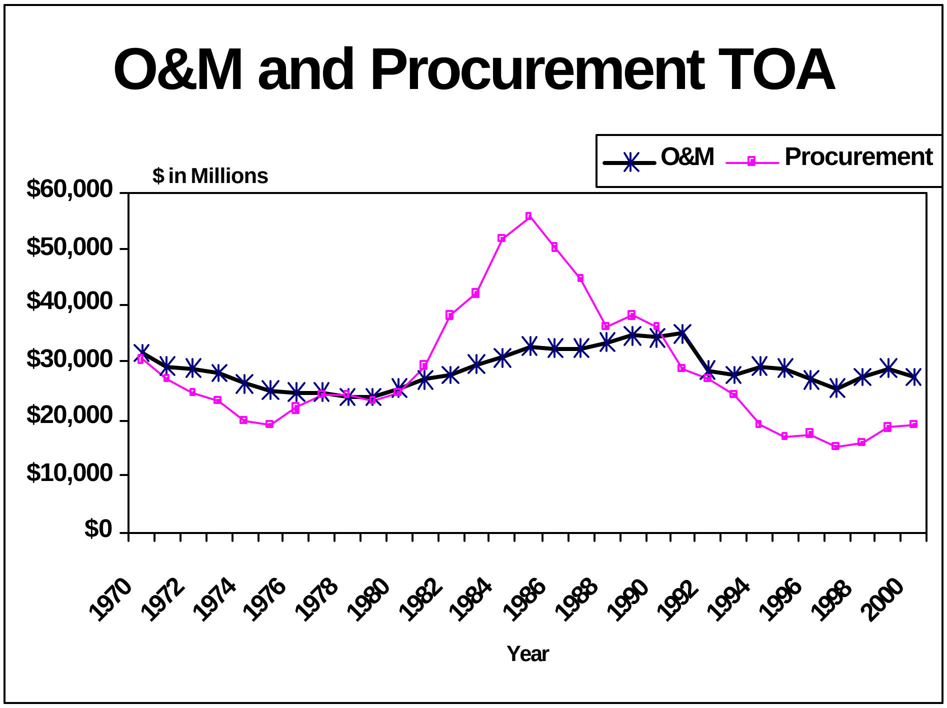


Figure 2. O&M and Procurement Total Obligation Authority (DoD, 2000)

During this period, personnel levels decreased dramatically. In 1970, Air Force personnel levels stood at approximately 791,000 active duty personnel and was plagued by defeated, demoralized, drug ridden personnel consisting of numerous high school dropouts and Category IVs that were deserting, going AWOL and being court-martialed (Record, 1995). Throughout the 1970s, the number of Air Force personnel was sharply reduced until the number of active duty members stood at roughly 558,000 in 1980 (DoD, 2000). Although the force reduction of the 1970s was relatively painless due to the high percentage of draftees and undesirable personnel leaving the service, the end of the 1970s saw competition from the private sector in the form of higher pay and more opportunities affecting the Air Force's ability to retain its higher quality personnel. Moreover, the failure of the DoD to match private sector pay, resulting in a "pay gap" that approached

14 percent, contributed to second term reenlistment rates dropping from 75 percent in 1974 to a low of 60 percent in 1979 (Cuda, 1994). Since second term airmen represent the bulk of the Air Force's most technically proficient segment of its workforce, readiness in other areas declined as well.

While it was in the midst of transitioning to more technologically complex weapons systems designed to replace its fleet of aging Korean and Vietnam War era systems, the Air Force lost a significant number of its experienced personnel. This transition coupled with the personnel problems and other reasons previously listed, as well as its funding posture throughout the 1970s, had a substantial negative effect upon the mission capable rates of Air Force fighter aircraft and its readiness.

Re-Arming – The 1980s. This era was completely the converse of the one it followed. From a defense standpoint, the United States was primarily focused on one adversary – the Soviet Union – and geared much of its effort at countering the threat the Soviets presented. The United States realized it needed a military capable of countering the Soviet threat and proceeded to rebuild its military forces from the hollow forces of the 1970s.

The 1980s was an era of substantial resources, new equipment and demanding training standards. At the beginning of the 1980s, mission capable rates hovered at approximately 65 percent, but as the decade progressed, mission capable rates improved dramatically (Figure 1). The new, modern weapons systems introduced in the late 1970s were almost fully deployed throughout the Air Force in the early 1980s. This infusion of new, more reliable aircraft coupled with the retirement of many of the older systems, in conjunction with other factors, helped create a sharp upward trend in mission capable rates that reached levels up to 85 percent or more for some systems where they remained for the remainder of the decade (Humphrey, 1999).

One primary reason mission capable rates reached and remained at such high levels was the amount of funding the Air Force received during this period of time. President Ronald Reagan was elected based in part on his stated commitment to restore the status of the military and counter the Soviet threat (Noonan, 2000). To achieve the promises he made, President Reagan worked with the Congress to achieve tremendous increases in the Department of Defense's budget. Using the constant 2001 dollars, the Air Force's total obligation authority rose 12.6 percent in 1981 ($84B to $94.5B) and increased another 14 percent (to $108B) in 1982. Over the span of the decade, operations and maintenance funding increased over 37 percent ($27B to $34.75B) while procurement funding increased by 31 percent ($29.18B to $38.24B). However, even with this overall growth in funding, the defense budget began to steadily decline starting in 1986 when it fell 4.6 percent (Figure 2) (DoD, 2000).

With the introduction of new aircraft and the increased amount of funding available, the Air Force had more reliable aircraft and was able to purchase vast quantities of spare parts (Bell, 2000a). Additionally, in 1985, the DoD maintained a policy that required each service to retain all serviceable and economically repairable items that could be used on actively operated weapons systems (OSD, 1991). The funding increases and spare parts retention policy led to huge inventories of spare parts for repairing Air Force aircraft, resulting in a continual decline in TNMCS rates throughout the 1980s that can be seen in Figure 1.

During this time, the number of personnel on active duty increased significantly. The number of Air Force active duty personnel rose from 558,000 to 608,000 from 1980-1986 before the personnel drawdown of the late 80s and early 90s took place. Eventually, portion of the drawdown that occurred in the 1980s reduced the active duty force to 539,000 by 1990 (DoD, 2000). Although the average annual number of active duty Air Force personnel in the 1980s was less than that of the 1970s, the quality of the individuals was much better. The Air Force's emphasis was to recruit and retain the highest quality individuals possible. By 1983, almost 100 percent of new Air Force recruits held a high school diploma (or its equivalent) and the number of category IV recruits (those determined to be of low trainability based on their Armed Forces Qualification Test) accepted by the Air Force was substantially reduced (Cuda, 1994). The Air Force was able to attract these high quality recruits by offering improved pay, from substantial raises in military pay, and job security to protect the recruits from the increased unemployment levels (Asch et al., 1999). With better quality recruits, the Air Force was able to develop a workforce that possessed the technical skills and intelligence to sustain the high mission capable rates it was achieving. One indication of the relationships among personnel, training and mission capable rates was the reduction in TNMCM rates that occurred. The reduction is indicative of the effect a better manned and better-trained aircraft maintenance workforce can have on mission capable rates (Merry, 2000). Figure 1 appears to support this assertion as TNMCM rates continually declined throughout the 1980s.

Improved funding levels, full fielding of new weapons systems such as the F-15 and F-16, increased availability of spare parts and the increased quantity and quality of personnel of the 1980s helped the Air Force recover from the readiness decline it suffered through in the 1970s. All of these factors, among many others, led to some of the highest readiness levels the Air Force had experienced during since its inception in 1947. In 1986, fiscal reality set in and the United States began to draw down its forces and reduce defense spending. However, even through the portion of the drawdown that occurred during the late 1980s, the Air Force was able to maintain and even improve the high readiness levels it had achieved. By the end of the decade, the level of readiness achieved by the DoD and the Air Force played a key role in ending the Cold War and the collapse of the Soviet Union. Faced with fiscal reality and its primary threat dispatched, the United States began to drawdown its forces and reduce defense spending at a faster pace.

Time of Change – The 1990s and Beyond. Readiness in the 1990s proved to be a combination of both the 1970s and 1980s levels. Like the 1970s, it opened up with reductions in both personnel and funding levels that began in the previous decade; yet, it experienced extremely high readiness levels such as those of the 1980s. Although personnel and funding levels were dropping, the large inventories of spare parts and equipment, more reliable aircraft and a force composed of high quality personnel from the 1980s were still in place, keeping readiness levels at all time highs. Unfortunately, the signs of decreasing readiness were becoming apparent (Figure 1).

As early as 1994, it was apparent that these changes in the defense environment were affecting readiness. In August 1994, the Defense Science Board's Task Force on Readiness, created as an early warning system to detect trouble with readiness to keep the United States military from reverting to a hollow force, reported that readiness of US forces was acceptable in most areas. However, it also reported that pockets of unreadiness had appeared and were probably associated with the drawdown of forces and that they needed to be monitored closely or US forces could lapse into a hollow force. The report listed one of the signs of the services deteriorating readiness was a growing maintenance backlog caused by unscheduled OPSTEMPO, availability of spare parts and the availability of properly trained maintenance personnel (DSB, 1994). In the Air Force, mission capable rates for its aircraft were beginning to slip. According to Lieutenant General Thad A. Wolfe, Vice Commander of Air Combat Command (ACC), its mission capable rates for the F-16 declined from 85 percent in 1991 to 79.5 percent in 1994 (Maze, 1994).

With the demise of the United States' primary threat over the last 40 years and other domestic and international changes, the U.S. military began its transformation from a large overseas garrison force to a smaller CONUS –based, mobility-centered force. These changes in the Air Force's operating environment (among others) resulted in a tremendous increase in the number of deployments for the Air Force and the rest of the services, primarily in support of military operations other than war (MOOTW). During the 1980s, the U.S. military was deployed 16 times as compared to the 50-plus times it was deployed in the 1990s (Lehman and Sicherman, 1997). In a March speech to the Air Force Academy's class of 2000, Secretary of the Air Force F. Whitten Peters stated the root of the Air Force's problems were rooted in the unparalleled increase in peacekeeping and other missions abroad. *"This was ad hocism at its worst, and we have paid a tremendous price,"* he said (Diedrich, 2000). In another speech about readiness and increased commitments, General Ryan said, *"We went to the Gulf War and didn't come* *back…and we went to the Balkans in Operation Deliberate Force and then a bigger operation and ended up with 21 overseas locations versus the dozen that had been funded"* (AFPN, 2000). The number of deployments the Air Force aircraft participated throughout most of the 1990s can be seen in Figure 3 and the number of people deployed since 1989 is shown in Figure 4.

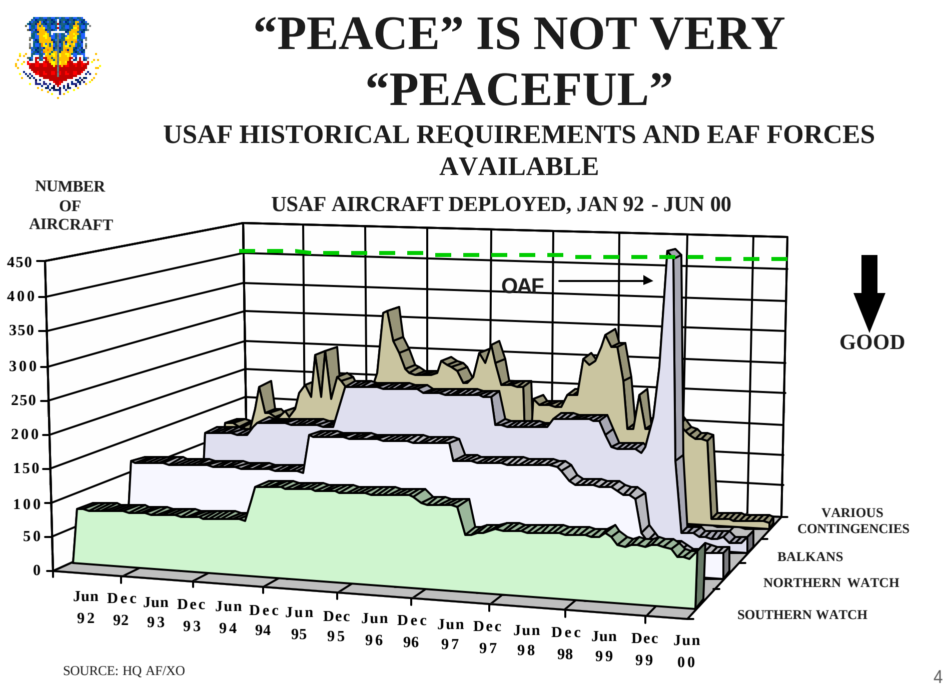


Figure 3. Number of Aircraft Deployed Throughout the 1990s (Merry, 2000b)

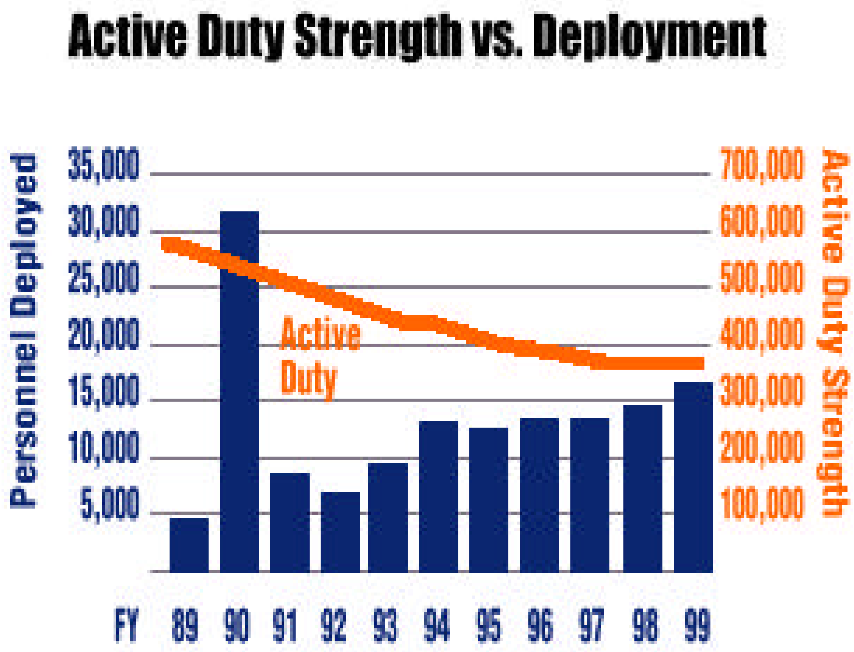


Figure 4. USAF Deployed Abroad (Ryan, 1999)

At the onset of the 1990s, mission capable rates for Air Force aircraft were at all time highs but began to decline as the decade progressed. Since 1991, the overall mission capable rate has declined nearly ten percent from 83.4 percent to 73.7 percent at the end of 1999. Fighter mission capable rate drops averaged 10 percent while strategic airlift and bombers dropped 6.2 and 2.3 percent respectively (Hunter, 1999 and AFA, 1999). There are many reasons behind the Air Force's falling mission capable rates. On March 10 1999, Chief of Staff of the Air Force, General Michael Ryan and Secretary Peters, testified before a House appropriations subcommittee of defense that Air Force readiness had declined in recent years and that high operations tempo, aging equipment and years of under funding equipment and parts were the cause. They went on to say that the problems in each of these areas (as well as retirement and low pay) had also contributed to the Air Force's personnel retention problems (Jordan, 1999).

The 1990s saw the reliability of many of the Air Force's aircraft begin to falter (Figure 5). For example, the F-15E, which achieved a mission capable rate of 88 percent in 1991, saw its mission capable rate drop to 76.1 percent by 1998 (Dorr, 1999). Although the average age of Air Force aircraft and OPSTEMPO increased during this period, the break rate, which measures the number of aircraft that land from a sortie with a code 3 grounding condition, for most aircraft remained fairly steady. However, increases in preventative maintenance and more "hard" breaks that took longer to repair helped drive up both TNMCM and TNMCS hours (Humphrey, 1999).

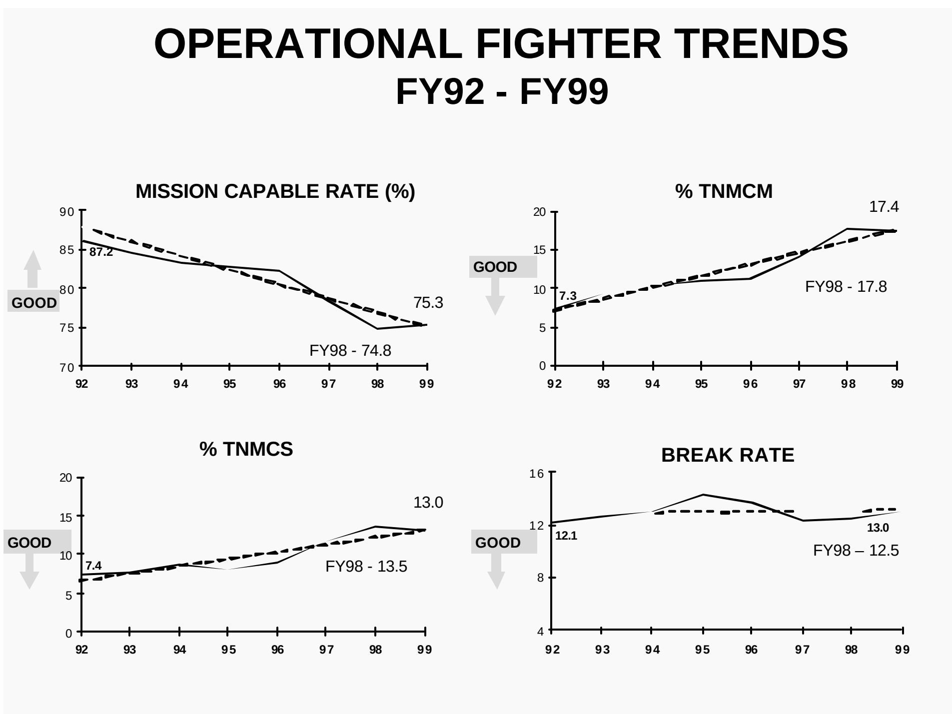


Figure 5. Operational Fighter Trends (Merry, 2000a)

Changes in the defense environment also prompted changes in the level of funding provided to the DoD. With the United States' "victory" in the Cold War, the President and Congress looked to the DoD for the "peace dividend." Collecting the dividend came in the form of reduced DoD budgets. Although funding levels had been dropping since 1986, total obligation authority for the Air Force dropped significantly in 1990 and was reduced by an average of 6.38 percent per year from 1990-2000. Operations and maintenance total obligation authority fell over 20 percent from 1990 to 2000 (from $34.3B to $27.3B). Reductions in procurement, which includes support equipment, initial and replenishment spares as well as repair parts, were even worse. Total obligation authority fell 48 percent during the same period of time (from $36.3B to $18.9B) (Figure 2)(DoD, 2000). The reduction in procurement, coupled with Defense Management Report Decisions pertaining to the management and maintenance of spare parts inventory levels, had a significant impact upon aircraft mission capable rates. In a speech to the Air Force Association's Air Warfare Symposium, General Ryan stated, *"we didn't realize how very small changes in funding, equipage and spare parts could affect the readiness of the total force"* (AFPN, 2000). Even more recently, Lt Col Tom Meredith, the Supply Management Activity Group Chief in the Air Force Aircraft and Missile Support Division at the Pentagon, stated *…constrained spare parts funding combined with an unusually high operations tempo and an aging fleet directly contributed to an increase in non-mission capable rate*s (Bosker, 2000).

Contributing to the Air Force's readiness decline in the 1990s were the changes taking place in its force structure. With the exception of the Reagan buildup of the 1980s, the Air Force has been continually downsizing its personnel levels (Figure 6). In the 1990s, shrinking defense budgets, changes in the defense environment and the Air Force's transformation to a highly mobile and deployable force required it to reduce its personnel levels even further. With an all-volunteer force in place, personnel reduction was much more difficult as compared to the reduction that took place in the 1970s. So in 1986, the Air Force implemented several methods to help it reduce its numbers.

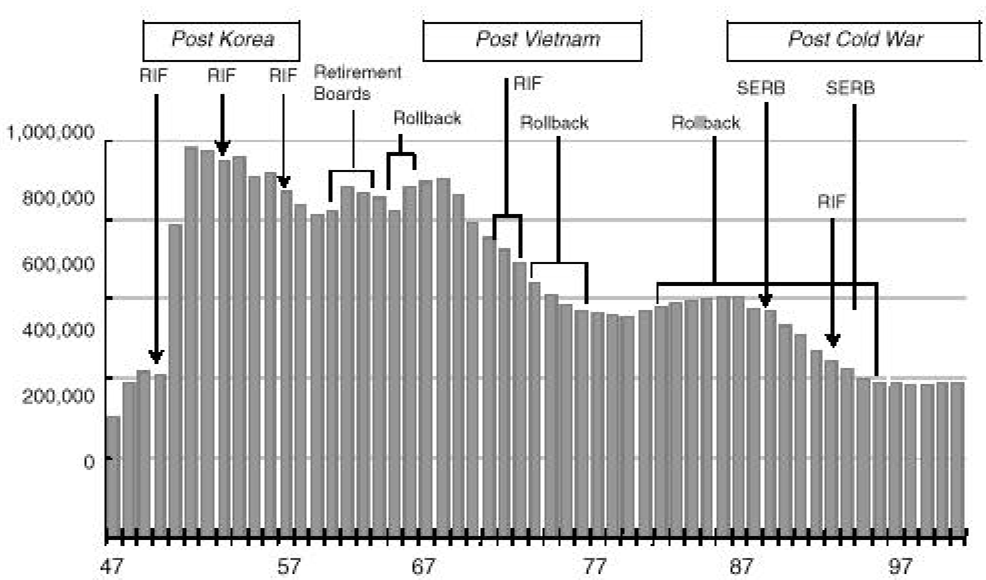


Figure 6. USAF Personnel Levels Since 1947 (AF, 2000)

Beginning in 1986, the Air Force implemented two different passive force reduction policy changes to reduce its size. First, it reduced its accession levels by slowing the recruitment of new members, which helped reduce personnel levels at the time but had future implications in the areas of experience, pay-grade and occupational mix. For the personnel already on active duty, entry into the career force was limited. Officers' opportunities for regular augmentation dropped from three to one and enlisted personnel not promoted to E-5 by their tenth year of service were forced to separate whereas before, promotion to E-4 could allow a member to stay on active duty 20 years (Martin, 1999)

In the 1990s, the Air Force took a more aggressive approach to reducing its personnel levels, using several new force shaping tools made available to it by Congress. In 1993, Congress authorized two new programs for the services to use to reduce personnel levels. Both the Voluntary Separation Incentive and the Special Separation Benefit paid members to voluntarily leave the service. By the end of FY 1996, the Air Force paid 6,000 officers and almost 35,000 members to separate early. To reduce the retirement eligible portion of the officer corps, the Air Force implemented Selective Early Retirement Boards, separating over 4,000 officers since 1991. For the enlisted force, the high year of tenure ceilings were reduced for four enlisted grades, forcing many enlisted personnel to retire earlier than planned. The Air Force also used the Temporary Early Retirement Authority given by Congress to the services, allowing members with over 15 years of active service to retire early. By the end of 1996, over 16,000 personnel elected to retire using this program. Finally, when there weren't enough officer volunteers for separation, the Air Force used one Reduction in Force board to involuntarily separate officers from the service, driving over 1,500 officers out of the active duty ranks (Martin, 1999).

From 1986 to 1997, the Air Force met its personnel reduction goals, reducing the active force by 36% (from 871,000 to 558,000) with plans to reduce the force to 491,000 by 2003. Although the Air Force met its force shaping goals, achieving them did not come without a price.

In his testimony to Congress, Lieutenant General Billy Boles, former Deputy Chief of Staff, Personnel, said, *"…the RIF and SERB have done more damage to morale and injected more uncertainty into the force than any other personnel action I've encountered in more than 32 years of active military service"* (Martin, 1999). For numerous reasons, between 1994 and 2000, Air Force retention has dropped below its established goals (Figure 7). Since 1995, Air Combat Command's manning (categorized by skill level) and retention levels, with the exception of 3-level manning, have decreased substantially as well (Figure 8).

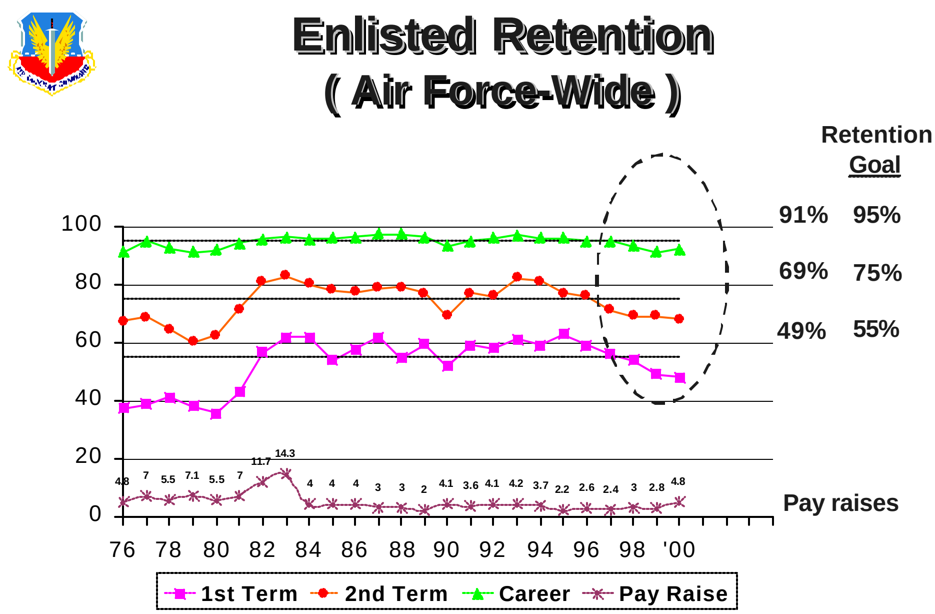


Figure 7. Air Force Retention Trends (ACC, 2000a)

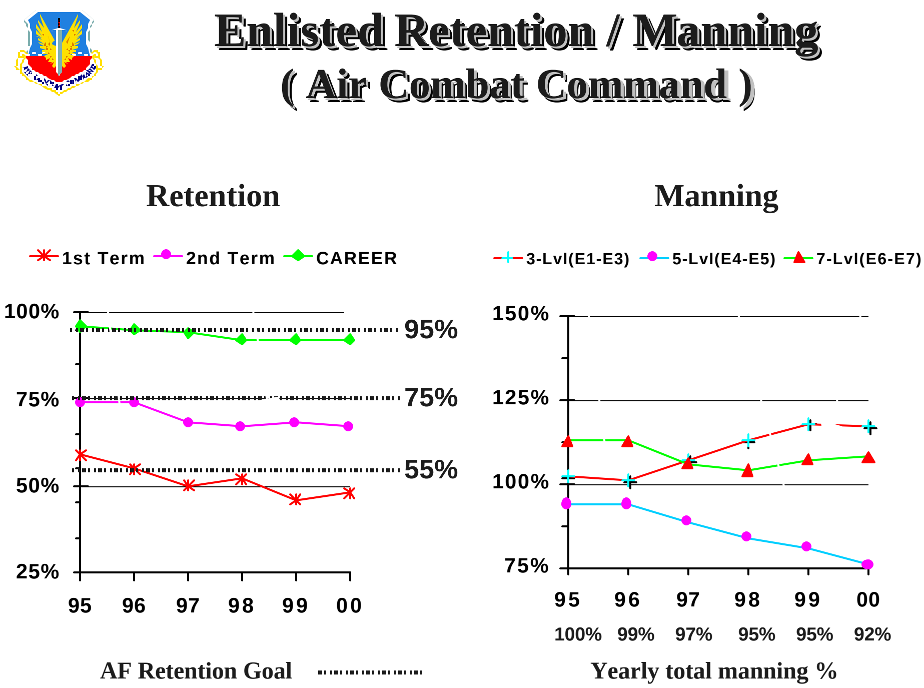


Figure 8. Air Combat Command Retention and Manning Levels (ACC, 2000a)

Aircraft maintenance manning levels have not gone unscathed either. In Air Combat Command, data from the last 4 years tells the same story. Overall enlisted manning levels in the primary aircraft maintenance areas, crew chiefs, avionics, munitions, structures, engines and aircraft systems, have declined, reducing the pool of experienced technicians in each area (Figure 9). According to the Brigadier General Wetekam's Expeditionary Aircraft Maintenance briefing at ACC's 2000 Senior Leaders Maintenance Course, the continued shortfall in personnel could jeopardize the execution of the annual flying program and could cause ACC to fall short of meeting the CINC's requirements in a two major theater war scenario (Wetekam, 2000).

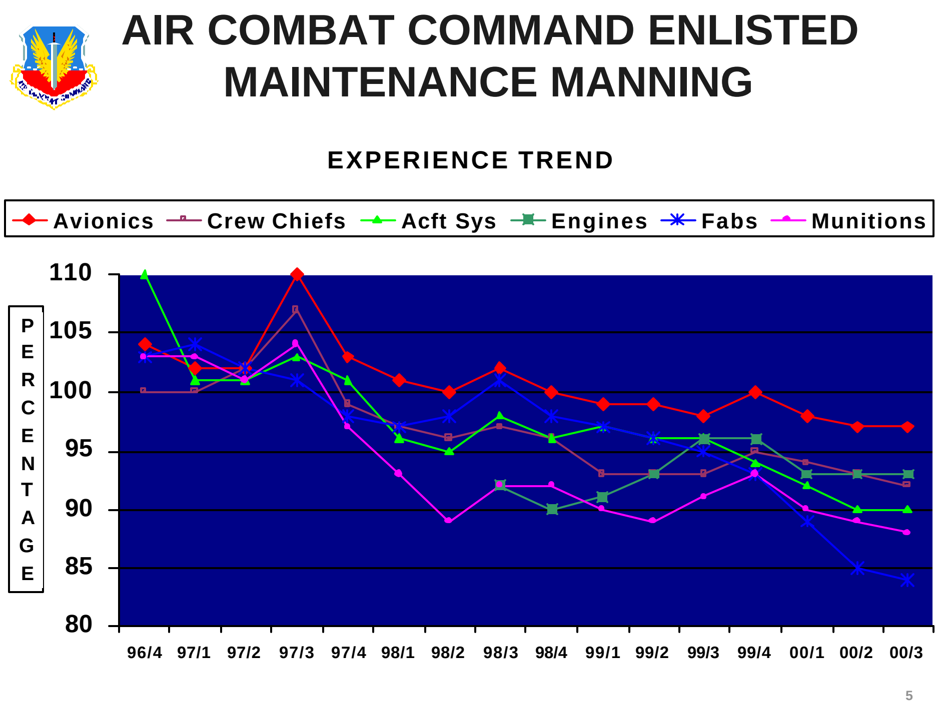


Figure 9. ACC Maintenance Personnel Manning Levels (ACC, 2000b)

Recall that one of the anticipated outcomes from the end of the Cold War was the peace dividend that would be realized from reduced defense spending; consequently, funding levels for all the services throughout the 1990s, including the Air Force, were slashed. In addition to reduced funding, part of this dividend was to be obtained from savings achieved through inventory reductions. Defense Management Report Decision (DMRD) 987 was implemented to achieve further savings by reducing the DoD’s $110B spare parts inventory. The policy called for each service to dispose of inactive inventory items while reducing future spare parts buys. The Office of the Secretary of Defense (OSD) developed service-specific inventory reduction goals under the premise that reductions in inventory should be proportional to reduction in force structure. When the services failed to meet established inventory reduction goals, the OSD cut their spare parts budgets (OSD, 1991).

In the Air Force, inventory reduction cost savings goals for FY92-97 from DMRD 987 were anticipated to reach $37.96B. To achieve these cost savings, the Air Force implemented the PACER TRIM and PACER REDUCE inventory reduction programs. Through these two programs, the Air Force reduced or terminated contracts for obsolete reparable items and equipment, created flexible contracting arrangements to accommodate changing requirements and disposed of unserviceable inventory (AFLC, 1990; Mattern, 1997). By the end of 1997, these two programs achieved cost savings of over $19B and eliminated over 900,000 reparable items from its inventory (Hutson, 1999).

Unfortunately, even as the size of the Air Force was reduced, its OPSTEMPO increased tremendously. The impact of increased OPSTEMPO combined with inventory reduction initiatives (both inventory reduction and reduced spares funding) became quite apparent as the 1990s progressed. One area where it was very visible was that of aircraft mission capable rates. From 1990-2000, the overall TNMCS rate for ACC's operational fighters increased over 100 percent from 6.1 percent to 13.1 percent (Figure 10) (Merry, 2000b). This increase serves as an indication that aircraft maintenance personnel lack the spare parts they need to keep aircraft flying which leads to increased cannibalizations of parts from one aircraft to repair another which doubles the maintenance workload (Bosker, 2000). Furthermore, increases in parts cannibalizations increase the probability that parts will be broken when removed from one aircraft and placed in another which could increase the demand placed on the supply system for parts (Matthews, 1998).

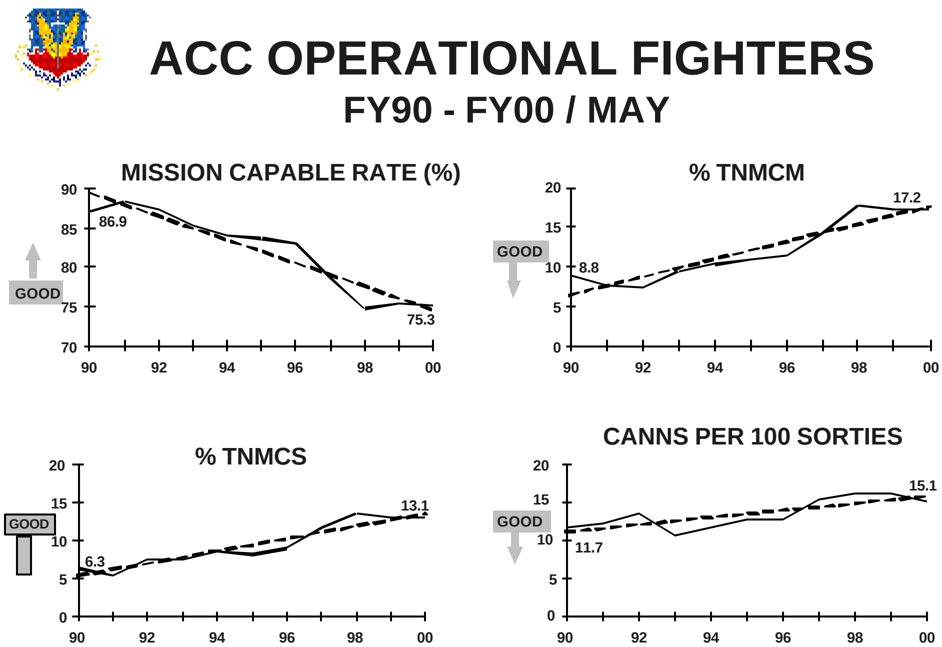


Figure 10. ACC Aircraft Readiness Trends (Merry, 2000b)

Today, Air Force readiness is still on the razor's edge. Representative Floyd Spence's opening comments during the September 27, 2000 Hearing on Readiness and Service Budgets spoke of Air Force readiness in the following manner:

> *The Air Force is also experiencing readiness difficulties across the board. This past April, the Air Force experienced its lowest readiness levels in fifteen years, with only 67 percent of its combat units reporting C-1 or C-2, the highest readiness ratings. Although spare parts and personnel shortages continue, the Department's latest Quarterly Readiness Report noted that the Air Force is "beginning to arrest the declining trend in aircraft mission capable rates."*(Spence, 2000)

During his testimony, General Ryan stated, *"Air Force readiness has not turned around…at best the increased funding from the administration and Congress have leveled off the decline."* As his testimony progressed, General Ryan explained that the current OPSTEMPO, past under funding of spare parts, an aging aircraft fleet and a less experienced workforce coupled with low retention were significant contributing factors to the continued readiness decline (Ryan, 2000). These comments, among many others reviewed in the literature, make it very apparent that readiness will be an important issue for years to come.

Mission Capable Rates

Importance, Purpose and Cost. Aircraft mission capable rates, as reported through Air Force logistics status reporting, provide both the Air Force and our nation's leadership an indication as to the readiness of Air Force aircraft to perform their missions. According to Air Force Instruction 21-103, *Equipment, Inventory and Status and Utilization Reporting*, mission capable rates are used for the following purposes:

1. *Compute the official Air Force inventory.*
2. *Build the Air Force programming documents and their related budget and staffing requirements.*
3. *Produce statistical analysis for congressional committees, the Office of Management and Budget, and the Department of Defense.*
4. *Establish mission capability (MC) goals. These goals enable HQ USAF to assess resource allocation funding on a quarterly basis. The MC-rate goals and plans also go into the yearly DoD Materiel Readiness Report to Congress.*

Since this data is used to develop and justify Air Force plans, programs and budgets, it is critical that timely and accurate reporting of the data occur since failure to do so could result in the Air Force losing funding, manpower authorizations and supplies.

These rates are readiness indicators that are directly proportional to the amount of time an aircraft is not mission capable (NMC) because of a lack of spare parts (TNMCS) or because maintenance needs to be completed to make the aircraft available (TNMCM). For a fleet of 10 aircraft, a mission capable rate of 70 percent normally indicates that seven of the 10 aircraft are available to perform their mission while the remaining three aircraft are unavailable either due to a lack of spare parts or because maintenance still needs to be completed or both (Grier, 1994; Ryan, 2000; ACCI 21-118, 1993). While achieving a 100 percent mission capable rate is possible, it is not a cost-effective course of action to undertake.

As with any piece of equipment not available for use, there are various costs related to its unavailability such as in the case of an NMC aircraft. Not only are these costs are hard to identify; they are extremely difficult to measure. Furthermore, in the case of NMC aircraft, many of these costs are interconnected with the others and appear primarily as lost opportunity costs (i.e. the cost of lost training opportunities). According to Admiral James Loy, Commandant of the Coast Guard, *"…operational tempo, parts and personnel problems feed off each other"* (Loy, 2000). Inadequate quantities of the right mix of spare parts typically leads to increased cannibalizations of needed parts from other aircraft. Cannibalizing parts from one aircraft to support another doubles the amount of maintenance manhours required to return an aircraft to mission capable status, eventually transforming parts shortages in personnel problems. Cannibalization of the part could result in the part being damaged during removal or installation, rendering it useless and leaving the aircraft NMC, possibly resulting in canceled sorties. Additionally, the increased workload placed on the technicians cannibalizing the part might result in lost training opportunities for themselves or to train others, increased stress both on themselves and family members and decreased productivity for the unit (Loy, 2000).

So what costs to the Air Force are associated with this example? Lack of aircraft availability due to spare parts and maintenance problems has led command officials to try and persuade regional CINCs to do without some Air Force assets or to look to other units that can fly real-world missions in their place. Actions such as these usually increase the OPSTEMPO for the other units (Bird, 1997). Lack of mission capable aircraft also leads to reduced training opportunities for aircrews resulting in degradation of their skills. In 1999, Major General Glen Moorehead, the commander of the Air Warfare Center at Nellis AFB, told a House Armed Services subcommittee that 15 percent of the Air Force Weapons School's sorties were canceled in 1998 for lack of spare parts and that a lack of trained pilots forced the 20th Fighter Wing from Shaw AFB to cancel its participation in the February 1998 Red Flag training exercise. He also testified that weapons testing programs had to be restructured because of broken test aircraft and insufficient manning levels (Palmer, 1999; Naylor, 1999). Conditions and situations such as these have affected pilot retention and have kept the Air Force from completely executing its annual flying hour programs (Figure 11). According to Senator James Inhofe, many aviators leaving the Air Force have cited concerns about reduced training, poor maintenance, lack of spare parts and excessive cannibalizations as reasons for their departure (Kreisher, 1999).

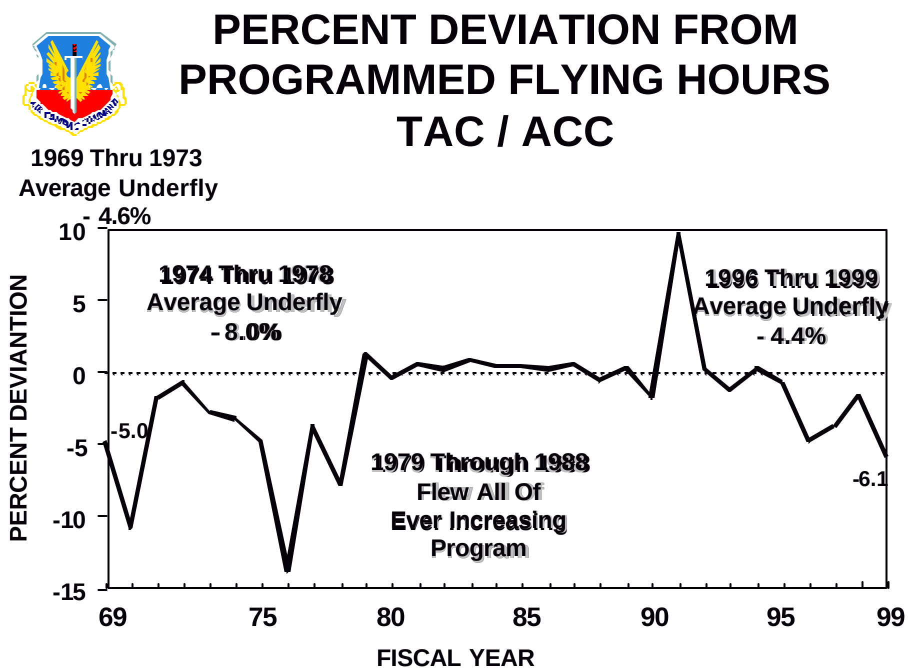


Figure 11. ACC/TAC Flying Hour Program Execution (Wetekam, 2000)

The costs aren't just limited to pilots and flying; they go much further. Increased maintenance requirements resulting from inadequate funding, spare parts shortages, manning shortages, skill and experience imbalances and the resulting turmoil from each have impacted the enlisted aircraft maintenance community. Increased workloads brought upon by aging aircraft, parts shortages and under manning have fallen upon the shoulders of the mid-level NCOs, composed primarily of second term and career 5- and 7-level technicians, resulting in many becoming frustrated and separating from the Air Force (Figures 12 and 13). Not only does the Air Force lose highly experienced technicians, it also loses highly skilled trainers since both 5- and 7-level technicians are responsible for on-the-job training of 3-level technicians. With a reduced number of trainers and an increased number of trainees that have replaced the technicians that separated, the need for supervision and training increases at the same time maintenance and sortie production needs to be accomplished (Dahlman and Thaler, 2000). According to Major General Morehead, in his units *"Young aircraft maintainers stand around waiting for training because there are too few supervisors to train them. Most mid- to senior-level NCOs have been deployed"* (Palmer, 1999). In most cases, there is no way to get around this increased training need because units generally can only get experienced technicians by training 3-levels. These conditions, lack of experience and under manning, appear degrade the ability to generate sorties and conduct training (Dahlman and Thaler, 2000).

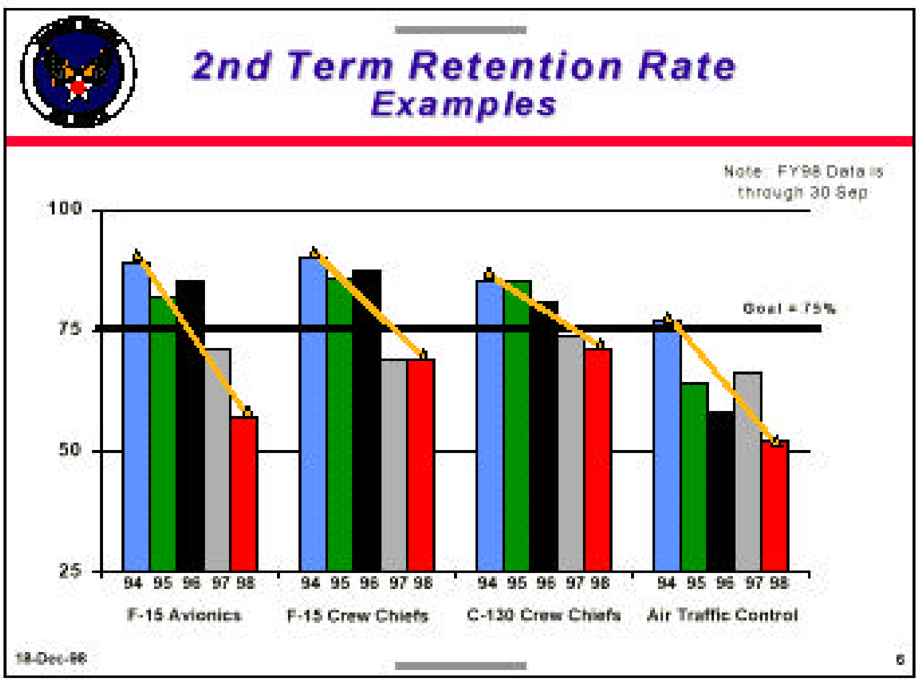


Figure 12. Second Term Retention Rates (Ryan, 1999)

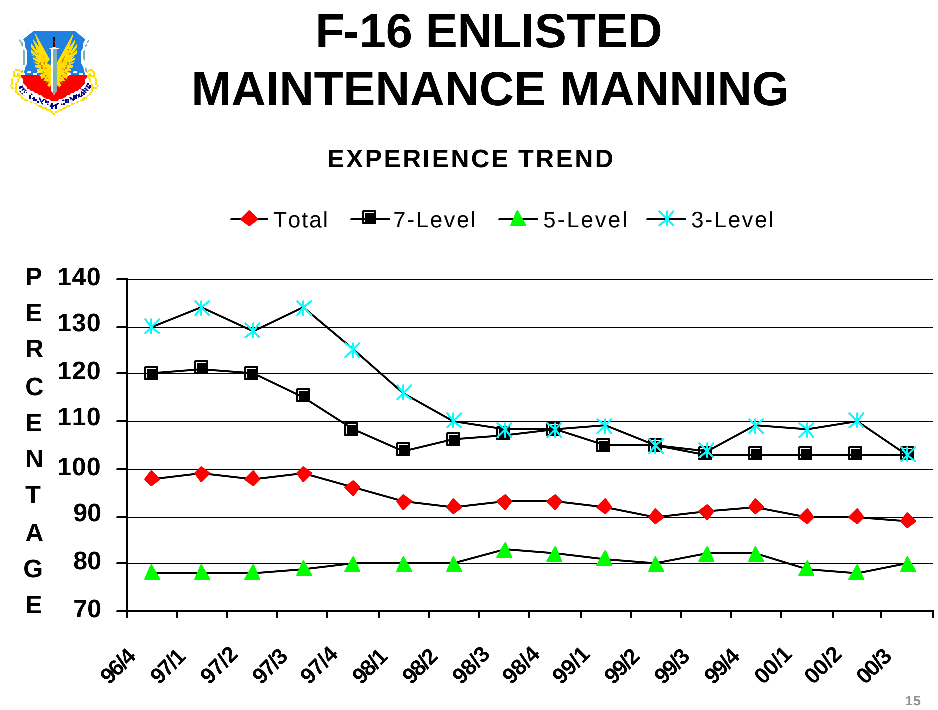


Figure 13. F-16 Maintenance Manning by Skill Level (Merry, 2000b)

While the costs associated with filling the holes left by departing service members (pilots, maintainers and others), aircraft reliability and maintainability modifications and the procurement of additional spare parts can be quantified, the intangible costs that ripple across the Air Force generated by these conditions and the problems that brought them about are almost impossible to measure. Reduced flexibility, decreased operational support, the loss of leadership from experienced mid-term service members, poor morale and increased family stress are only a few among many intangible costs associated with the decreased readiness in the form of falling mission capable rates and increased OPSTEMPO (Roos, 1998; Bird, 1997; DSB, 1994; Lamontagne, 2000). Representative Spence recognized the price the Air Force and the other services were paying for their readiness levels, stating that…

"Doing more with less is the military's new motto, but it is not a sustainable strategy nor is it conducive to ensuring the long-term preparedness of an all-volunteer force" (Williams, 1997).

From comments made by senior military and civilian leaders and the personnel in the field, it appears the net effect of declining mission capable rates is that they affect many areas and the costs associated with them, both tangible and intangible, are considerable, having a significant impact upon the Air Force and its operations.

TNMCM Variables

The Total Not Mission Capable Maintenance (TNMCM) rate describes the percentage of aircraft that are not mission capable (NMC) due to one or more maintenance conditions. A grounding maintenance condition could be almost anything ranging from the replacement of a leaking fuel cell to the completion of scheduled maintenance or a Time Compliance Technical Order (TCTO). The amount of TNMCM time (measured in hours) an aircraft accumulates is related to and influenced by many different factors – some that are easily measured and some that are not. A study conducted for HQ USAF/ILSY by Dynamics Research Corporation (DRC) identified factors such as manning, skill levels, retention, increased inspections and modifications to aging aircraft, break rates, cannibalizations, increased manhours, OPSTEMPO and aircraft maintenance management policy changes as being related to TNMCM time (Humphrey, 1999). Furthermore, a TNMCM study performed by the Air Force Logistics Management Agency (AFLMA) identified many of the same factors (Bell, 2000b). Some factors, such as cannibalizations, are related to both TNMCM (increased maintenance time removing and installing parts) and TNMCS (inadequate spares driving increased cannibalizations) and will not be addressed in this section. The remaining factors identified by DRC and AFLMA can be mostly grouped into three areas: personnel, reliability and maintainability and aircraft maintenance management policies.

Personnel. Personnel are a key part of the readiness equation. There are many factors to consider when addressing the relationship between personnel and TNMCM rates (measured in hours). A review of the literature indicated that in the maintenance arena, changes in manning levels, experience (skill level and rank), morale and retention were related to changes in TNMCM rates. Some of these factors are easily quantified (manning levels and number of NCOs) while others are not (maintenance experience and morale). With respect to the quantifiable variables, several studies have indicated manning levels in the enlisted maintenance career fields (2AXXX and 2WXXX) appear to be negatively correlated to TNMCM hours (Dahlman and Thaler, 2000; Humphrey, 1999; Gauthier, 1998). As the number of personnel in these career fields decreased, the number of TNMCM hours increased (Humphrey, 1999).

Not only does the number of personnel correlate to TNMCM rates, experience of personnel (defined by their AFSC skill level or by their time-in service) also demonstrates a similar relationship. DRC's TNMCM study explored this relationship and found that reductions in the number of 5- and 7-level technicians as well as a reduction in the number of NCOs also exhibited a negative correlation with TNMCM hours (Humphrey, 1999).

Reliability. Reliability is another variable that has a dramatic influence upon TNMCM rates. *Reliability is the probability that an item will perform its intended function under stated conditions for either a specified interval or over its useful life*

(DAU, 1998). As cumulative operating time of a system increases, the probability of it failing tends to increase. Reliability also decreases when the conditions under which the system was designed to operate change (Bresnahan, 1998). In the Air Force, the average aircraft is 20 years with 40 percent of the fleet 25 years or older (Figure 14.). Many of these aircraft are have reached critical points in their life cycle (Matthews, 1998). For example, many F-16s have reached 2400 hours of flying time, a critical point in their 8000-hour service life. As these aircraft age and their operating conditions change, the reliability of their systems and components decreases and they start to break more often and costs increase (Figure 15). More breaks require more maintenance actions be performed to return aircraft to a mission capable status. In the case of the F-16, operational usage has been more severe than design usage (8 times more), resulting in the acceleration of its airframe service life at a rate in which it may not reach its expected overall service life (Bouck, 2000; Paddock 2000).

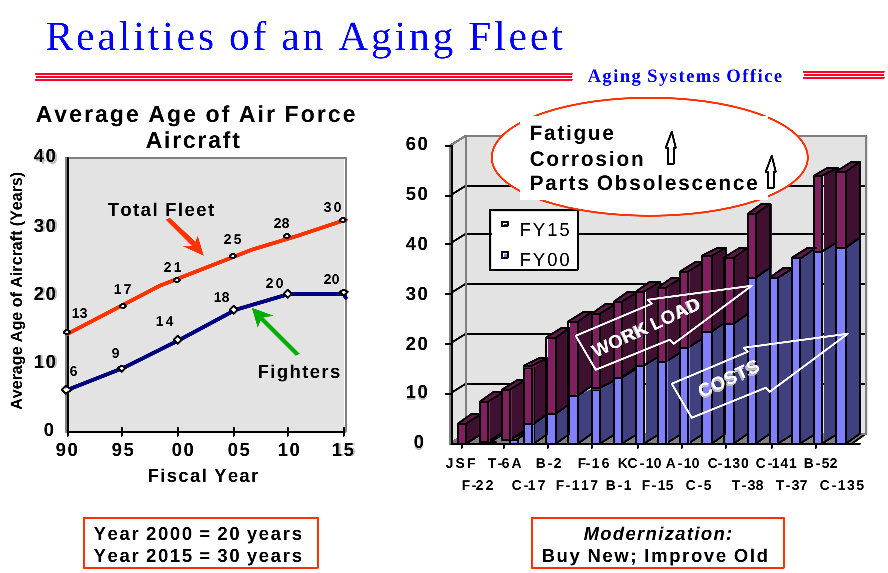


Figure 14. Aging Trends of Air Force Aircraft (Bailey, 2000).

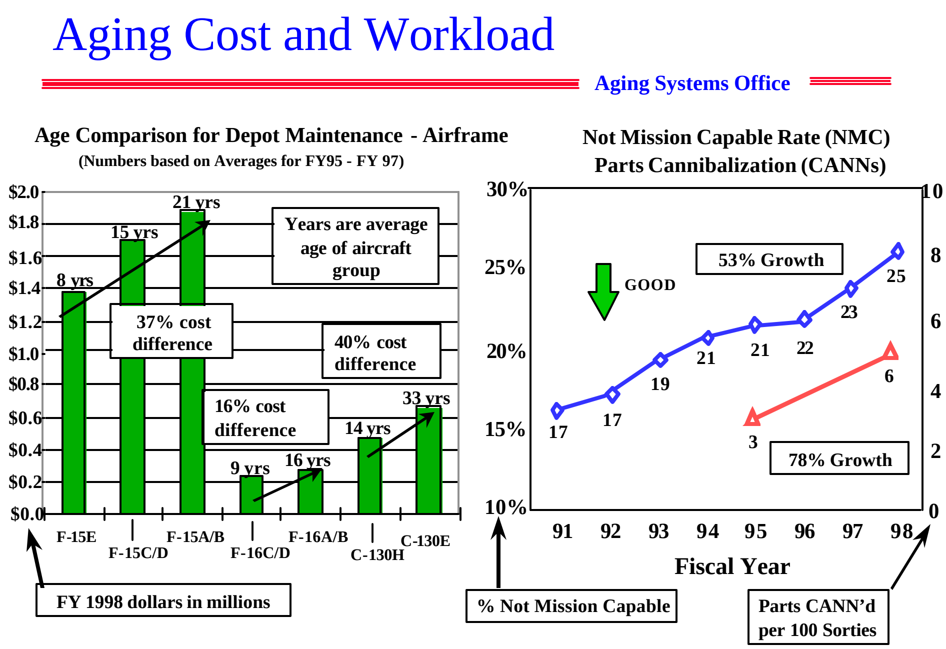


Figure 15. Cost and Impact of Aging Aircraft (Bailey, 2000).

In spite of increased operational usage, fighter aircraft breaks have increased only slightly. However, break rates only account for pilot-reported discrepancies and therefore cannot serve as the sole indicator of aircraft reliability. Other maintenance problems discovered during routine and special inspections and while performing maintenance are also part of the reliability issue. For example, AFLMA's TNMCM study found that the number of TNMCM hours attributed to phase maintenance inspections increased 174 percent from 1995 to 1999 (Bell, 2000b). In ACC, fuel leaks on F-16s, F-15 flight control delamination problems and cracked A-10 fuselage station 365 bulkheads, typically not pilot-reported discrepancies, are a few of the main TNMCM reliability drivers for these types of aircraft in recent years (Merry, 2000b). Additionally, high failure rates of numerous engine components for F-16 and F-15 aircraft discovered by both maintainers and pilots have accounted for a large part of the TNMCM time as well (Humphrey, 1999; Bell, 2000b).

Declining reliability has also affected TNMCM time in another way. In an effort to improve reliability, numerous new inspections and modifications have been initiated and implemented. A great number of these new efforts manifest themselves in the form of time compliance technical orders (TCTO) and special inspections. AFLMA's study of the F-16 block 42 aircraft revealed that the total number of manhours expended on TCTOs increased 120 percent from FY95 to FY99 and the hours per TCTO event increased 69 percent, indicating TCTOs are becoming more manpower intensive and more technically challenging. The report also indicated that low manning and limited numbers of experienced technicians contributed to the increase in manhours required to complete them (Bell, 2000b). While these modifications and inspections are necessary to maintain the long-term health of an aging Air Force fleet of aircraft, they will continue to make up a substantial portion of TNMCM time.

Maintenance Management Policies. The management techniques employed in and applied to aircraft maintenance can influence the amount of TNMCM time an aircraft accumulates. At unit level, poor planning and poor use of resources might result in an aircraft being NMC for longer periods of time than necessary. Furthermore, changes in maintenance policy initiated at higher levels of command can also impact TNMCM rates. While it is not possible to identify and quantify all of these changes, it is important to identify that these changes could have an impact upon TNMCM rates. A few of the more prominent changes are discussed below.

One of the biggest changes in aircraft maintenance during the early 1990s was the implementation of two-level maintenance. Two-level maintenance was designed to eliminate the intermediate level of maintenance (wing level repair shops) in order to save money and make units easier to deploy by reducing personnel and equipment. For the most part, two-level maintenance achieved its goals of cost savings and reduction of the logistics footprint saving $259 million and eliminating 4,430 personnel positions (Hallin, 1998). However, even with these successes, it has had an impact upon TNMCM rates. When an aircraft is grounded because of a failed part and the unit cannot acquire a replacement part from the supply system in time for the aircraft to fly its next scheduled mission, the unit typically cannibalizes the replacement part from another aircraft. Cannibalizing parts doubles the amount of time spent on maintenance and increases the probability of damaging the part being cannibalized (Matthews, 1998). While the rate of cannibalization varies depends on various factors and the increase in cannibalizations can not be solely attributed to implementation of two-level maintenance, the overall rate of cannibalization has increased by 78 percent since its inception in the early 1990s (Figure 16) (Ryan, 1999). Further compounding the problem were the different maintenance priorities being applied by the operational wings and the depots. The main priority of the operational wings was to acquire the proper parts to return broken aircraft to fully mission capable status. The depots' primary concern was to conduct repairs in a cost effective manner. In many instances, this meant that the depot would delay repair activities until enough parts accumulated so that it was cost effective to repair them (Humphrey, 1999).

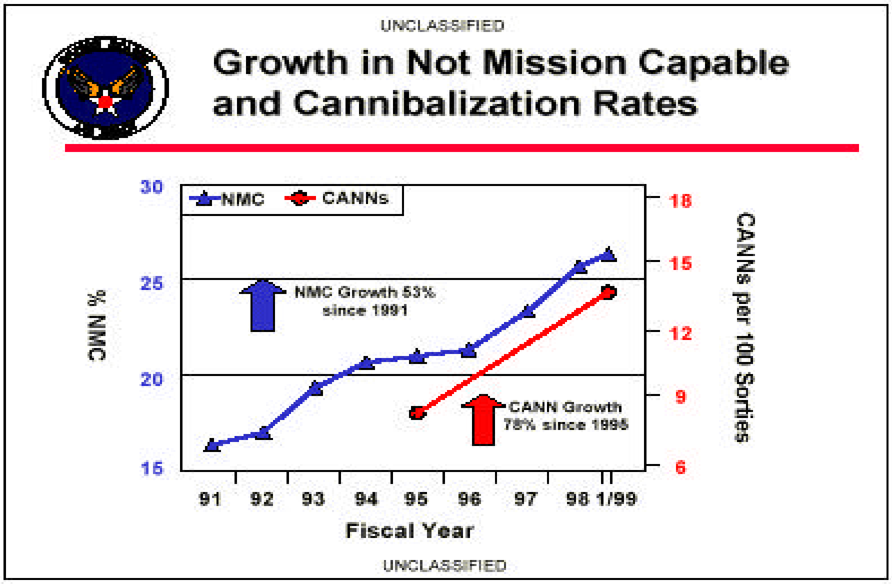


Figure 16. Growth in NMC and Cannibalization Rates (Ryan, 1999)

Another maintenance policy change that occurred involved the area of maintenance information reporting. Up until FY97, aircraft within ACC were returned to mission capable status after all maintenance was complete, but before operational checks had been completed on the aircraft. However, in FY97, ACC changed its policy, requiring aircraft be returned to mission capable status after all maintenance and operational checks were complete. This change led to an increase in the number of TNMCM hours for its aircraft. According to a TNMCM study conducted at Hill AFB in 1997, operational checks account for five percent of the total TNMCM time for their aircraft (Bell, 2000b). While this represents a small amount of TNMCM time, it has been identified as one of the contributing factors responsible for its increase.

In early 1990s, the Air Force initiated an organizational change that drastically altered Air Force maintenance and may have influenced TNMCM rates. This change was the implementation of the objective wing structure that took place in most major commands. The objective wing structure removed the day-to-day leadership and oversight of flightline maintenance operations provided by each wing's senior maintenance officers and their staff and transferred that responsibility to the less experienced operations community and left the maintenance complex fragmented. While the senior leadership in the operations community was perfectly capable of leading maintenance operations, their increased area of responsibility – flying operations and now flightline maintenance, as well as their lack of in-depth maintenance experience may have led to less than optimal decisions being made concerning aircraft maintenance (Ralston, 1995; Kinnan, 1995; Bernitt, 1995).

TNMCS Variables

The Total Not Mission Capable Supply (TNMCS) rate describes the percentage of aircraft that are not mission capable (NMC) due to a lack of spare parts. A review of the literature has revealed several factors that influence the amount of TNMCS time an aircraft accumulates. Like the factors that influence TNMCM time, some of these factors are easily measured while others are not. Regarding TNMCS, some its variables that are easily quantifiable include the reliability of components and their demand, proper mix and level of inventory, repair times for reparable assets and order and ship time. Other factors, which are important, but not easily measured, are diminishing manufacturing sources, material shortages and inventory forecasts (Hamm, 1999). Funding is also a key variable related to TNMCS; however, since it affects TNMCM as well, it will be discussed later.

Reliability and Demand. Reliability affects TNMCS time through demand. The more unreliable a component, the more often it fails. Failures necessitate that the component either be repaired or replaced. While this does initiate maintenance actions that result in the accumulation of TNMCM time, it also affects TNMCS time by placing a demand on the supply system to provide a replacement part to return the aircraft to mission capable status. If a part has been designed with sufficient reliability or its reliability characteristics are well understood then the appropriate level of inventory can be procured or repair capacity/capability established to ensure that demands for the part are satisfied in a timely manner that helps maximize aircraft operational availability and reduce TNMCS time (Heizer and Render, 1999).

In the 1990s, the reliability of many aircraft components has declined. The primary reason for the decline in reliability has been attributed to aircraft (and their components) being operated outside of the set of conditions in which they were to be operated. This condition primarily manifests itself in the form of aging aircraft and increased failures brought about by the increased OPSTEMPO of weapons systems (Bailey, 2000). For many different reasons, Air Force aircraft that were designed for a certain expected service life and certain operating conditions, are being operated beyond them. This has resulted in many components prematurely failing that were not anticipated to fail (Humphrey, 1999). In a 1998 article on aging aircraft by William Matthews, Colonel Irving Halter, the 1st Fighter Wing Operations Group Commander stated,

> *In 1997 the wing sent sixteen F-15s to Saudi Arabia…and over the course of 6 months they accumulated an average of 485 hours each…ordinarily it would take an F-15 more than a year and a half to fly that much…we are finding things breaking on the jets that we had not predicted…"*
> (Matthews, 1998)

Furthermore, since these failures were not anticipated, sufficient quantities of spares and in some cases, adequate repair capability, were not established to support these items. Consequently, delays in obtaining and/or repairing replacement parts occur while replacements are sought or repair capability established. In some cases, the delay in obtaining replacement parts grows even more due to the need to establish contractual relationships to obtain replacement parts or repair capability (Sieg, 2000).

Level and Mix of Serviceable Inventory. Inventories are used to provide organizations with increased flexibility in executing operations. It gives organizations a buffer that allows them to better handle the variability they might encounter in demand, production, price and transportation. When inventory levels are reduced problems that were once hidden by inventory (poor reliability or excessive repair times) reveal themselves, requiring management to take actions to correct them (Heizer and Render, 1999). The impact of inventory reduction programs driven by DoD policy decisions depleted stocks of spare parts throughout the Air Force (Bosker, 2000; Peters, 2000). As the inventory levels dropped in the Air Force, reliability and depot repair process problems became more apparent resulting in even lower levels of serviceable inventory that contributed to an escalation in TNMCS rates (GAO, 1999).

Repair Time. In the case of reparable items, the amount of time it takes a depot to repair and return them to serviceable condition also affects TNMCS time. Under two-level maintenance, most base-level repair capability was eliminated. Consequently, the majority of reparable parts are sent to depot repair facilities where they are either condemned or repaired and returned to serviceable inventory stocks, making the TNMCS time for operational units very dependent on the depots. Repair times vary among components and repair facilities and are influenced by factors such as repair capacity, funding, personnel levels and skill and policy decisions (Vanderman, 1998). One of the major policy issues that affected depot production was the announcement of the closure of two air logistics centers. According the Secretary Peters,

> *"Directly relevant to readiness were the closures of two of the five Air Force maintenance depots…almost immediately upon announcement, these closures created turmoil at our depots as skilled workers started to leave the closing depots well in advance of the actual closure dates. The most serious aircraft readiness problems…were caused by our inability to move depot production lines on schedule and…our inability to hire skilled manpower at the receiving depots…we are still hundreds of people short at two of our depots."* (Peters, 2000).

Further illustrating the impact of repair times, a 1990 study conducted by HQ AFLC found the amount of time it takes to repair an item at a depot is about 30 days (Porter et al., 1990) and an F-16 Logistics Chain Management Study found that depot repair time averaged 34.9 days for 10 critical F-16 avionics components (KPMG, 1998). Data collected by Synergy, Inc., from the D041 system and a report by the General Accounting Office indicate repair time at the depot is the lengthiest portion of the Air Force's reparable pipeline (Synergy, 1999; GAO, 1999).

Order and Ship Time. Another variable that influences TNMCS time is order and ship time (OST). Order and ship time starts when the customer initiates an order with a depot for a replacement for a failed part and ends to when it is received (Arostegui, 2000). Not only is OST highly dependent upon the availability of serviceable inventory, it is significantly affected by shipping and transportation factors. Data collected by Synergy, Inc. showed that OST from the third quarter of FY98 to the second quarter of FY99 was 7.4 days for 121, 516 transactions (Synergy, 1999) while an earlier assessment by the Air Force Logistics Management Center suggested an average OST of 16.4 days (Kettner and Wheatley, 1991). However, when a serviceable part is not available, OST could encompass the entire repair cycle time, making it possible for large variances to occur. A study conducted by KPMG on 10 critical F-16 components found that OST for these items averaged 37 days (KPMG, 1998).

Underlying Variables

Two primary underlying variables affecting mission capable rates are funding and the environment. While neither can cause readiness, they can significantly affect it. Funding provides the resources used to achieve readiness while the environment provides the conditions that shape it. While the nature of each of these variables makes the degree to which they affect readiness difficult to quantify, the literature indicates that virtually all are in agreement that both are having an impact upon it.

Funding. Funding is the common denominator in the mission capable equation. While funding cannot cause readiness, the amount of funding made available can have a significant impact upon it. If there is no funding available, there will probably be no people or equipment available either since there is a cost for having both. Furthermore, properly allocating limited funds between competing needs also has to be achieved. Fully funding spares purchases while under funding personnel could lead to situation where the Air Force has plenty of spare parts with an insufficient numbers personnel to install them on the aircraft (Sherbo, 1998). A study conducted by DRC found that in FY

95 and FY 96 funding for the purchase of spare parts through AFMC's material support division was 58 percent and 74 percent respectively. According to the study this level of funding had a huge negative impact upon mission capable rates. Furthermore, it concluded that if funding for spare parts is even marginally less than the requirement the result will be less aircraft availability. If inadequate funding exists or funds are not properly allocated, mission capable rates can suffer (Sherbo, 1998; Humphrey, 1999).

While the relationship between funding and readiness may not always be obvious, the literature indicates that reductions or improper allocation of funding can affect both TNMCM and TNMCS and most of the factors that fall under each. Although clear examples regarding the potential impact of reduced funding exist, lower procurement of additional spare parts or manpower reductions, others are less apparent. For example, diminished funding used to enhance the reliability and maintainability existing weapons systems, maintain infrastructure or provide training have a more subtle impact that stretches across time (DSB, 1994). Some of the literature identified lower levels spare parts and modernization funding as contributing to reduced mission capable rates (Humphrey, 1999; Sherbo, 1998; Bosker, 2000; Ryan, 2000 and Peters; 2000; Dahlman and Thaler, 1999). Others have attributed lower operations and maintenance funding coupled with increased competition for these limited funds (primarily unplanned contingency operations) as another contributing factor. When the cost of contingency operations is not fully paid for by planned budget or supplemental appropriations, the remaining balance comes out of the operations and maintenance accounts as well as others. Even the temporary shifting of funds in and out of the operations and maintenance account can be disruptive by having a negative impact upon training and maintenance (DSB, 1994; Pulley, 1999; Humphrey, 1999; Thaler and Norton,). Figure 17 depicts how the Air Force's total obligation authority (TOA) has related to mission capable rates over time, appearing to support the literature.

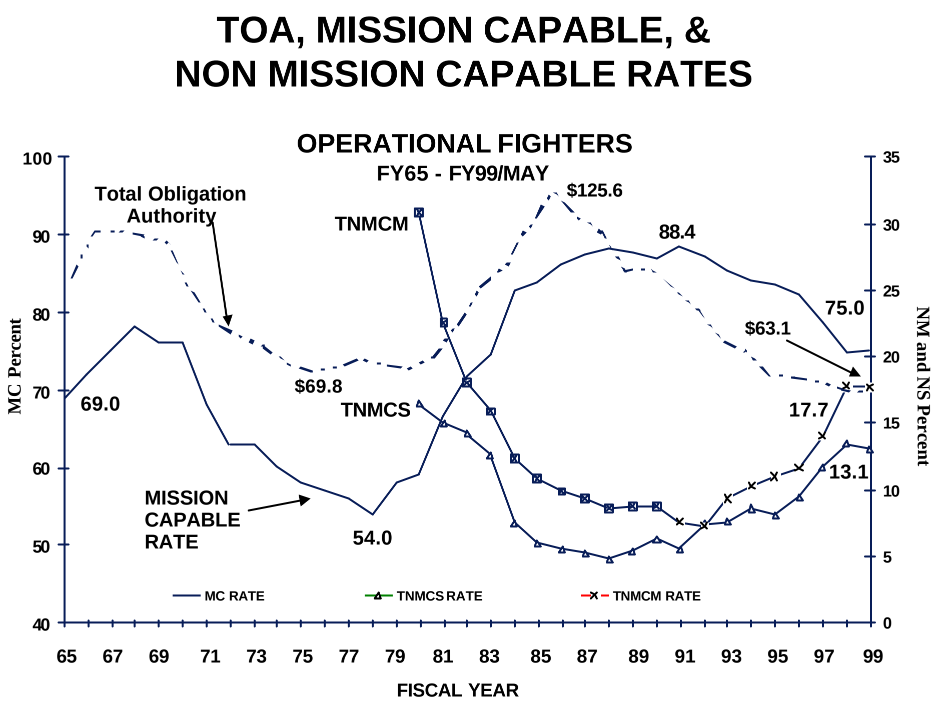


Figure 17. Total Obligation Authority versus MC Rates, 1965-1999 (Sieg, 2000)

Environment. The environment the DoD operates within also affects mission capable rates. The end of the Cold War transformed a fairly stable defense environment to a very dynamic one, causing numerous changes to occur, both internally and externally, in the Department of Defense and the Air Force. The changes that took place affected virtually every aspect of the Air Force from its structure and operations to its funding and personnel. For the Air Force, substantial increases in the OPSTEMPO and PERSTEMPO, the frequency and size of workload on both personnel and equipment, resulted from the new defense environment. Since the early 1990s, the number of deployments and contingency operations has increased tremendously, driving up OPSTEMPO and PERSTEMPO (Figure 18). According to a Rand study, the amount of time devoted to MOOTW operations (in terms of flight hours) shot up from almost zero at the end of the Cold War to take up over 10 percent of active duty Air Force flight hours, placing unanticipated, heavy demands on support personnel and equipment (Figure 19) (Vick et al., 1997).

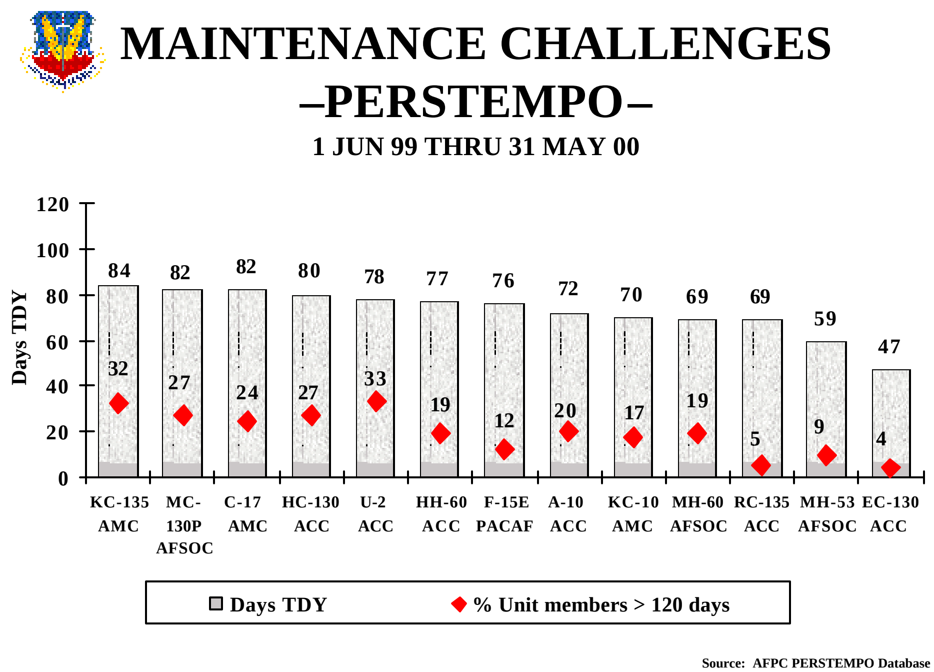


Figure 18. PERSTEMPO of Selected Weapons Systems (Lamontagne, 2000)

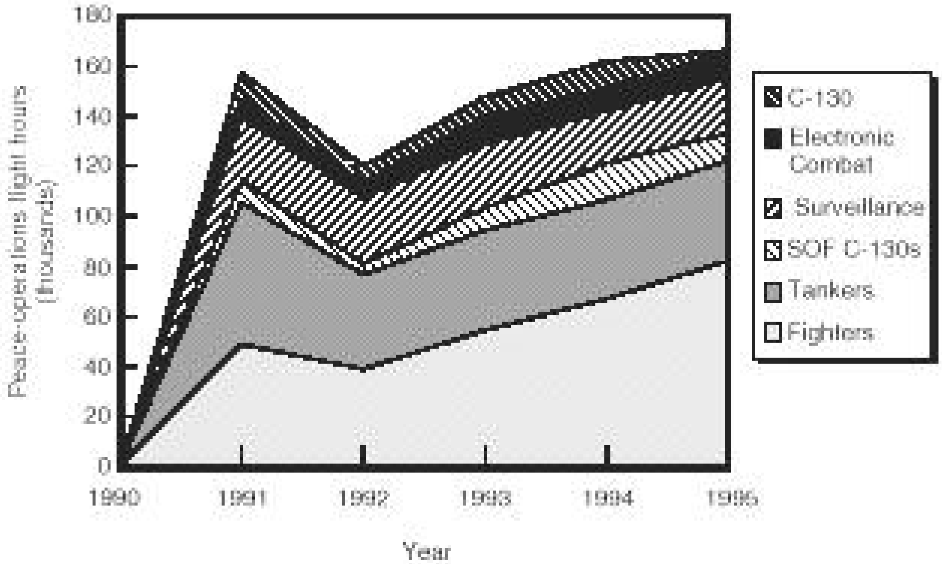


Figure 19. USAF Peace Operations' Flight Hours, 1990-1995 (Vick et al, 1997)

Increases in OPSTEMPO and PERSTEMPO have had a negative affect on both equipment and personnel. It has forced both to work longer and harder. While the literature indicates there is currently no sole measurement that captures OPSTEMPO and/or PERSTEMPO in its entirety, it does outline their effects, many of which have already been discussed and are measurable. Some of the effects can be seen as decreased aircraft reliability and maintainability and spare part levels, increased maintenance manhours and deployments and reduced retention and morale (DSB, 1994; Humphrey, 1999; and Williams, 1997). The impact of some of these effects can be seen in the decline in monthly F-16 mission capable rates from 1990 – 1999 (Figure 20).

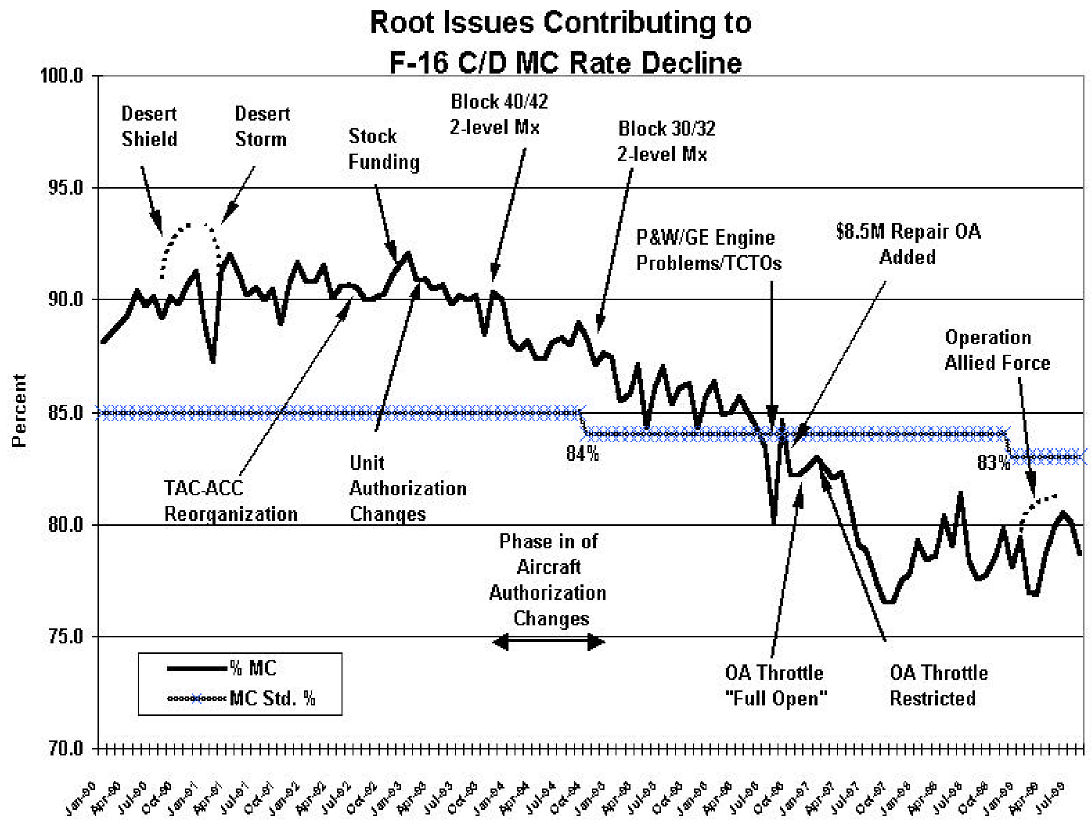


Figure 20. F-16C/D Mission Capable Rates, 1990-1999 (Krueger, 1999)

Coupled with reduced funding levels, the effects of OPSTEMPO and PERSTEMPO can be magnified even more. Furthermore, it is expected that the effects of OPSTEMPO and PERSTEMPO will continue to grow if they are not reduced (Bird, 1997; Maze, 1998).

Forecasting

Forecasting Defined. What is forecasting? *Forecasting is the art and science of predicting future events* (Heizer and Render, 1999: 142). It is an integral part of the decision-making activities of management. Typically, an organization will create goals and try to predict the factors that have an effect on its attainment and then choose the actions that it anticipates will result in their accomplishment. The use of forecasting has increased considerably as managers have stopped relying on chance and have started to deal with the environment from a more scientific perspective. Because different functions within an organization are usually related to one another, the effects of forecasting affect the entire organization. Although there are other areas the use of forecasting is critical to an organization, Makridakis et al. (1998: 5) lists the following three areas in which forecasting plays a key role:

> *Scheduling: The efficient use of resources requires the scheduling of production, transportation, cash, personnel and so on. Forecasts of the level of demand for a product, material, labor, financing or service are an essential input to such scheduling.*
>
> *Acquiring resources: The lead time for acquiring raw materials, hiring personnel or buying machinery and equipment can vary from a few days to several years. Forecasting is used to determine future resource requirements.*
>
> *Determining resource requirements: All organizations must determine what resources they want to have in the long term. These decisions depend on market opportunities, environmental factors and the internal development of financial, human, product and technological resources. These determinations require good forecasts and managers who can interpret the predictions and make appropriate decisions.*

Forecasts are usually classified by the future time horizon each covers. Typically the forecast time horizons fall into three categories. The first is short-range which typically have time spans of up to one year, but are usually less than three months. Short-range forecasts are used for planning many things including job scheduling, workforce levels and production levels. Next, medium-range or intermediate forecasts, with time spans ranging from 3 months to 3 years, are used for activities such as sales planning, budgeting and production planning. Long-range forecasts, the last type, generally are used for periods of time longer than 3 years. They are typically used for new products, capital expenditures and research and development (Makridakis et al., 1998).

Although similar in nature, Heizer and Render (1999) state that medium and long-range forecasts are set apart from short-range forecasts by three characteristics. First, medium and long-range forecasts deal with more wide-ranging issues and support managerial decisions regarding planning and processes. Second, short term forecasting generally uses different techniques than longer-term forecasting. Typically, the longer the forecast period, the less quantitative the forecasting methodology employed. Finally, short-range forecasts tend to be more accurate than longer-range forecasts because the factors that shape forecasts change every day. As the forecast time horizon gets longer, the more changes take place, which causes uncertainty to increase and affect forecast accuracy (Heizer and Render, 1999).

Forecasting techniques fall into two major categories qualitative and quantitative methods. Qualitative forecasting methods incorporate subjective factors, such as the decision-maker's presentiment, emotions, values and personal experiences, in making a forecast and are typically used where little quantitative information is known but sufficient qualitative knowledge exists (Makridakis et al., 1998). For example, the jury of executive opinion, a qualitative forecasting technique, uses the opinions of groups of high-level experts sometimes in conjunction with statistical tools, can be used to make a group estimate of demand for a new technology. The Delphi method, another qualitative technique, uses questionnaires to illicit responses (judgments) from a valued group of individual experts to be used by decision-makers to arrive at a forecast (Heizer and Render, 1999). Qualitative forecasting techniques can vary widely with regard to expense, intricacy and worth and are best employed in conjunction with quantitative methods (Makridakis et al., 1998).

Quantitative forecasting techniques usually employ mathematical models that rely on historical data to make forecasts. According to Makridakis et al. (1998: 9), the use quantitative forecasting techniques requires three conditions:

Information about the past is available

The past information can be quantified in the form of numerical data

The assumption of continuity is present – some aspects of the past pattern will continue into the future

There are a wide variety of quantitative forecasting techniques available with each having its own properties accuracies and cost and fall into two categories: time series and explanatory.

Time Series Forecasting Models. Times series forecasting models make predictions on the assumption that the future is a function of the past. Unlike explanatory models, time series models make no attempt to discover the factors that influence the forecasts. This category of models uses a series of evenly spaced (monthly, quarterly annually etc.) past data to detect past trends and project those trends into the future to arrive at a forecast. Time series models include naïve approaches, moving averages and exponential smoothing methods (Heizer and Render, 1999 and Makridakis et al., 1998).

Naïve forecasting approaches are the simplest of the time series forecasting models. The Naïve Forecast 1 (NF1) model uses the most recent information available and uses it as its forecast. Another naïve forecast, the Naïve Forecast 2 (NF2), performs in the same manner as the NF1 but goes beyond it by considering the possibility of seasonality in the past data. Naïve approaches to forecasting are the most cost effective and efficient forecasting models and provide a starting point at which more sophisticated models can be compared (Makridakis et al., 1998).

Moving average models are another type of times series forecasting model. To provide stable estimates, these models use a number of actual historical data values to estimate the trend cycle by smoothing the past data of the averaged data used to make the forecast. Increasing the number of periods being averaged can increase smoothing out the fluctuations of historical data trends; however, this makes the model less responsive to real changes in the data. When detectable trends or patterns are evident, historical data used to generate forecasts can be weighted (weighted moving averages) in varying degrees to emphasize the past historical data of one period (usually the more recent the period the heavier the weight) over that of another and makes the model more responsive to changes. Moving average models are simple to use and tend to provide accurate short-term forecasts; however, they require an extensive amount of past data, and because they use averages, these models forecasts will always stay within the levels of the past data used to make the forecast (Heizer and Render, 1999 and Makridakis et al., 1998).

Exponential smoothing time series models are sophisticated moving average models that are fairly simple to use and do not require an extensive amount of historic data. These models use a smoothing constant between 0 and 1 that is selected by the forecaster. The smoothing constant is a weighting factor that gives more or less emphasis to the influence of the most recent historic data. Smoothing constants closer to 1 assign more emphasis to recent historical data observations when generating forecasts. When smoothing constants are closer to 0, the emphasis on the most recent periods is removed and is spread across many more periods of historic data. As with moving average models, exponential smoothing models also have trouble responding to trends. They too can be modified to incorporate trend and seasonality adjustment factors in second-order exponential smoothing models and the Holt-Winters' trend and seasonality method (Heizer and Render, 1999 and Makridakis et al., 1998).

Explanatory Forecasting Models. Explanatory forecasting models are the other type of forecasting models. These models assume that the variable being forecasted displays an explanatory relationship with one or more independent variables. Explanatory models are used to discover the form of the relationship between the dependent and independent variable and use it to forecast future values of the dependent variable (Makridakis et al., 1998). Explanatory models do not show cause and effect. For example, explanatory forecasting models can be used to forecast the height of an individual using past height and weight data since the two variables demonstrate a relationship with one another. However, weight does not cause height (or vice-versa); the two variables only have a mathematical relationship that allows forecasts to be made (White, 2000).

The most common explanatory forecasting model is a regression model. Regression models are statistical forecasting tools that can be used to predict one dependent variable (*Y)* using one or more explanatory or independent variables (*X).* It is commonly used in industry and science to predict and gain intuitive understanding of future performance or events. Neter et al. (1996: 9) state, "*regression analysis serves* *three major purposes: (1) description (2) control and (3) prediction."* It allows the analyst to create a straight-line (or curvilinear) mathematical model to describe the functional relationships between independent and dependent variables.

Forecasting Mission Capable Rates. In January 2000, General Ryan asked *"what are the main causes for increasing TNMCM rates over the last few years?"* His question and the recent concern over why Air Force readiness is decreasing are the primary reasons as to why regression analysis was selected over time series methods as the forecasting method to be used in this study. While time series methods might produce accurate forecasts that is all they provide. Time series forecasts are based on historical data and not on the explanatory variables, which might be able to be manipulated to have an effect upon the dependent variable. Explanatory models, such as regression, can be used with greater success for policy and decision-making (Makridakis et al., 1998). Regression models not only provide a forecast – they also explain the functional relationship between the dependent variable (in this analysis, mission capable rates) and numerous independent variables. The use of regression analysis to explain and forecast mission capable rates provides two critical pieces of information – a forecast that allows for planning and potential reasons behind the forecast that can be manipulated to help improve the next forecast (Makridakis et al., 1998).

In order to assess the impact of changes in its environment (including many of the variables previously discussed) on its readiness, the Air Force uses a wide variety of tools to forecast the mission capable rates of its aircraft. A review of the literature, along with several interviews, revealed that the Air Force has over 30 models it uses to forecast mission capable rates. Most of the models are tailored to forecast mission capable rates for specific aircraft and therefore cannot readily be used for other aircraft (Dierker, 2000).

Funding/Availability Multi-Method Allocator for Spares Model. One of the Air Force's primary forecasting tools is the Funding/Availability Multi-Method Allocator for Spares (FAMMAS). Presently, Dynamics Research Corporation operates the model, validating the current version of the model (3.0.1) in September 1996. It is used by the Air Staff to predict mission capable for different weapons systems based primarily on past, present and future annual spares funding profiles. FAMMAS also includes other elements such as inflation, carry-over (policy decisions) and lead-time factors as well as historical TNMCS and TNMCM rates as adjusting factors when computing its forecasts (Figure 21). These data inputs come from the Unit Cost Document, Reliability and Maintainability Information System (REMIS) and other reliable sources and are used in an exponential smoothing algorithm to develop its mission capable forecast. FAMMAS output data are primarily used in performing POM/Budget Assessments, Weapons System Assessment Reviews and in the Sustainment Executive Management Report process (DRC, 1997; Reynolds, 2000).

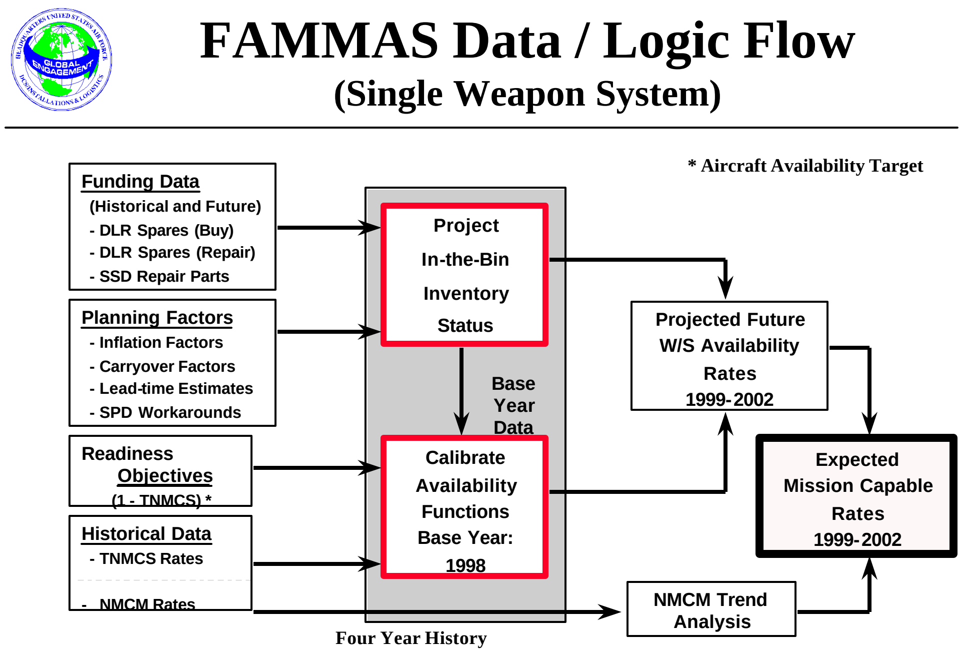
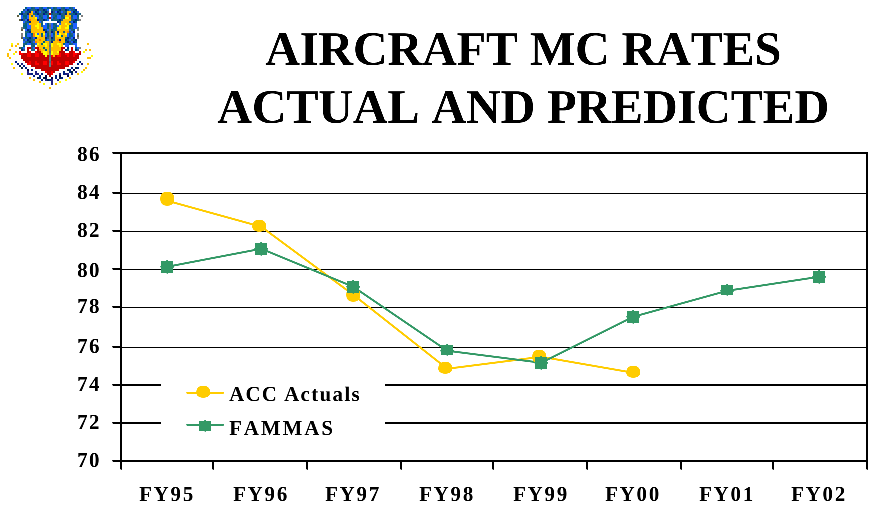


Figure 21. FAMMAS Forecasting Model (DRC, 1997)

FAMMAS has proven to be a fairly accurate forecasting model. According to the Defense Science Board Task force on Readiness, FAMMAS in conjunction with other Air Force systems have predicted peacetime mission capable rates for each aircraft in the inventory with an accuracy of +/- 2 percent over three years and +/- 5 percent forecasting over six years (DSB, 1994). A comparison of FAMMAS' forecasted mission capable rates and actual rates for Air Combat Commands fighters provides a good illustration of the model's accuracy (Figure 22).



	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02
ACC ACTUALS	83.6	82.2	78.6	74.8	75.4	74.6		
FAMMAS	80.1	81	79.1	75.8	75.1	77.5	78.9	79.6

SOURCES: PREDICTED - FAMMAS AF/ILSY, FY01 BES, 21 OCT 99 ; ACTUALS – ACC ONLY, FY00/2
ASSUMES NMCM WILL IMPROVE 1% FOR EVERY 3% IMPROVEMENT IN TNMCS

Figure 22. FAMMAS' Forecasts versus Actual MC Rates (Merry, 2000b)

Multi-Echelon Resource and Logistics Information Network. Another Air Force system that can be used to forecast mission capable rates is the Multi-Echelon Resource and Logistics Information Network (MERLIN). Although MERLIN is primarily used by Air Staff to access and evaluate logistics data for almost all of its aircraft, it also has the capability to forecast mission capable rates (DRC, 2000). MERLIN uses multiple linear regression to generate forecasts. The independent variables used in the model are possessed hours, flying hours and sorties (Reynolds, 1999). The latter variables, flying hours and sorties, cause the model to focus on the failure rate of aircraft components (as a function of usage), which is an approach supported by research conducted in this area (Sherbrooke, 1997; Slay and Sherbrooke, 1997).

With these models, the Air Force can predict either TNMCS or TNMCM hours as opposed to the actual rates. The following equations are used to forecast TNMCS and TNMCM rates for the F-16 (Reynolds, 1999) (statistical printouts shown in Figures 31 and 32 in Appendix A):

*F-16 TNMCS Hours = -832.911 – 0.364756*Flying Hrs + 0.117839*Possessed Hrs - 0.51937*Sorties*

*F-16 TNMCM Hours = 1736.96 – 7.09337*Flying Hrs + 0.204255*Possessed Hrs + 5.17764*Sorties*

To arrive at the overall mission capable rate for a particular aircraft, both TNMCS and TNMCM hours are divided by possessed hours of the aircraft being analyzed to obtain a rate for each (expressed as a percentage). Both percentages are then subtracted from 100 percent to arrive at the mission capable rate for the aircraft. Although the model was designed to generate accurate forecasts, its results tell a different story. For example, from 1991-1999, the TNMCM model's forecasts were very erratic and usually far below the actual rates that occurred, possibly suggesting that other independent variables have an influence upon the rates (Figure 33, Appendix A).

Overview of Next Chapter

Chapter III develops the methodology used in this study. First, data collection and preparation is discussed, and data limitations and assumptions are presented. Next, correlation analysis is used to select the independent variables for use in the construction of the regression models. Finally, the statistical method used in the study, regression, is reviewed. This discussion focuses on the benefits of regression as well as some of the problems that can occur in using this method.

III. Methodology

Introduction

As shown in the literature review, mission capable rates are influenced by numerous factors and the complex relationships among those factors. Changes in many of the variables from each of the three areas previously discussed; for example, the level of reparable parts (TNMCS) or changes in personnel levels (TNMCM); can have either a positive or negative impact upon mission capable rates. Because of the wide assortment and extent of factors that can affect mission capable rates, the Air Force has had a difficult time identifying and understanding the root causes that drive its aircraft mission capable rates. Although the Air Force does possess and use various models to forecast mission capable rates, its primary models only provide time series forecasts and do not provide explanatory forecasts which might be used to identify potential causal relationships between mission capable rates and the variables thought to affect them most. The intent of this chapter is to construct a methodology to analyze potential relationships between a multitude of independent variables and mission capable rates. After reviewing the literature on forecasting, it became evident that correlation and regression analysis would be effective tools to use for this research.

Data, Sources and Variables

Since this study uses correlation and regression analysis, it requires an extensive amount of data to provide a forecast (Fitzsimmons and Fitzsimmons, 1998). Data was collected from several Air Force databases to provide the data points to be used in the analysis. Because of the multiple data sources used several assumptions are necessary and limitations regarding the data need to be identified.

Assumptions and Limitations. The assumptions and limitations for this study are as follows:

1. Data from the Reliability and Maintainability Information System (REMIS), the Personnel Data System (PDS), the Air Combat Command (ACC) Assessments Division (ACC/LGP) and the Recoverable Consumption Item Requirements System (D041) are complete and accurate. Data are input into each of these systems from thousands of users and therefore are more susceptible to error. However, studies conducted for the Air Force by Rand, Dynamics Research Corporation, KPMG and other organizations have repeatedly used these systems as their data source, supporting their validity as reliable data sources.
2. The 8-hour fix rate for Air Combat Command F-16 aircraft (1990-2000) is representative for the entire fleet of Air Force F-16 aircraft. REMIS is not able to easily compute the 8-hour fix rate for a particular mission design series aircraft. Since ACC possesses the majority of F-16C/D aircraft in the Air Force, its 8-hour fix rate data was used to represent the 8-hour fix rate for all Air Force F-16C/D aircraft.
3. Data from D041 was only available in fiscal year quarterly format. This limitation required that the data from the other systems be converted to a fiscal year quarterly format, which reduced the total number of potential data points from approximately one hundred to thirty-two.

4. REMIS uses a single status reporting procedure to track TNMCM and TNMCS conditions. Even though an aircraft may be Not Mission Capable for a number of reasons, REMIS only credits a single work unit code (WUC) with the downtime. Even if the aircraft breaks for a second, more significant WUC fault, the aircraft still only accrues time against the first WUC it was broken for (unless it is manually changed in REMIS). This limitation can result in a sizeable amount of hidden or lost information, which could have an effect upon the results of this study.
5. The use of general WUCs, such as 23000, 11000 and 74000, is common in recording TNMCM status when the aircraft initially breaks. These types of WUCs are normally entered into the Core Automated Maintenance System (CAMS) (which feed into REMIS) until the specific discrepancy can be ascertained and the specific WUC for that discrepancy entered in place of the general WUC. Unfortunately this does not always occurs and limits the analysis of potential component level influences upon mission capable rates.
6. Quarterly authorization data is representative of actual Air Force quarterly authorization data. Historical authorization data was only available on a fiscal year basis (fourth quarter of each fiscal year) from the Manpower Data System. Computing the difference in authorizations between each fiscal year and dividing it by four resulted in this study's quarterly authorization data. If authorizations between fiscal years increased, quarterly authorization numbers incrementally increased each quarter by adding the difference divided by four

to the end of year authorization data. If there was a decrease between quarters, quarterly authorization data gradually declined each quarter.

7. The AFSCs used from the FY90 – FY93 timeframe (45XXX, 46XXX and 405X) accurately translate to the AFSCs for the FY94 – FY00 timeframe. In 1993, the Air Force completely redesigned its airman and officer classification systems, redesignating, combining, separating and deleting numerous AFSCs to restructure the force. Air Combat Command career field functional managers, Air Force instructions and the Air Force Personnel Center's AFSC historical files were consulted to ensure the same population of personnel in the AFSCs for the FY90 – FY93 timeframe is the same as the population of personnel in the AFSCs for the FY94 – FY00 timeframe. However, the combining of certain AFSCs, such as electrical and environmental systems and the division of other single AFSCs into multiple AFSCs may not allow for an accurate count of all personnel providing support to the F-16 aircraft.
8. The criteria for the awarding of AFSC skill levels have changed between 1990 and 2000. These changes are not accounted for in the analysis and skill levels for the personnel in this analysis are assumed to accurately represent the experience level of each individual.
9. The number of personnel assigned to F-16 aircraft maintenance AFSCs does not accurately represent the number of personnel who perform on- and off-equipment maintenance. Typically, between 15 and 25 percent of the maintenance personnel assigned to an F-16 fighter wing fill support staff functions such as support section personnel, production superintendents,

expeditors, quality assurance, and logistics/squadron commander staff functions among many others. Furthermore, enlisted personnel assigned to these AFSCs that work in MAJCOMs, Numbered Air Forces and other management and policy organizations are also included in the personnel data. The inclusion of these personnel in the data for the analysis masks the true relationship of mission capable rates and personnel as it pertains to the performance of aircraft maintenance and should be considered a limitation of the analysis.

Reliability and Maintainability Information System (REMIS). After reviewing the literature and speaking with experts in the field, it became apparent that the data for this study that pertain to aircraft should come from REMIS (Merry, 2000a; Reynolds, 2000; Bell, 2000b). REMIS is the Air Force's central database for Air Force equipment that provides near-real time on-line data for tracked aircraft and equipment to DoD, Air Force and MAJCOM staffs. The system interfaces with a multitude of other DoD and contractor systems; however, the majority of Air Force aircraft and engine data are transferred into REMIS from the Core Automated Maintenance System or the Comprehensive Engine Management System (Figure 26).

REMIS INTERFACING SYSTEMS

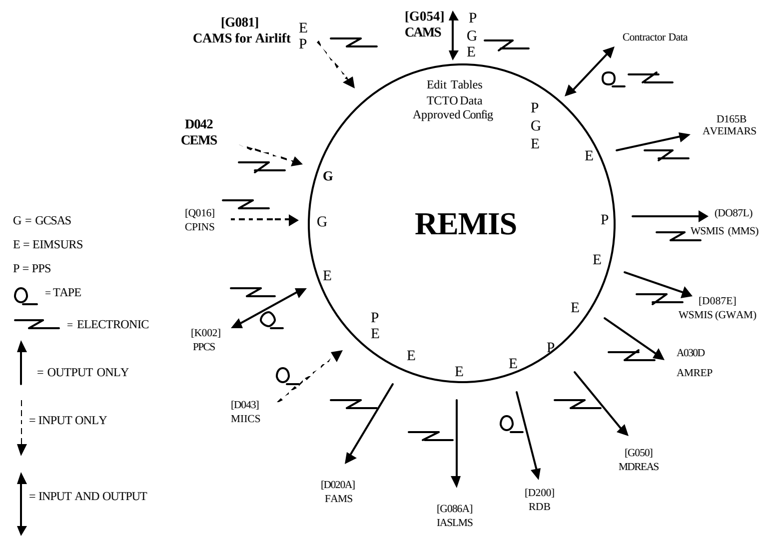


Figure 23. REMIS Interfacing Systems (Cox, 1999)

REMIS is divided into three functional areas that contain specific types of data. The following captions provide a short description of each REMIS subsystem:

> Equipment Inventory, Multiple Status, Utilization Reporting Subsystem (EIMSURS) – provides worldwide inventory tracking; equipment status (MC, TNMCM and TNMCS rates, etc.) and equipment utilization (flying hours, landings, sorties etc.) data.

> Product Performance Subsystem (PPS) – Provides on and off equipment maintenance and repair data as well as support general maintenance data (generic maintenance actions – inspections, refueling etc.).

> Generic Configuration Status Accounting Subsystem (GCSAS) – Provides and allows for configuration data to be input or obtained from the database. It also allows for the input of TCTO data into the system.

The literature review revealed numerous variables that could potentially be related to mission capable rates. For this analysis, data (status, utilization and on/off equipment maintenance and repair) for each work unit code (WUC), a 5-digit alphanumeric code that identifies individual aircraft components and systems, were only extracted from the EIMSURS and PPS subsystems of REMIS. The data request was submitted to the REMIS program office at https://www.wpafb.af.mil/organizations/MSG/. Appendix B lists and defines the data variables extracted from the EIMSURS and PPS subsystems and Appendix C lists the queries used to extract the data.

REMIS data could not be extracted in a quarterly format so the data had to be retrieved by in monthly increments. The data output was converted from text files into Microsoft Excel® files by repeatedly cutting and pasting the monthly data and grouping it into quarterly increments. Next, a combined master list of over 7,000 F-16C/D work unit codes (also retrieved from REMIS) was used to combine the monthly data for each category's work unit code data into quarterly totals through a series of Microsoft Excel® SUMIF algorithms (Appendix D, Figure 34). This resulted in each REMIS variable having its data disaggregated to the 5-digit work unit code level for each quarter. A partial list of F-16 work unit codes can be found in Appendix F.

Once the data was transformed into a quarterly format, a wide variety of new data variables were created so a more in-depth analysis could be performed. It was believed that the new variables would provide greater insight into how REMIS data and specific work unit codes impact mission capable rates. Of particular note are the weighted variables that were developed. Through the use of simple weighting and ranking algorithms, a final ranked-ordered list of work unit codes was developed for each variable (manhours expended, TNMCM hours, supply reliability etc.) based on the total amount of hours each work unit code contributed each quarter over the entire 8 year period of the analysis. From those ranked-ordered lists, data pertaining to the top 50 work unit codes were used in the analysis to determine how each variable's top 50 ranked work unit code dataset was related to mission capable rates. It was believed that analyzing the REMIS data in this manner would better focus the analysis on specific groups of work unit codes (different groups for different REMIS variables) and their relationship to mission capable rates. Appendix B (Table 14) lists the new variables created from the REMIS data while the tables contained in Appendix E list the rank-ordered weighted top 50 work unit codes for each REMIS variable. The tables in Appendix E also list the totals for each of the weighted top 50 work unit codes for the entire 8-year period as well as their percent of the total for each category (Tables 15-28).

Recoverable Consumption Item Requirements System (D041). To determine how inventory and supply pipeline factors influence F-16 mission capable rates, data on these factors (specifically for the F-16) had to be obtained for analysis. The literature review, in addition to interviews with subject matter experts, indicated the best source of data for these types of variables would be the Recoverable Consumption Item Requirements System (D041) (Hutson, 1999; Morgan, 2000).

The D041 system is a wholesale level supply management system that is used to compute reparable and consumable (consumables since 31 December 1998) spare parts requirements by national stock number (NSN) for all customers worldwide on an aggregate basis. The system collects a wide variety of data from a multitude of different systems on reparable items such as failures, lead times, repair times at base and depot levels of maintenance, excess inventory etc (Figure 24). D041 operates on a quarterly basis so that it coincides with Stock Balance and Consumption Reports, which are posted on the last day of each fiscal quarter (AFMCMAN 23-1, 1997:16-17).

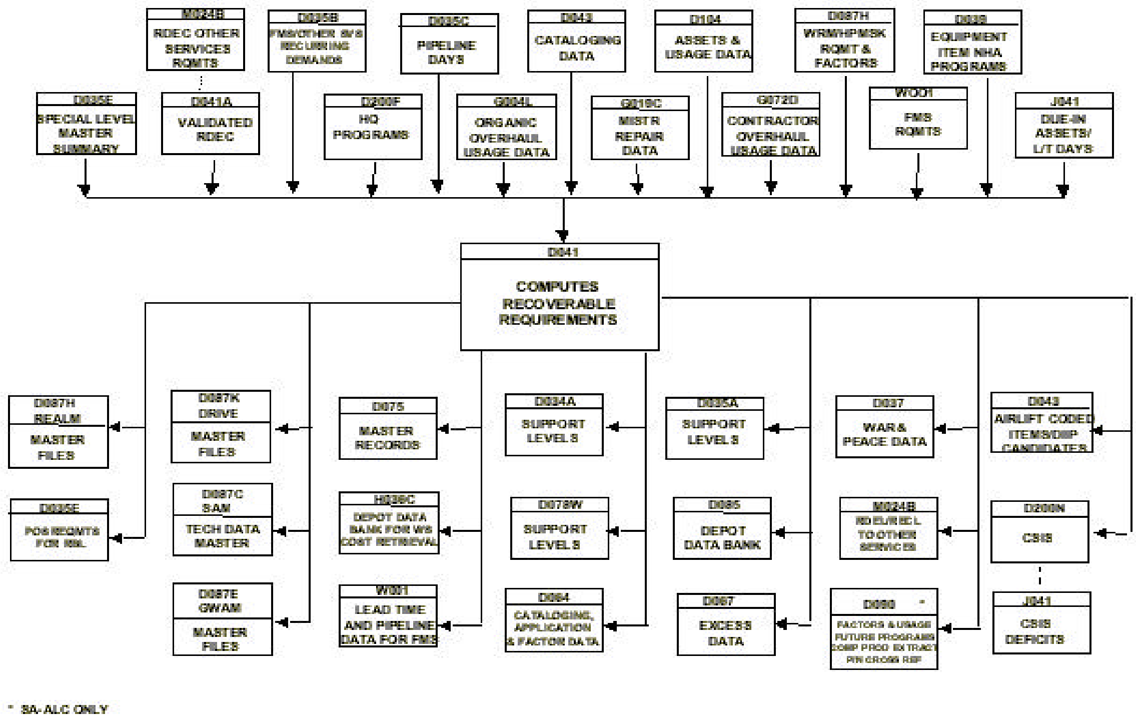


Figure 24. D041 Interfacing Systems

In order to obtain data on F-16 reparable items, a software program was developed using SAS® to isolate and extract F-16C/D-specific NSN data (Appendix I). The baseline set of NSNs used to isolate the data was a listing of all F-16C/D reparable items currently installed on the aircraft (in 2000). This set of F-16 NSNs (7,377 total) served as the total population of NSNs to be used in the analysis. Data on these NSNs was retrieved from D041 for the years FY89-FY00. Unfortunately, missing data and corrupt files only allowed for data from FY92-FY00 to be used in the overall mission capable analysis. Data output from the program was in text format and was subsequently copied into Microsoft Excel® for data manipulation. Unlike the data process used with REMIS, data from D041 were already in a quarterly format and required no further data manipulation. Appendix G lists the data variables extracted from D041 and Appendix H lists the D041 derived data variables (similar to the derived REMIS data variables) that the literature review indicated could influence mission capable rates.

Personnel Data System (PDS). Throughout the literature review, personnel issues were repeatedly cited as major influences upon mission capable rates. At Air Combat Command's November 2000 Wing Commander's Senior Leaders Maintenance Course, newly assigned wing commanders received briefings on the impacts that maintenance personnel end strength, experience levels and retention have upon mission capable rates (Sherman, 2000). In order to assess the influence of these factors upon F-16 mission capable rates, a request for data was submitted to the Air force Personnel Center's Data Retrieval Section (HQ AFPC/DPSART), which obtained the personnel data from AFPC's Personnel Data System needed for this research.

The Personnel Data System is an integrated personnel data system that collects, stores, processes and communicates personnel data. Personnel data stored at AFPC primarily enter the PDS from base-level military personnel flights, but also can come from MAJCOMs and Air Staff personnel managers. The system provides worldwide support personnel managers for planning, programming and managing Air Force active duty military, civilian, Air National Guard and Air Force Reserve personnel. The PDS maintains current data and historical personnel data which is used to compute future Air Force programs, controlling personnel procurement, training, budgeting and funding, and to measure the effectiveness of management policies and programs (AFM 30-3, 1994:22.1-26).

As with the D041 database, data retrieval programs were created to facilitate the acquisition of AFSC personnel data and retention data for this research. The programs are designed to retrieve data on all enlisted personnel with control AFSCs assigning them to the manned aerospace maintenance (45XXX and 2AXXX) and the munitions and weapons (46XXX and 2WXXX) career fields. The programs also retrieve data on the number of officer personnel assigned to the 21AX and 405X career areas. Copies of the data retrieval programs and examples of the types of data retrieved for both officer and enlisted personnel (including retention and separations) can be found at Appendices J, K and M. With the exception of enlisted retention data, all data extracted from the PDS were in a fiscal year quarterly format. Due to the nature of the data, the retention data output was only available in a monthly format and had to be converted to quarters in Microsoft Excel®.

In an effort to include only those personnel associated with F-16 maintenance in the research, Air Force Instructions 36-2108 (Airman Classification) and 36-2105 (Officer Classification) were reviewed and Air Combat Command career field functional managers were consulted, resulting in a list of AFSCs that would typically be assigned to provide maintenance support in an F-16 fighter wing (Appendix L). All other AFSCs not associated with supporting F-16 aircraft were removed from the data. While some of the personnel on the list assigned to these AFSCs normally support only F-16 aircraft (crewchiefs and avionics AFSCs), other AFSCs (fuels and structures) support a wide variety of aircraft. For completeness, both types of AFSCs were included in this research.

As stated earlier, personnel issues such as end strength, experience levels and retention repeatedly were often cited in the literature as key factors influencing mission capable rates. To understand the relationship between F-16 personnel and F-16 mission capable rates, numerous data variables were created from the personnel data. The following table lists the variables created from the F-16 personnel data:

In order to create these variables, regular SUMIF and a series of matrix algebra conditional SUMIF statements were created in Microsoft Excel®. To create the set of brackets that encases the entire formula and signals Microsoft Excel® to perform matrix algebra with the multiple conditional SUMIF statements, the Ctrl, Shift and Enter keys must be pressed simultaneously after each formula is entered into a cell. Using these formulas allowed data for the personnel variables to be developed (Appendix D, Figure 35).

Headquarters Air Force (HAF) Manpower Data System (MDS). Although the end strength data from AFPC is an integral part of the personnel picture, by itself, it fails to take into account the fiscal reality of how many personnel the Air Force is authorized by Congress (via the Department of Defense Future Years Defense Plan and the Air Force and Financial Plan) to maintain in its ranks. Fiscal reality comes in the form of authorizations, the number of personnel the Air Force is authorized to maintain in a particular AFSC by grade and skill level.

The Headquarters Air Force (HAF) Manpower Data System (MDS) maintains required and authorized grades for all Air Force military manpower requirements to support approved Air Force programs. The HAF MDS lists unconstrained required grades to accomplish specific workloads. Authorized grades listed in the HAF MDS reflect fiscal reality and define grades allowed by applying allocated grade base support factors to the budgeted end strength (AFI 38-201, 1999 and AFI 38-204, 1999).

Authorization levels for each AFSC/grade/skill level combination can change throughout and between each fiscal year based on the execution of and changes to programs throughout the year. In the fourth quarter of each fiscal year, the Air Force must ensure the number of personnel assigned in each AFSC/grade/skill level combination fall within the AFSC/grade/skill level combination authorized for the next fiscal year.

In order to factor in fiscal reality and determine the percentage of assigned personnel to authorizations, authorization data regarding AFSC/grade/skill level combinations for the manned aerospace maintenance (45XXX and 2AXXX) and munitions and weapons (46XXX and 2WXXX) career fields as well as the 21AX and 405X officer career areas was retrieved from the HAF MDS. To facilitate data retrieval, a data retrieval program was created to extract AFSC/grade/skill level authorization data for the aforementioned enlisted career fields and officer areas. The program extracted historical authorization data from the fourth quarter from fiscal years 1989-2000. A copy of the data retrieval program and examples of the data output can be found at Appendix N. AFSCs listed in the authorization data were compared to the F-16 AFSC list and those AFSCs not on the list were removed from the authorization data. Because historical HAF MDS data is only available for the fourth quarter of each fiscal year, the increase/decrease in authorizations between fiscal years was divided by four and added/subtracted to/from the previous fiscal years data (and then each quarter until the next fiscal year) to develop quarterly authorization data points.

Variable Analysis Methodology

Correlation Analysis. Due to the large number of variables obtained and created for the analysis, a correlation analysis will be performed to examine the strength of the relationship between each independent variable and the dependent variable (mission capable rate) to determine which variables should be included in the explanatory and forecasting regression models. Additionally, each independent variable will be lagged with respect to time (1–4 quarters into the future), to analyze the relationship between an independent variable in one quarter and the dependent variable in future quarters. For example, the number of 5-levels in the first quarter of a particular year may be more strongly associated with the mission capable two quarters into the future (the third quarter) rather than the mission capable rate of the first quarter.

Neter et al. (1996: 353) suggests several techniques, such as forward selection, forward stepwise regression and backward elimination, for determining which variables to include a model, but ultimately states that no there is no procedure that will always identify the best variables for the best model. Neter et al. (1996: 354) goes on to state that selection of key variables can be very subjective and the model builder's judgment is an important factor in model building. For this study, positive correlations of 0.7 or more and negative correlations of -0.7 or less will serve as the initial criterion used as to whether or not a variable should be included in the pool of independent variables used to construct the regression models. Additionally, other variables not meeting the criterion that are thought to strongly affect mission capable rates (based on the literature review) will also be included in the pool of independent variables. Furthermore, strong correlation associations that do not make intuitive sense will be excluded from the pool of independent variables (i.e. as base repair cycle times increase mission capable rates increase).

After the initial correlation analysis is completed, a second correlation analysis will be performed and diagnostic scatter plots will be developed (as needed) to help identify cases of multicollinearity. Instances of multicollinearity will be analyzed and the variable thought to best explain the correlation relationships of each of the variables in question will be used in their places to reduce the amount of multicollinearity among the variables. Due to the nature of the data, it is expected that numerous instances of multicollinearity will be encountered.

After completion of the second correlation analysis, a final correlation analysis will be performed on the remaining variables using new criteria to determine whether or not a variable should be included in the regression models. Additionally, in conjunction with the final correlation analysis, simple linear regression will be performed to assess the strength of the relationship between mission capable rates and each of the remaining variables. For maintenance and supply-related variables, those with a correlation coefficient above or below 0.8 or -0.8 and an RSquare of 0.8 or more will be included. For personnel-related variables, those with a correlation coefficient above or below 0.7 or -0.7 and an RSquare of 0.6 or more will also be included. Additionally, other variables not meeting the aforementioned criteria that are believed to be related to mission capable rates (based on the literature review) will also be included in the models. Furthermore, interactions (ratios) among the remaining variables and higher order terms (quadratic, exponential and logarithmic etc.) will also be examined and included in the model if they meet the aforementioned criteria.

The remaining variables will be classified as to whether or not each can be controlled with respect to the future. For example, in the case of an F-16 crewchief variable, there are several processes (recruiting, funding, cross-training, drawdowns, etc) used to ensure a specific number of F-16 crewchiefs are in the Air Force at some future point in time. Furthermore, each of those processes can be manipulated to alter the specific number of F-16 crewchiefs in the future to adjust for projected changes in future requirements. However, in the case of the F-16 cannibalization actions variable, there are no known specific processes or combination of processes that can be manipulated to cause a specific number of F-16 cannibalization actions to occur 2 years into the future. While there may exist processes that affect the number of cannibalization actions (policies, component reliability improvements, etc.) that take place, there are too many unknown factors that will still influence the specific number of cannibalization actions that occur, making the final outcome 2 years into the future an uncertainty. Classifying the variables in this manner will help identify which variables should be used in the forecasting model.

The application of these criteria should ensure both models only contain those variables that demonstrate the strongest relationships with mission capable rates. Additionally, 20 percent of the data for the independent and dependent variables (by quarter) will be randomly selected and excluded from the explanatory model building process so they can be used for sensitivity analysis. For the forecasting model building process, the last 8 quarters of data (20 percent) will removed and used to assess the forecasting accuracy of the completed model and test the overall usefulness of the model.

Model-Building Methodology

Regression Analysis. Since there are a multitude of independent variables, multiple linear regression analysis will be used to create the models. The development of the multiple linear regression models with the correlated variables that will take the mathematical form of:

$$Y = ?_0 + ?_1X_1 + ?_2X_2 + \ldots + ?_fX_f + ?$$

Where:

Y = dependent or response variable (F-16 C/D mission capable rate)
X_1, X_2 …X_f = independent or predictor variables (identified through correlation)
$E(Y) = ?_0 + ?_1X_1 + ?_2X_2 + \ldots + ?_fX_f$ = deterministic component
? (epsilon) is the random error component
$?_f$ = depicts contribution of each independent variable X_f (McClave et al., 1998).

According to McClave et al. (1999: 444), model building can be viewed as a five-step process. The steps are as follows (McClave et al., 1998: 501):

Step 1. Hypothesize the deterministic component of the model. This component relates the mean, E(Y), to the independent variables. This involves the choice of the independent variables to be included in the model.

Step 2. Use the sample data to estimate the unknown model parameters ($?_0$, $?_1$, $?_2$,) in the model.

Step 3. Specify the probability distribution of the random error term, ?, and estimate the standard deviation of this distribution, ? .

Step 4. Statistically evaluate the usefulness of the model.

Step 5. When satisfied that the model is useful, use it for predictions, estimation, and other purposes.

These model-building process described above will be used to construct the regression models for this analysis.

Backward Stepwise Regression Analysis and the Explanatory Model. The specific multiple regression technique used to develop the explanatory model in this analysis is backward stepwise regression. Backward stepwise regression is a technique in which all potential independent variables are included in the initial regression model. As the model is analyzed, variables that minimally contribute to the predictive nature of the model are removed from the model. The reduced model is then re-run and an F-test is performed to verify the reduced model is statistically equivalent to the initial regression model. If the reduced model is found to be statistically equivalent, the contribution of each independent variable is reassessed within the reduced group of independent variables in the reduced model and once again, those variables found to be insignificant are removed from the model. As long as each reduced model continues to be statistically equivalent to the initial model, the process of reassessing and removing variables is repeated over and over until only the most significant explanatory independent variables remain in the model. The result is simpler explanatory model containing the most significant independent variables that is statistically equivalent to the initial model proposed (Neter et al., 1996: 353 and White, 2000).

Sensitivity Analysis of the Final Explanatory Model. Sensitivity analysis will be performed both a theoretical and empirical standpoint. In order to test the robustness of the predictive reliability of the final explanatory model, independent variable data from the quarters that were randomly removed from the original data-set (20 percent) will be combined with the data used to be used to build the model (80 percent) in JMP_{IN}®. The dependent variables for each of the randomly selected quarters will excluded from this process so that when the model (without 20 percent of the dependent variables) is run, JMP_{IN}® will generate individual confidence intervals for F-16 mission capable rates for each of those quarters. The confidence intervals will be saved and analyzed to determine whether or not the actual and predicted mission capable rate for each of the randomly selected quarters will fall within the bounds of each of the confidence intervals generated for each quarter. For both the theoretical and empirical analysis, the number of times the predicted and actual observation (mission capable rate) falls within the range of the confidence interval for each quarter will be divided by the total number of observations so the overall robustness of the model's predictive reliability can be determined.

Forecasting With Multiple Linear Regression. After the explanatory model is developed, a separate multiple linear regression model will be developed to forecast F-16 mission capable rates. The variables to be used to build the forecasting model will be those identified through variable analysis as variables that can be controlled directly or indirectly with respect to time and may be different than the variables used to build the explanatory model. The data used to build the forecasting model will be imported into JMP_{IN}® and arranged in chronological order. After the data are imported into JMP_{IN}®, a multiple linear regression model will be built using data from the first 80 percent of the time-ordered quarters (FY92-1 – FY98-4). Data from the remaining time-ordered quarters (FY99-1 – FY00-4) will be set aside for performing sensitivity analysis. To determine which combination of variables produces the most accurate forecast, the mean absolute percentage error (MAPE) will be computed for each forecasting model developed. The MAPE measures the percentage error of a model's ability to forecast and is computed by dividing the sum of the absolute percent error for each period and dividing it by the total number of forecast periods and is represented in the following equation (Makridakis et al., 1998):

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\left|PE_t\right|$$

The model that generates the smallest MAPE (the smallest overall forecasting error) will be the model that is selected to forecast F-16 mission capable rates.

Next, the robustness, the usefulness of the model's forecast outputs for planning, of the forecasting model will be analyzed. Using $\text{JMP}_{\text{IN}}^{®}$, confidence intervals (at a 95 percent confidence level) for each period's forecast will be generated to provide confidence intervals, a range of predicted mission capable rates, that the true mission capable rate should fall within at a 95 percent level of confidence. The width of the confidence interval will serve as an indicator of the model's robustness. The narrower the confidence interval, the more robust the model; alternatively, as the confidence interval widens, the model's robustness decreases. The average prediction error will be computed (average width of the confidence interval for the forecast period) for the final model and a series of alternative models so that comparisons can be made. The smaller average prediction error the more robust the model. In addition to the prediction error, a graphical plot of the actual and predicted mission capable rates, along with the confidence interval, will be used to depict the model's degree of robustness.

Theil's *U*-Statistic. This statistic allows a relative comparison of formal forecasting methods against each other and with naïve approaches (Makridakis et al., 1998:48). By squaring the errors involved in forecasting, this method ensures that large errors in forecasting are given more weight than small errors. It is mathematically defined as:

$$\sqrt{\frac{\sum_{t=1}^{n-1}(FPE_{t+1} - APE_{t+1})^2}{\sum_{t=1}^{n-1}(APE_{t+1})^2}}$$

where $FPE_{t+1} = \frac{F_{t+1} - Y_t}{Y_t}$ (forecast relative change)

and $APE_{t+1} = \frac{Y_{t+1} - Y_t}{Y_t}$ (actual relative change)

Y is the observation and F is the forecast

This technique offers a viable approach to check the performance of the predictions generated by the forecasting model as compared to a naïve method. A naïve method is defined as a method where a forecasts is obtained with a minimal amount of effort and data manipulation and is based solely on the most recent information available; for example, using the most recent quarter's mission capable rate observation as a means of predicting or forecasting the mission capable rate for the next quarter.

For the final forecasting model, a Theil's *U*-statistic will be computed to assess a naïve forecast against the predicted rates generated from the forecasting model. The following explanation is provided on the results of the Theil's *U*-statistic (Makridakis et al., 1998:48):

> $U = 1$: the naïve method is as good as the forecasting technique being evaluated.
>
> $U < 1$: the forecasting technique being used is better than the naïve method. The smaller the U-statistic, the better the forecasting technique is relative to the naïve method.
>
> $U > 1$: there is no point in using a formal forecasting method, since using a naïve method will produce better results.

Regression Assumptions. Additionally, McClave et al. (1998: 444) supply the following key assumptions concerning regression analysis:

> Assumption 1. The mean of the probability distribution of ? is 0. That is, the average of the values of ? over an infinitely long series of experiments is 0 for each setting of the independent variable x.
>
> Assumption 2. The variance of the probability distribution of ? is constant for all settings of the independent variable x.
>
> Assumption 3. The probability distribution of ? is normal.
>
> Assumption 4. The values of ? associated with any two observed values of y are independent. That is, the value of ? associated with one value of Y has no effect on the values of ? associated with other y values.

All of the aforementioned assumptions will be verified for both models in Chapter IV. Assumption 1 will be checked through residual plots and analyzed to see how residuals are distributed about a mean line of 0. Assumption 2, the assumption of constant variance, will be assessed visually by plotting the error estimates using an overlay plot. While this is not an actual test, an overlay plot of the error estimates should reveal whether or not abnormal patterns of variance exist. If none exist, the assumption will be upheld. Assumption 3, normality, will be verified with the Shapiro-Wilk test while Assumption 4, independence, will be checked with the Durbin-Watson test. For the forecasting model, the assumption of independence will not be verified since the data to build the model will be ordered chronologically, introducing dependency into the model.

For completeness, all regression assumptions will be checked (except as noted above) to determine whether or not they have been upheld, but it is doubtful that the assumptions are ever entirely satisfied in practical applications. However, according to McClave et al. (1998: 540) "*experience has shown that the least squares regression analysis produces reliable statistics, confidence intervals and prediction intervals as long as departures from the assumptions are not too great.*"

Cook's D Influence Statistic. Additionally, the influence of each quarter's data in both models will be analyzed using the Cook's D Influence statistic. The Cook's D statistic measures overall influence, or the effect that omitting a case (quarter in this analysis) has on the estimated regression coefficients. Cases with Cook's Distances having measures greater than one should be examined to try and determine the reasons each is so influential. Large Cook's Distance measures may result from data problems (data entry mistakes), large studentized residuals or actual instances of extreme outliers (Neter et al., 1996). In this analysis, quarters with large Cook Distances (greater than one) will be excluded from the data set and the model will be re-run in an attempt to determine whether or not the data should remain in the model (via changes in the model's overall p-value).

Problems with Regression. Although regression is an effective forecasting method, its use in this analysis may invite several possible problems. These problems are micronumerosity, parameter estimability, multicollinearity, autocorrelation and extrapolation. *Micronumerosity* refers to small samples of data points per independent variable and appears to be a heuristic that each model builder applies differently. One approach to avoiding micronumerosity calls for a minimum of 100 data points per variable (White, 2000) while another calls for having at least 10 data points per variable while having one more observation that the number of parameters to be estimated (Gujarati, 1995: 319). The data in this study are limited to 36 (28 in the regression analysis) data points per variable due to the quarterly time periods used to acquire the data. For this study, micronumerosity should only be considered a limitation in the analysis.

Parameter estimability occurs when data are concentrated at a single *x* value. In these cases, a straight line cannot be fitted to the data since it takes two points (*x* values) to fit a straight line. In the case of a quadratic model, at least three different x values must be observed before the model can be fit to the data (McClave et al., 1998: 551). Accordingly, McClave et al. (1998: 551) state that *"the number of levels of observed x values must be one more than the order of the polynomial in x that one wants to fit."* If parameter estimability is encountered, different independent variables can be assessed.

Multicollinearity is the third problem that might be encountered in regression analysis. This problem occurs when two or more independent variables contribute redundant or overlapping information to the model. Usually, multicollinearity among independent variables can be detected using correlation analysis, since these variables are highly correlated with one another. Although multicollinearity does not affect the ability of the model to predict, it does add confusion to the model by making it difficult to understand the individual contributions of each independent variable to Y without out the influence of the other variable(s) (Makridakis et al., 1998; McClave et al., 1998:551 and White, 2000). In this analysis, multicollinearity will be eliminated from the model if it is encountered to reduce confusion and keep the model as simple as possible.

Autocorrelation is another problem that can be encountered in regression analysis when data are time series. Autocorrelation is defined as "the correlation between time series residuals at differing points in time" (McClave et al., 1998: 779). Data points for the independent and dependent variables are examined sequentially over a period of time and tend to be correlated over time. The presence of autocorrelation causes prediction errors in the model to be autocorrelated, which goes against the assumption of independence and may cause the model to be considered invalid (McClave et al., 1998: 553).

To combat the effects of autocorrelation, a Durbin-Watson test will be performed on the data set to check for its presence. If strong autocorrelation is detected, uncertainty will surround the model's results and any conclusions that are drawn. If significant autocorrelation results in the analysis, further analysis will be performed and documented in Chapter IV.

The final problem that can occur with regression analysis is *extrapolation*. Extrapolation occurs when one attempts to use the model to make a prediction of the dependent variable and the representative data that is input into the model to make the prediction falls outside of the bounds of the parameters of the original data set used to build the model. If a prediction is made using independent variable(s) that falls outside of the range of the original sample data, the model may no longer be able to make valid predictions. In this study, extrapolation is considered more of a problem for those who use the explanatory model than it is for the actual research. Since the analysis includes the entire range of independent variables, extrapolating with the explanatory model should not present a problem. However, the forecasting model, by its nature, relies on extrapolation to provide forecasts to its users. As long as the extrapolation limitations of two types of models are understood, extrapolation should not present a problem in this study.

Overview of the Next Chapter

Chapter IV will present the analysis and results of the methodology developed in Chapter III. First, correlation analysis will be examined followed by development of the regression models. Finally, the assumptions will be verified and the results of the analysis presented.

IV. Analysis and Results

Introduction

This chapter will discuss the analysis and results of this study. First the analysis methodology is outlined and hypotheses are developed. Next the results of each hypothesis are presented.

Explanatory Model Analysis

Variable Analysis. A correlation analysis was performed on 606 variables to examine the strength of the relationship between each independent variable and the dependent variable (mission capable rate) to determine which should be included in the model. Furthermore, to analyze how each variable affects mission capable rates over time; each of the 606 variables was lagged by time period (one, two, three and four quarters), which increased the total number of variables to be analyzed to 3030. Based on the criterion discussed in Chapter III that were established for the correlation analysis, the analysis revealed 1246 variables that demonstrated either positive or negative relationships with mission capable rates. Results of the initial correlation analysis can be found at Appendix O.

After the 1246 variables were identified, a second correlation analysis was performed and diagnostic scatter plots (as needed) were developed to help identify cases of multicollinearity. The analysis revealed numerous instances of multicollinearity among the maintenance, personnel and retention variables. For example, the number of 3-levels assigned to each of the AFSCs examined was highly correlated with the total number of 3-levels assigned in all F-16 maintenance AFSCs. In these instances, the variable thought to best explain the correlational relationships of each of the multicollinear variables was used in their places, which reduced the amount of multicollinearity among the variables. In the case of the example cited above, the number of 3-levels in all F-16 maintenance AFSCs is used to represent the number of 3-levels assigned to each specific AFSC. This step of the analysis reduced the number of variables from over 1246 to 87. Next, simple linear regressions and a third correlation analysis was performed on the remaining 87 variables, and by applying the criteria developed in Chapter III, the collection of variables was reduced from 87 to 16. Table 3 lists the independent variables included in the initial model. The specific data point for each independent variable can be found at Appendix P. Figure 25 contains the full explanatory model.

Table 3. Full Explanatory Model Regressor Variables

Total TNMCM hours of the top 50 weighted/rank-ordered work unit codes for the period of FY92–FY00	Total Maintenance Reliability hours of the top 50 weighted/rank-ordered work unit codes for the period of FY92 – FY00	Total Cannibalization Hours of the top 50 weighted/rank-ordered work unit codes for the period of FY92 – FY00
Total Number of F-16 Maintenance Personnel Assigned (Lag 3)	Ratio of F-16 Maintenance Personnel to Total O-3, (4024/21A3) Maintenance Officers (flightline) (Lag 3)	Total O-3, (4024/21A3) Maintenance Officers (flightline) (Lag 3)*
3-Levels Assigned*	5-Levels Assigned*	7-Levels Assigned*
Ratio of 3-Levels to 5 and 7-Levels*	8-Hour Fix Rate (ACC)	Ratio of 3-Levels to 7-Levels*
Average Aircraft Inventory*	Total Number of F-16 Maintenance Personnel Assigned*	Ratio of F-16 Maintenance Personnel per Aircraft (all grades all skill levels)*
Total F-16 Crewchiefs Assigned*	All variables at Lag 0 unless otherwise noted * Variables that can be controlled	

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \beta_{12} X_{12} + \beta_{13}(X_{10}/\{X_{11} + X_{12}\}) + \beta_{14} X_{10}/X_{12} + \beta_{15} X_9/X_5 X_{15} + \beta_{16} X_3/X_8 + e$$

Predicted Y: F-16C/D Mission Capable Rate

Original Effects:
X_1 = TNMCM Hours of Wtd Top 50 WUCs
X_2 = Cannibalization Hours of Wtd Top 50 WUCs
X_3 = Total F-16 Maintenance Personnel Assigned (Lag 3)
X_4 = Maintenance Reliability of Wtd Top 50 WUCs
X_5 = Average Aircraft Inventory
X_6 = 8-Hour Fix Rate (ACC)
X_7 = Total F-16 Crewchiefs Assigned
X_8 = Total O-3, Maintenance Officers Assigned (Lag 3)
X_9 = Total F-16 Maintenance Personnel Assigned (Lag 0)
X_{10} = Total 3-Levels Assigned (Lag 0)
X_{11} = Total 5-Levels Assigned (Lag 0)
X_{12} = Total 7-Levels Assigned (Lag 0)

Interactions:
$X_{10}/(X_{11}+X_{12})$ = 3-Levels Assigned/5 and 7-Levels Assigned
X_{10}/X_{12} = 3-Levels Assigned/7-Levels Assigned
X_9/X_5 = F-16 Maintenance Personnel/Avg Aircraft Inventory
X_3/X_8 = Total F-16 Maintenance Personnel Assigned/ Total O-3, 4024/21A3 Maintenance Officers Assigned

Higher Order: No significant higher order terms were revealed

Figure 25. Full Explanatory Model

Explanatory Model Regression Analysis. From the 36 quarters of data, 20 percent of the quarters (8 quarters) were randomly selected and removed from the data population so they could be used for model validation and sensitivity analysis. The remaining 80 percent of the data points for each variable were copied from Microsoft Excel® into the JMP_{IN}® statistical analysis software package (academic version 4.0.2) to produce the full explanatory model (Figure 36, Appendix Q). The sum of squared errors (SSE) was calculated to be 0.00018279 (compared to 0 which is a perfectly fitted model) and the RSquare was 0.0990886 while the adjusted RSquare was 0.972658. To determine if the model was useful, the following hypothesis test, using an F statistic, was conducted and indicated the model was useful:

H_o: $_{i=1}$? ^{16} $ß_i$ = 0 (the model does not predict the dependent variable)
H_a: At least one of the beta coefficients is nonzero (the model is useful)
Test Statistic: F = 54.3613
Critical Value: Fa = 3.201634513 (based on k = 16 and n = 25, n-(k+1) = 8)
Rejection region: F > Fa
AOV Test Result: Since the F statistic exceeds the critical value, there is sufficient evidence, at a = 0.05 significance level, to reject the null hypothesis, H_o, that the model does not predict the dependent variable

Although the null hypothesis was rejected, the results of the first model indicated there were several variables (p-values greater than 0.4), which could be removed to produce a reduced and simpler predictive model. The variables removed from the initial model are listed in Table 4 below.

Table 4. Variables Removed from Full Model

Variable	**Prob > F**
Ratio of F-16 Maintenance Personnel to Total O-3, (4024/21A3) Maintenance Officers (flightline) (Lag 3)	0.8970
8-Hour Fix Rate (ACC)	0.7550
Total Number of F-16 Maintenance Personnel Assigned (Lag 3)	0.4559
Total O-3, (4024/21A3) Maintenance Officers (flightline) (Lag 3)	0.5870
Total F-16 Crewchiefs Assigned	0.6152

The reduced model was run in JMP_{IN}® (Appendix Q, Figure 37) and indicated a statistically equivalent model. The results of the F-Test which test that the subset of Beta parameters were equal to zero are listed below:

Full model (first) reduced to second model:
H_o: $ß_{16} = ß_6 = ß_7 = ß_8 = ß_3 = 0$
(the removed coefficients do not contribute)
H_a: At least one of these coefficients is nonzero
(at least one of the parameters should remain in the model)
Test Statistic, F = 1.574685714
Critical Value, $F_{5, 8, 0.05} = 3.687503636$
Rejection region: F > Fa
Since F < Fa, the second model is statistically equivalent to the full (first) model.

The results of the second model (Appendix Q, Figure 37) indicated that other variables could be removed from the model to make it simpler. Any variable demonstrating p-values greater that 0.05 was removed from the model with the exception of original effects variables that were part of an interaction that its contribution was significant. The variables removed from the second model are listed in Table 5.

Table 5. Variables Removed from Second Model

Variable	Prob > F
Ratio of 3-Levels to 5 and 7-Levels	0.5000
5-Levels Assigned	0.1749

Using JMP_{IN}® to fit the model, a third model was developed (Appendix Q, Figure 38) and proved to be statistically equivalent to the second model. The results of the F-Test are listed below:

Second model reduced to third model
H_o: $ß_{11} = ß_{13} = 0$
(the removed coefficients do not contribute)
H_a: At least one of these coefficients is nonzero
(at least one of the parameters should remain in the model)
Test Statistic, F = 2.023928571
Critical Value, $F_{2, 13, 0.05} = 3.805667417$
Rejection region: F > Fa
Since F < Fa, the 3rd model is statistically equivalent to the 2nd model.

Further analysis revealed that another variable could be removed from the third model (Appendix Q, Figure 38) to make it simpler. The variable removed from the third model is listed in Table 6.

Table 6. Variables Removed from Third Model

Variable	**Prob > F**
Total Maintenance Reliability hours of the top 50 weighted/rank-ordered work unit codes for the period of FY92 – FY00	0.0833

Using $JMP_{IN}^{®}$ to fit the model, a fourth model was developed (Appendix Q, Figure 39) and proved to be statistically equivalent to the third model. The results of the F-Test are listed below:

<u>Third model reduced to fourth model</u>
H_o: $ß_{11} = ß_{13} = 0$
(the removed coefficients do not contribute)
H_a: At least one of these coefficients is nonzero
(at least one of the parameters should remain in the model)
Test Statistic, F = 3.004583333
Critical Value, $F_{1, 15, 0.05}$ = 4.543068144
Rejection region: F > Fa
Since F < Fa, the third model is statistically equivalent to the second model.

The fourth model's results (Appendix Q, Figure 39) revealed that additional variables could be removed from the model to make it simpler. The variables removed from the third model are listed in Table 7.

Table 7. Variables Removed from Fourth Model

Variable	Prob > F
Ratio of F-16 Maintenance Personnel per Aircraft (all grades all skill levels)	0.1290

Using JMP_{IN}® to fit the model, the fifth and final model was created (Appendix Q, Figure 40) and proved to be statistically equivalent to the fourth model. The results of the F-Test are listed below:

Fourth model reduced to fifth model
H_o: $ß_{15} = 0$
(the removed coefficients do not contribute)
H_a: At least one of these coefficients is nonzero
(at least one of the parameters should remain in the model)
Test Statistic, F = 2.334339623
Critical Value, $F_{1, 15, 0.05}$ = 4.493998063
Rejection region: F > Fa
Since F < Fa, the fourth model is statistically equivalent to the fifth model.

Additionally, a review of the remaining seven variables indicated that each variable significantly contributed to the predictive ability of the model ("Prob > F" < 0.05) and that none of them should be removed, indicating the fifth model would become the final, simplified model. The final model was compared to the full (first) model (Appendix Q, Figure 36) and validated for statistical equivalence using the following F-Test:

Full (first) model compared to final (fifth) reduced model
H_o: ? $ß_{removed} = 0$
(the removed coefficients do not contribute)
H_a: At least one of these coefficients is nonzero
(at least one of the parameters should remain)
Test Statistic, F = 1.236477987
Critical Value, $F_{9, 8, 0.05}$ = 3.388123559
Rejection region: F > Fa
Since F < Fa, the final model is statistically equivalent to the full model.

Assumption Verification. Prior to using the model to predict mission capable rates, the assumptions of normality, constant variance and independence were tested and verified. The assumption of normality concerning the normality of the error (e) variable (residuals and studentized residuals) was tested using the Shapiro-Wilk test for normality in JMP$_{IN}$®. The results (Appendix R, Figure 41 and 42) using the hypothesis test below indicate the error estimates are from a theoretical normal population:

Shapiro-Wilk test for normality (residuals)
H_o: The error estimates (residuals) are normally distributed
H_a: The error estimates (residuals) are not from a theoretical normal population
Test Statistic, “Prob<W” = 0.1675
Critical Value = a = 0.05
Rejection region: “Prob<W” < a
Shapiro-Wilk Test Result: Since “Prob W” is greater than a, there is insufficient evidence, at a = 0.05 significance level, to reject the null hypothesis, H_o, that the error estimates are normally distributed

Shapiro-Wilk test for normality (studentized residuals)
H_o: The error estimates (studentized residuals) are normally distributed
H_a: The error estimates (studentized residuals) are not from a theoretical normal population
Test Statistic, “Prob<W” = 0.6714
Critical Value = a = 0.05
Rejection region: “Prob<W” < a
Shapiro-Wilk Test Result: Since “Prob W” is greater than a, there is insufficient evidence, at a = 0.05 significance level, to reject the null hypothesis, H_o, that the error estimates are normally distributed

The assumption of constant variance of the error (e) variable was tested visually by plotting the residuals against the predicted values. A linear plot of the error estimates in the order given showed constancy and failed to demonstrate any abnormal patterns of variance (Appendix R, Figure 43).

The independence of each of the error (e) estimates was tested using the Durbin-Watson test in JMP_{IN}®(Appendix Q, Figure 40). The results are shown below along with the hypothesis test, indicating that the error estimates were independent:

H_o: The error estimates are independent
H_a: The error estimates are not independent
Test Statistic, “Prob<DW” = 0.6649
Critical Value = a = 0.05
Rejection region: “Prob<DW” < a

Durbin-Watson Test Result: Since “Prob<DW” is less than a, there is insufficient evidence, at a = .05 significance level, to reject the null hypothesis, H_o, that the error estimates are independent.

However, the Durbin-Watson Test also assumes that the data points are serially ordered and equally spaced over time. Based on the methodology used to construct the model and the assumptions used by the Durbin-Watson Test, the validity of the result from the independence test performed on this model are questionable. Therefore, the assumption of independence will be assumed to be valid.

Finally, the influence of each quarter of data on the model was analyzed using the Cook’s D Influence statistic. Although a plot of the Cook’s D statistic (Appendix R, Figure 43) data points revealed that several data points (quarters) were very influential in comparison to the other data points, the data points were not removed from the model nor was further analysis conducted since none of the data points exceeded the Cook’s D threshold measurement of one.

Explanatory Model Results. The culmination of the explanatory regression analysis is a final explanatory model (Figure 26) that can be used to predict F-16C/D aircraft mission capable rates provided the independent variables fall within the data set used to build the model (Table 8). The beta parameters for each of the variables in the final model can be found at Table 9.

$$Y = ß_0 + ß_1X_1 + ß_2X_2 + ß_3X_3 + ß_4X_4 + ß_5X_5 + ß_6X_6 + ß_7X_{10}/X_{12} + e$$

Predicted Y: F-16C/D Mission Capable Rate

Original Effects:
X_1 = TNMCM Hours of Wtd Top 50 WUCs
X_2 = Cannibalization Hours of Wtd Top 50 WUCs
X_3 = Average Aircraft Inventory
X_4 = Total F-16 Maintenance Personnel Assigned (Lag 0)
X_5 = Total 3-Levels Assigned (Lag 0)
X_6 = Total 7-Levels Assigned (Lag 0)

Interactions: X_{10}/X_{12} = 3-Levels Assigned/7-Levels Assigned

Higher Order: No significant higher order terms were revealed

The X variables were renumbered to simplify the model

Figure 26. Final Explanatory Model

Table 8. Data Ranges of Explanatory Model Independent Variables

Variable	Min	Max
$ß_1$, TNMCM Hours of Wtd Top 50 WUCs	141,102.10	341,401
$ß_2$, Cannibalization Hours of Wtd Top 50 WUCs	2,415.9	17,133.3
$ß_3$, Average Aircraft Inventory	1130.59	1303.76
$ß_4$, Total F-16 Maintenance Personnel Assigned (Lag 0)	35,770	45,160
$ß_5$, Total 3-Levels Assigned (Lag 0)	6,891	8,367
$ß_6$, Total 7-Levels Assigned (Lag 0)	8,336	11,825
$ß_7$, 3-Levels Assigned/7-Levels Assigned	.62	.97

Table 9. Final Explanatory Model Beta Parameters

Beta Parameter	Value
$ß_0$	1.938179
$ß_1$, TNMCM Hours of Weighted Top 50 WUCs	-3.886e-7
$ß_2$, Cannibalization Hours of Weighted Top 50 WUCs	-0.000003
$ß_3$, Average Aircraft Inventory	0.0000142
$ß_4$, Total F-16 Maintenance Personnel Assigned (Lag 0)	-0.00041
$ß_5$, Total 3-Levels Assigned (Lag 0)	0.0000682
$ß_6$, Total 7-Levels Assigned (Lag 0)	-0.000104
$ß_7$, 3-Levels Assigned/7-Levels Assigned	-0.712375

Explanatory Model Sensitivity Analysis. To analyze the robustness (predictive reliability) of the final explanatory model both theoretically and empirically, the independent variable data from the randomly selected quarters were combined with the data used to build the final model while the randomly selected dependent data variables were excluded. The final model, with all of the independent variable data points, was run in $JMP_{IN}^{®}$ which generated individual confidence intervals (at a 95% confidence interval) for each dependent variable. The confidence intervals generated by the final model, for the excluded dependent variable quarters, were analyzed to determine, empirically, the model's predictive reliability.

The robustness of the model was first analyzed theoretically. From a theoretical standpoint, at least 95 percent of the predicted mission capable rates should fall within the confidence intervals the final explanatory model produces in $JMP_{IN}^{®}$. The predicted mission capable rates were analyzed to determine, from a theoretical standpoint, the reliability of the model. Based on the model's parameters (using a 95 percent confidence interval), the analysis indicated the model was able to predict mission capable rates (seven observations) within the confidence interval 100 percent of the time, indicating the model's predictive reliability to be 100 percent. However, with only seven observations, it is likely that with an increased number of observations the true predictive reliability would be approximately 95 percent. The results of the theoretical sensitivity analysis can be found at Table 10.

Next, the model was analyzed empirically. The robustness final model's predictive reliability was computed in accordance with the methodology established in Chapter III. The sensitivity analysis revealed the observed mission capable rates for each respective quarter fell within the individual confidence intervals generated by the model six out of seven times, indicating the model's predictive reliability to be 85.71 percent. Once again, the small number of observations significantly influences the robustness of the model's empirical predictive reliability and a larger number of observations should produce more accurate results. Additionally, the widths of the confidence intervals at the prediction points were summed and averaged. The computation produced an average prediction error of 1.9% for the model. The results of the empirical sensitivity analysis for the model can be found in Table 10 and Figure 27.

Table 10. Sensitivity Analysis Results

Quarter	Lower Individual Confidence Interval	Predicted MC Rate	Observed MC Rate	Upper Individual Confidence Interval
99-4	0.75444	0.77348	0.76200	0.78975
95-3	0.79021	0.80814	0.80194	0.82375
93-1	0.84252	0.85773	0.85602	0.87828
98-2	0.74555	0.76341	0.75578	0.78208
99-1	0.71745	0.73497	*0.75730**	0.75441
00-3	0.75321	0.77919	0.78687	0.79911
00-4	0.74545	0.77041	0.76323	0.78826
*Observation outside range of confidence interval				

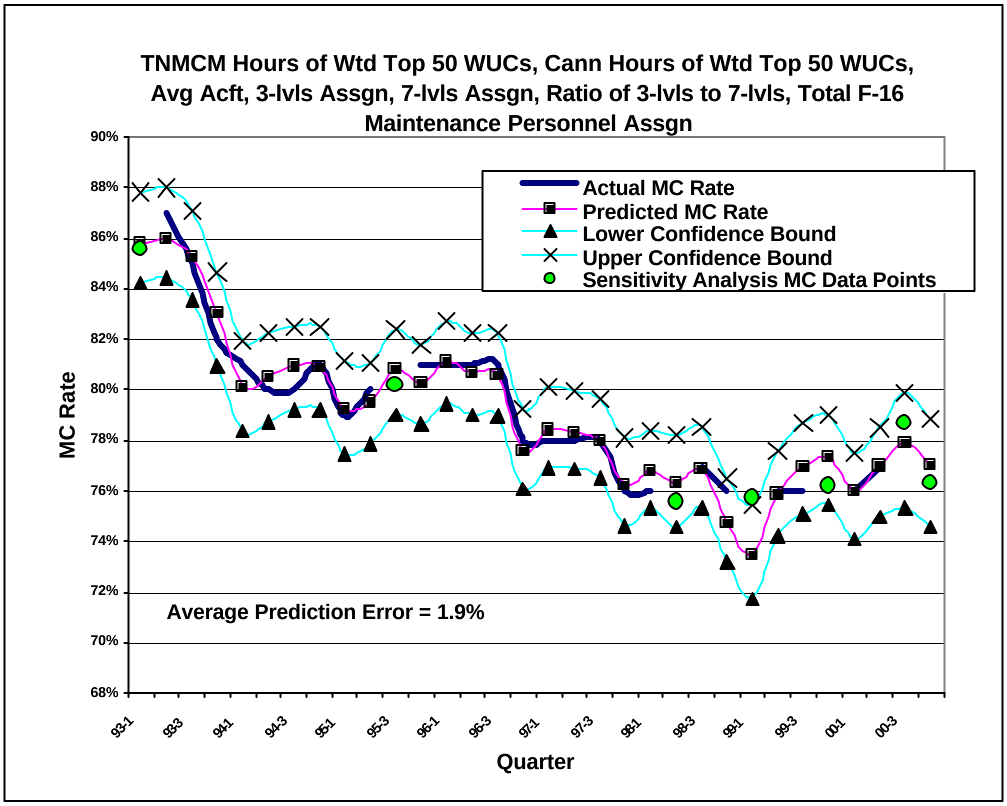


Figure 27. Explanatory Model Sensitivity Analysis

Forecasting Model Analysis

Variable Analysis. Analysis of the variables for the forecasting model followed the same methodology and analysis as used for the explanatory model in Chapters III and IV. However, for the forecasting model, the only variables considered for inclusion were those that could be directly or indirectly controlled. Consequently, the variables included in the forecasting model did not include the entire population of variables used in the full explanatory model. After building over 50 models using different combinations of variables and analyzing the mean absolute percent error of each, the following model (Figure 28) and its combination of variables (Table 11) generated a mean absolute percent error of 0.824679 percent which was the lowest MAPE of all the models tested. JMP_{IN}® model output data and the MAPE computations for the final forecasting model and at Appendix T in Table 51 and the data set used to construct the model can be found in Appendix S.

$$Y = ß_0 + ß_1X_1 + ß_2X_2 + ß_3X_3 + ß_4X_4 + ß_5\, X_4/X_3 + e$$

Predicted Y: F-16C/D Mission Capable Rate

Original Effects:
X_1 = Sorties
X_2 = Flying Hours
X_3 = Average Aircraft Inventory
X_4 = Total F-16 Maintenance Personnel Assigned (Lag 0)

Interactions: X_4/X_3 = Total F-16 Maintenance Personnel Assigned/ Average Aircraft Inventory

Higher Order: No significant higher order terms were revealed

Figure 28. Final Forecasting Model

Table 11. Final Forecasting Model Variables

Total Maintenance Personnel Assigned	Ratio of Maintenance Personnel to Aircraft	Average Aircraft Inventory
Sorties		Flying Hours

Assumption Verification. As with the explanatory model, the assumptions of normality and constant variance were used to build the forecasting model and required verification. The normality of the error (e) variable (residuals and studentized residuals) was tested using the Shapiro-Wilk test in JMP_{IN}®. The results (Appendix U, Figure 46 and 47) using the hypothesis test below indicate the error estimates are from a theoretical normal population:

Shapiro-Wilk test for normality (residuals)
H_o: The error estimates (residuals) are normally distributed
H_a: The error estimates (residuals) are not from a theoretical normal population
Test Statistic, "Prob<W" = 0.7755
Critical Value = a = 0.05
Rejection region: "Prob<W" < a
Shapiro-Wilk Test Result: Since "Prob W" is greater than a, there is insufficient evidence, at a = 0.05 significance level, to reject the null hypothesis, H_o, that the error estimates are normally distributed

Shapiro-Wilk test for normality (studentized residuals)
H_o: The error estimates (studentized residuals) are normally distributed
H_a: The error estimates (studentized residuals) are not from a theoretical normal population
Test Statistic, "Prob<W" = 0.7230
Critical Value = a = 0.05
Rejection region: "Prob<W" < a
Shapiro-Wilk Test Result: Since "Prob W" is greater than a, there is insufficient evidence, at a = 0.05 significance level, to reject the null hypothesis, H_o, that the error estimates are normally distributed

The assumption of constant variance of the error (e) variable was tested visually by plotting the residuals against the predicted values. A chronological linear plot of the error estimates showed constancy and failed to demonstrate any abnormal patterns of variance (Appendix U, Figure 48).

Once again, the influence of each quarter of data on the model was analyzed using the Cook's D Influence statistic. Although a plot of the Cook's D statistic (Appendix U, Figure 49) data points for the forecasting model revealed that several data points (quarters) were very influential in comparison to the other data points used to build the model, the data points were not removed from the model nor was further analysis conducted since none of the data points exceeded the Cook's D threshold measurement of one.

Forecasting Model Sensitivity Analysis. To analyze the model's degree of robustness, the actual mission capable rates, were plotted over time along with the predicted mission capable rates and the associated confidence intervals generated by $JMP_{IN}^{®}$. The width of the confidence interval for forecast period was analyzed in the same manner as the confidence interval in the explanatory model and was found to have an average prediction error of 4.8 percent (Figure 29). The width of the final forecasting model's confidence interval was compared to those of alternative models to validate the final model's robustness. The comparison revealed that one of the alternative models (as well as others) produced a narrower confidence interval and smaller prediction error (2.1 percent) than that of the final model (Figure 30). The data set used to construct the second (alternative) forecasting model can be found in Appendix V. The consequences of the difference in robustness between the two models will be addressed in Chapter V of this study.

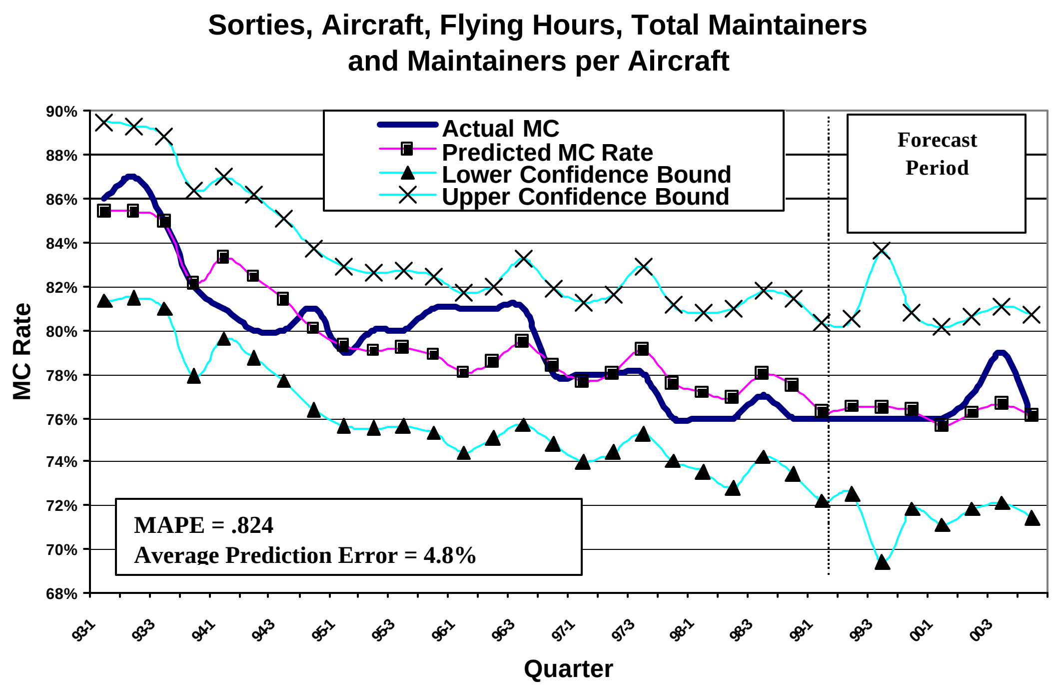


Figure 29. Forecasting Model Sensitivity Analysis – Model 1

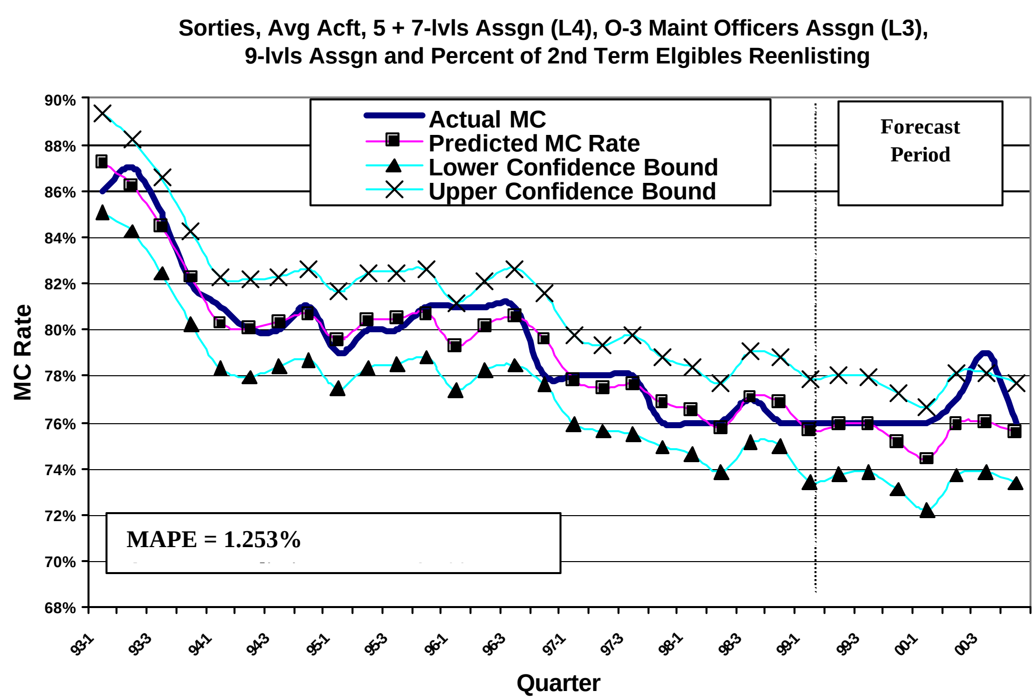


Figure 30. Forecasting Model Sensitivity Analysis – Model 2

To assess the overall performance of the model, a Theil's *U*-statistic was computed for the final forecasting model to compare its performance against a naïve forecast. The results of the algorithm (0.7119), using the criteria established in Chapter III, indicated the forecasting model's performance was better than the performance of a naïve forecast. The Theil's *U*-statistic was computation for the second model was 1.003, indicating the naïve forecast is better than the forecast produced by the second model.

Overview of the Next Chapter

Chapter V concludes this research effort. First, the research questions presented in Chapter I are answered. Next, managerial recommendations are made. Finally, research limitations are examined and future recommendations are suggested.

V. Conclusions and Recommendations

Introduction

This chapter discusses the conclusions drawn from the research. Each of the research questions is addressed and managerial implications are discussed. Finally, areas for further research are suggested.

Findings

This section answers the research questions posed in Chapter I. Questions 1 and 2 are answered from information collected through the literature review. The answers to Questions 3 and 4 are obtained from the analysis contained within Chapter IV.

Research Question #1. What changes have taken place since 1990 that have affected the five areas (reliability and maintainability/aircraft factors, spares, personnel, funding and environment) that are believed to influence mission capable rates?

First, it is important to note that none of the variables contained within these five areas stand in isolation. Most of the variables contained within each area are interrelated with one another so that changes in one variable may cause a "ripple effect" that impacts other variables. Additionally, changes in the most influential variables generate a much stronger effect than lesser variables. In this study, the research indicated that unforeseen changes in the world environment (environmental variables) created a series of powerful "ripple effects" which lead to a series of decisions that significantly influenced mission capable rates.

As the literature review indicated, the 1990s were a time of change. Several momentous changes occurred in the 1990s that reshaped the environment in which the

Air Force resides. The demise of the Soviet empire completely reshaped the defense environment of the United States, leaving it with a defense strategy that was incompatible with its new environment. Instead of reassessing its new defense environment and adjusting to it, the United States focused on reducing the size and cost of its armed forces in an effort to quickly reap the benefits of the “peace dividend”. Unfortunately, the fall of the Soviet Union left the United States’ defense environment very unstable, which was something unforeseen by the Air Force. Shortly thereafter, Iraq invaded Kuwait. The Air Force deployed its forces to participate in Operation DESERT STORM and never returned home. The Air Force remained in Southwest Asia to help stabilize the region, resulting in a “temporary” deployment of forces that has lasted for over 10 years. This “deployment”, coupled with a dramatic increase in Air Force involvement in military operations other than war (MOOTW), pushed the Air Force to its limits. Furthermore, increases in economic prosperity, both at home and abroad, increased the level of competition between the military and private industry for resources such as skilled personnel, compounding the effects generated by other world events. Reductions in defense spending and Air Force efforts to deal with its changing environment, created “ripple effects” that negatively impacted the Air Force in all five areas.

First, the Air Force completely reorganized itself, transforming itself from a forward-deployed force to a garrison force. As this reorganization was occurring, the Air Force drew down its active duty forces to accommodate the fiscal reality of reduced funding. With a diminished overseas presence and a smaller force, the OPSTEMPO and PERSTEMPO increased dramatically as personnel and equipment deployed more frequently and worked harder to fulfill ever-increasing mission requirements.

Increases in OPSTEMPO accelerated the service life of many Air Force aircraft, causing them to break more often and require more maintenance. Furthermore, as components failed more often, the need for replacement parts increased. Unfortunately, a lack of spare parts caused cannibalizations to increase, doubling the workload for maintenance personnel and which contributed to increased TNMCM and TNMCS rates. Moreover, increases in preventative maintenance and cannibalizations created an increased workload for a smaller, less experienced group of maintainers that were the result of force-shaping policies that inadvertently increased the ratio of inexperienced to experienced personnel.

To further complicate matters, several new policy and organizational initiatives, designed to reduce costs by eliminating the inventory, personnel and equipment, altered the environment within the Air Force. The implementation of Defense Management Report Decision (DMRD) 987, two-level maintenance and the shift to the objective wing structure were three of the most significant changes. DMRD 987 reduced funding spare parts purchases and slashed the Air Force's inventory of spare parts at the same time two-level maintenance removed a significant portion of intermediate level maintenance capability from wing-level maintenance organizations. Furthermore, the implementation of the objective wing structure, which occurred at the approximately the same time as the other changes, removed maintenance oversight from senior maintenance officers and placed it with the less maintenance-savvy operations community. It appears the near simultaneous initiation of these three changes had a significant impact upon the five areas.

Research Question #2. What are the costs of lower mission capable rates to the Air Force?

There are many costs associated with lower mission capable rates that are both tangible and intangible. Many of these costs are captured (tangible), but the majority are not because they extremely difficult to quantify and measure. The costs of lower mission capable rates tend to appear as opportunity costs but also manifest themselves in the form of dollars, personnel and decreased readiness.

Increased OPSTEMPO and PERSTEMPO continue to take their toll on both personnel and equipment. As illustrated in the literature review, increases in OPSTEMPO accelerate the service life of aircraft, causing them to break more often. Furthermore, the breaks that occur tend to be much more severe. The inability to return the required number of aircraft to mission capable status degrades readiness, preventing Air Force units from meeting both their combat and non-combat commitments. The loss of readiness capability is an intangible cost that exists but is not effectively measured.

When another unit is tasked to meet an unfilled commitment, that unit's training opportunities are reduced at the same time as its OPSTEMPO is increased which may result in other requirements going unfulfilled. Training opportunities for both pilots and maintainers might be missed, resulting in training shortfalls that can lead to a less capable workforce and reduced unit productivity.

The cost associated with lower mission capable rates can also be "measured" in terms of frustration, poor morale and decreased retention. Increased workloads, coupled with a high OPSTEMPO, spare parts shortages, decreased training opportunities and personnel reductions that left a less experienced workforce caused morale to sag.

Because of low morale and frustration, separations have increased in both the pilot and maintenance communities. When the Air Force replaces separating airmen, it incurs the tangible costs associated with recruiting and training new airmen. Furthermore, there are also unrealized costs the Air Force incurs that it cannot currently quantify – the cost of losing the knowledge, experience and leadership of professional airmen. New recruits, both officer and enlisted, do not possess the equivalent intellectual capital of the individuals they are replacing. Moreover, it can take a long time for new airmen to reach knowledge and experience levels of the individuals they replace, which degrades productivity and contributes to low mission capable rates.

Although most of the costs associated with low mission capable rates are intangible, there are costs that can be measured. When poor mission capable rates cause testing opportunities to be missed, the financial costs can be tremendous. On those occasions, months of planning and millions of dollars obligated to pay for testing (range fees, analyst and contractor support, etc) might be lost. Furthermore, the completion of follow-on tasks may not occur. When this happens, acquisition schedules for new systems are extended, requiring additional unplanned acquisition management support and delaying the deployment of a needed capability to the field.

The bottom-line is that there are many of costs associated with lower mission capable rates that are tangible and intangible. While the Air Force does record many of the tangible costs, it does not effectively track them. The majority of the costs are intangible and not measured. To capture the true cost of low mission capable rates, intangible costs must be identified, defined and quantified.

Research Question #3. Which variables are related to mission capable rates and what are the associated relationships?

In Chapter IV, variables from three of the five areas (personnel aircraft reliability and maintainability and operations) thought to influence mission capable rates were analyzed. The remaining two areas were not analyzed because of the difficulties associated with obtaining and quantifying data variables from each area. Of the areas analyzed, all three contained variables that demonstrated relationships of varying intensity with mission capable rates. Additionally, when examined across time, many of the variables demonstrated even stronger correlations.

From the analysis, it was quite apparent that some areas were more strongly related to mission capable rates than others. Variables from the reliability and maintainability area demonstrated the strongest relationships; however, this was not unexpected since many of these variables contain components used to compute mission capable rates. For example, mission capable rates represent the percent of hours an aircraft is not broken for maintenance (TNMCM) or supply (TNMCS). Therefore, variables composed of data that measure the amount of time or number of occurrences an aircraft is not mission capable for maintenance or supply will be strongly related to mission capable rates. To make these measures more meaningful, the data were analyzed by 5-digit work unit code so links could be established between the measures and a population of aircraft-specific components, systems or processes.

The most meaningful variables from this area were the reliability and maintainability weighted data variables. These variables attempt link the number of hours or occurrences that a specific group of work unit codes, weighted and ranked over time, contribute over time to mission capable rates. This analysis transformed the data and made it more significant. Instead of analyzing how accumulated hours of quarterly maintenance time relate to mission capable rates, the weighted variables demonstrated how the cumulative quarterly maintenance hours of the 50 most problematic work unit codes over the last 10 years for a particular variable related to mission capable rates. Although the weighted measures were more meaningful than just summed hourly data, it is important to note that both types measurements are aggregate measurements that quantify the reliability and maintainability of a specific group of components, systems or processes and does not describe root causes.

After the reliability and maintainability variables were created, they were analyzed to determine what type of relationship they demonstrated with mission capable rates. The variables were analyzed for their direct effect (how variable data for each quarter was related to mission capable rates for the same quarters) and for their lagged effect over time (how variable data for each quarter was related to mission capable rates one to four quarters in the future). As expected with this type of data, the strongest correlations all appeared when analyzing the variables' direct effects. The results of these analyses conducted on these types of variables were anticipated since these variables act as lagging measures that quantify their impact upon mission capable rates at the end of the time period being analyzed and not future quarters. Most of the variables in this area were negatively correlated with mission capable rates. As the reliability and maintainability measures decreased mission capable rates increased and as they increased mission capable rates decreased. Correlations of weighted data reliability and maintainability variables were not as strong as were the correlations of variables using quarterly summed data. However, because they served as a more informative measure of each type of dataset, the weighted variables were selected over the summed variables, in most instances, as the reliability and maintainability variables that demonstrated the strongest relationships with mission capable rates.

Variables that fell into the aircraft and logistics operations area were also analyzed to understand how each related to mission capable rates. The aircraft operations variables were more closely related to mission capable rates than the logistics operation variables. However, the data used to construct many of the logistics operations variables were extracted from D041, which may have provided data that aggregated other aircraft data with F-16 data. This aggregation of the data would tend to diminish the true relationships these variables share with mission capable rates. Another logistics operation variable, Air Combat Command's 8-hour fix rate also exhibited strong positive correlation with mission capable rates as a direct effect variable.

The logistics support variables extracted from the D041 system were subjected to the same weighting and ranking methodology applied to the work unit code data for the reliability and maintainability variables. The resultant variables demonstrated stronger relationships than the quarterly sums of data for these variables. These variables were also analyzed for the effect of time as well. The most significant relationships for these variables appeared two quarters into the future. For instance, the level of unserviceable in quarter 1 is negatively correlated to the mission capable rate in quarter 3. For the logistics operations variables, the level of serviceable and unserviceable inventory of the weighted top 50 reparable items (identified by national item identification number) lagged two quarters into the future exhibited the strongest relationships with mission capable rates. Unfortunately, the relationships were not strong enough to warrant the inclusion of the variables in the regression analysis.

When compared to variables from the other two areas, aircraft and logistics operations variables demonstrated the weakest relationships with mission capable rates. However, when these variables were used as part of an interaction with either personnel or reliability and maintainability variables, the new variables demonstrated strong correlation with mission capable rates. For example, the ratio of maintainers per aircraft demonstrated stronger correlation with mission capable rates (0.912) than either total maintainers assigned (0.824) or average aircraft inventory (-0.874) did as stand-alone variables. Consequently, these variables were used to create new variables that linked system performance to either reliability and maintainability or personnel. However, the literature review indicated that despite weak correlations, many of aircraft and logistics operations variables should be considered significant and included as part of the regression analysis.

The last area analyzed, personnel, was the most difficult area to assess. The personnel area included retention and separation variables, as well as manning variables such as the number of personnel authorized, assigned and percent of authorizations filled for individuals assigned to a series of Air Force Specialty Codes (AFSC) that perform F-16 aircraft maintenance and aircraft maintenance officers. The personnel data was broken out by grade, skill level and AFSC to check for significant relationships between mission capable rates and these sub-groups. Additionally, the "number of personnel assigned" variables were combined with the average aircraft inventory variable to create a series of "personnel assigned per aircraft" interaction variables that served as the link between the areas of personnel and aircraft operations. As with the other areas, these variables were also lagged to analyze how they related to mission capable rates over time.

The results of the analysis were very similar to the findings of other studies that analyzed how personnel levels relate to mission capable rates. The underlying factor in the personnel data appeared to be experience. Whether the data was analyzed by grade, skill level or percent of authorizations filled, the story was the same as the number of inexperienced personnel (defined as 3-levels and E-3s) increased, mission capable rates decreased. Conversely, as experience increased (5, 7 and 9 levels as well as E-4 – E-9) mission capable rates increased. To better understand these relationships in an operational environment, the ratio of 3-levels to other skill levels was thought to be a useful measure of personnel conditions (experience mix) that might exist in a typical maintenance complex. The ratios were created to model the level of responsibility more senior and experienced personnel are shouldered with when training and supervising new/inexperienced personnel. When analyzed, increases in the ratio of 3-levels to either 5 or 7-levels (or both) are negatively correlated to mission capable rates. An drill-down analysis of these ratios for specific AFSCs was less clear. Some AFSCs, such as crewchiefs and flightline avionics, exhibited the same trends as the top-level analysis of the ratios; however, skill level ratios for other AFSCs, such as engines and structures, demonstrated positive correlation with mission capable rates. This could indicate that mission capable rates are more sensitive to skill level imbalances in certain career fields more than others.

Retention and separation variables were also analyzed in the same manner as personnel data with one exception. The data was also grouped by category of enlistment, first, second and career term airmen, to assess how the Air Force's retention rates for these groups of airmen related to mission capable rates. Instead of looking at raw numbers, the data were converted to percent of eligible personnel that reenlist or separate. It was felt that this provided an accurate measure of the Air Force's ability to retain high quality personnel. Retention data was also examined with respect to the number of personnel ineligible to reenlist and as well as other methods which appeared to be affected by confounding factors and proved to be inconclusive. The separation variables also seemed to be affected by confounding factors as well. An analysis of the percent of eligible airmen separating indicated that as separations increase mission capable rates increase. The confounding factors could be related to the failure of the variable to account for the recruitment of replacement airmen and/or cross-trainees. For example, the data may report that ten airmen in a particular AFSC separated in a particular quarter but fails to account for the three new accessions from technical training and four cross-trainees that entered the AFSC that same quarter. To accurately analyze these confounded variables the flow of personnel into and out of each AFSC needs to be analyzed to understand each career field's dynamics so accurate variable measurements can be developed. Because the analysis of separation variables and some reenlistment variables generated counter-intuitive results, the variables were left out of the regression analyses.

Retention variables, when analyzed by grade and AFSC, exhibited varying degrees of correlation with mission capable rates. The strongest correlation was demonstrated with percent of eligible crewchiefs that reenlisted which generated a correlation coefficient of 0.856. The majority of other retention correlations were very weak with the exception of first and career term airmen reenlistment rates and the overall reenlistment rate. These three retention variables along with crewchief retention rates were the variables that appeared to be the most significant in this area of personnel data. The second term retention rate variable, although not strongly related to mission capable rates, was also included in the regression analyses since several sources in the literature review cited lower second term retention rates as having a negative effect upon mission capable rates.

The effects of time were also analyzed with respect to all of the personnel variables analyzed. While the retention variables failed to demonstrate any overt interactions over time, other personnel variables demonstrated distinct patterns. The overall number of 3, 7 and 9-levels demonstrated direct effect relationships with mission capable rates with respect to time; while the total number of 5-levels in a particular quarter demonstrated the strongest relationship with mission capable rates four quarters in the future. When time lags were analyzed by AFSC and skill level, the same trends remained consistent in many AFSCs, but were less pronounced and in some cases, missing from others. Once again, this could indicate that mission capable rates are more sensitive to skill level imbalances in certain career fields more than others. Because of the inconsistent results generated by the AFSC skill-level data analyses, the total number of personnel assigned to each skill level was used as the variable that demonstrated the most representative relationship of each AFSC skill level to mission capable rates.

Research Question #4. What model best predicts mission capable rates and how helpful are they in demonstrating relationships among the variables and what is the result?

The answer to the first part of this research question is a resounding “it depends”. Regression models can be used to describe relationships among variables and provide forecasts. Many good regression models can be developed and some are more useful than others. Furthermore, there are many criteria that can be used to select the “best” model. The real answer as to which model predicts “best” resides with the individual that uses the model and depends upon the context in which the model is to be used.

Specifically, the study’s explanatory regression model focus is on explaining how a set of independent variables relates to mission capable rates. It contains only those variables that demonstrate significant relationships with mission capable rates. Additionally, the explanatory model can also be is used to make predictions that are strictly based upon the confined range of the explanatory independent variable dataset used to construct the model. Using a set of independent variables that fall within the bounds of the data set used to construct the explanatory model, the model can generate a prediction that will fall within ? 3.4 percent of the true mission capable rate at a 95 percent confidence level. However, if any of the data of any of the independent variables that are added to the model to generate a prediction fall outside the range of the data set used construct the model, extrapolation occurs and the prediction that is generated is meaningless. Because this prediction constraint, the explanatory model should be used to explain how these variables relate to mission capable rates and not to predict. The explanatory model resulting from this research does an excellent job of explaining and showing the relationship between mission capable rates and the combination of independent variables contained within the model.

The forecasting regression model uses different criteria for its construction, which allows it to be used to produce forecasts. Instead of focusing on significance of independent variables to the dependent variable, the forecasting model focuses on identifying the combination of controllable variables that provide the best forecasting accuracy for the type of forecast the user needs. Different user needs will result in the application of different criteria when selecting the best forecasting model. If the user's focus is on forecasting a point estimate, a measurement of model prediction accuracy, such as the mean absolute percent error, should be used as the criterion for model selection. However, if the user is interested in reducing the prediction error of the forecast so a narrower future planning window is created, selecting the model that produces that smallest prediction error (narrowest confidence interval in the forecast period) should be used as the criterion for model selection. With either use, the final forecasting model will be one that is composed of set of controllable variables that may or may not demonstrate significant relationships with the dependent variable. The only constraint the use of this model imposes is that the variables used in model are able to be controlled in the future – given a certain set of future conditions (number of 3-levels and number of aircraft) a predicted mission capable rate will occur at particular level of confidence. The forecasting model may or may not do a good job in demonstrating significant relationships between the dependent and independent variables; however, demonstrating relationships is not the purpose of this model. The purpose of this model is to provide forecasts.

The results are three tools that serve different purposes. The explanatory model identifies the variables that demonstrate the most significant relationships with the independent variable. In this study, the independent variables contained within the explanatory model explain 95 percent of the variability in mission capable rates. The forecasting models produce similar output, forecasts, but the focus of the each model's forecast is different. The first version of the forecasting model focuses on minimizing point estimate error whereas the second version of the forecasting model focuses on minimizing the prediction error (ranges of potential outcomes). Ultimately, the best model is the one that is most useful to the user for their purposes.

Recommendations for Action

This study proposes the following recommendations for action. They are not necessarily cost free, but are observations that may help improve readiness or at least help better predict effects to readiness and the utilization of resources.

Conduct analysis on top 50 time-weighted work unit codes for the reliability and maintainability variables identified as the most problematic from FY92 - FY00. Analyze the top 50 time-weighted work unit codes (WUC) for each R&M variable identified as the most problematic over the last 8 years. These variables' groups of work unit codes represent between 32 percent and 66 percent of the total data recorded for the entire 8-year time period. Root cause analysis of these work unit codes may reveal improvement opportunities that could lead to better variable performance and improved mission capable rates.

Implement and evaluate the usability of explanatory and forecasting models. AF/IL should "test-drive" the forecasting and explanatory models and assess usefulness as planning tools. Comparisons with existing forecasting tools should be should also be performed. If "test-drive" indicates models perform well and meets user needs, they should be used as an official F-16 forecasting tool.

Develop standards and personnel identifier codes that provide classification – aircraft support or support staff. Analysis of enlisted personnel data revealed that there is no distinction made between personnel performing "aircraft support" functions, individuals performing direct or indirect labor, and personnel providing "staff support" functions in management and policy-making positions. Under the current personnel system, categorical codes making this distinction between the two types of personnel do not exist. This shortcoming inflates the number of personnel that are actually available to perform direct and indirect labor, skewing the true labor capacity available to perform aircraft maintenance (as identified in Chapter III assumptions). Development and use of standards and special identifiers that categorize personnel as either "aircraft support" or "support staff" would provide a more accurate assessment of true aircraft labor capacity and a clearer picture of how it relates to mission capable rates.

Define and develop new metrics that measure mission capability from a systems perspective. Analysis revealed strong, quantifiable relationships between mission capable rates and the independent variables. Furthermore, variable interactions between and within areas (maintainers per aircraft or 3-levels per 7-level) also demonstrated strong, quantifiable relationships with mission capable rates. The analysis and literature suggest that using a systems approach to measure mission capability of a weapons system, assessing both aircraft and support structure capability, may provide a better assessment of overall weapon system capability. Using this approach, new metrics that provide meaningful measures of aircraft and support structure capability could be defined and developed.

Recommendations for Further Research

Throughout this research it became evident that several research projects could be pursued as follow-on research. While others research projects could evolve from this study, these four, in particular, would help further this area of research.

Expand study and apply methodology to other weapons systems – increase generalizability. The literature review indicated the five areas of reliability and maintainability, personnel, aircraft and logistics operations funding and environment apply to virtually all Air Force weapons systems. Using this study's methodology to analyze how variables from these five areas relate to the mission capable rates of a representative bomber or cargo aircraft would not only provide meaningful insights into the selected weapons system but also validate the analysis approach, increasing its generalizability. The results of this proposed research might also provide additional evidence that suggests the current weapon system assessment metrics and measurement processes need to be reevaluated

Investigate use of more advanced forecasting techniques. The forecasting tool used in this study was multiple linear regression. However, more advanced forecasting tools are available, such as autoregressive and dynamic regression models, which consider the effects of time when generating forecasts. Application of these advanced forecasting techniques using the data collected for this study may produce more useful forecasts.

Use study methodology to construct models that explain R&M root relationships. Analysis of the independent variables used in this study revealed numerous reliability and maintainability variables that demonstrated strong relationships with mission capable rates. Unfortunately, these variables could not be incorporated into the forecasting model because they could not be controlled to elicit a specific future state. By using the study's methodology to construct explanatory models for the "uncontrollable" variables, controllable root relationships might be revealed that could serve to transform the uncontrolled variable into a controlled variable. With the "controllable" root relationships identified, the previously "uncontrollable" variable could be incorporated into the forecasting model, which may improve the model's ability to forecast.

Identify and quantify the costs (tangible and intangible) associated with the effects of low mission capable rates. The study indicated the costs associated with mission capable rates are not adequately identified or quantified. The development of a methodology that identifies and quantifies the tangible and intangible costs of lower mission capable rates would enable the Air Force to collect critical information that could be used to assess the impact (or potential impact) of decisions that might affect mission capable rates.

Appendix A: MERLIN Forecasting Model

-1999 07:05 FROM DYNAMICS RESEARCH TO 93370567989 P.16/21

F-16 Results
4/11/1997 10:12 AM

Multiple Regression Analysis

Dependent variable: NMCM_HRS

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	1736.96	862.262	2.01442	0.0450
FLYING_HRS	-7.09337	0.977268	-7.25837	0.0000
POSS_HRS	0.204255	0.0120572	16.9406	0.0000
SORTIES	5.17764	1.65394	3.13049	0.0019

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	1.68316E11	3	5.61054E10	607.89	0.0000
Residual	2.36278E10	256	9.22968E7		
Total (Corr.)	1.91944E11	259			

R-squared = 87.6903 percent
R-squared (adjusted for d.f.) = 87.546 percent
Standard Error of Est. = 9607.08
Mean absolute error = 6991.01
Durbin-Watson statistic = 0.55591

F-16
TNMCM

The StatAdvisor

The output shows the results of fitting a multiple linear regression model to describe the relationship between NMCM_HRS and 3 independent variables. The equation of the fitted model is

NMCM_HRS = 1736.96 - 7.09337*FLYING_HRS + 0.204255*POSS_HRS + 5.17764*SORTIES

Since the P-value in the ANOVA table is less than 0.01, there is a statistically significant relationship between the variables at the 99% confidence level.

The R-Squared statistic indicates that the model as fitted explains 87.6903% of the variability in NMCM_HRS. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 87.546%. The standard error of the estimate shows the standard deviation of the residuals to be 9607.08. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 6991.01 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the DW value is less than 1.4, there may be some indication of serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0.0019, belonging to SORTIES. Since the P-value is less than 0.01, the highest order term is statistically significant at the 99% confidence level. Consequently, you probably don't want to remove any variables from the model.

Figure 31. MERLIN F-16 TNMCM Regression Forecasting Model (Reynolds, 1999)

JUL-09-1999 07:00 FROM DYNAMICS RESEARCH TO 99376567988 P.06/21

Outliers Removed CW

F16 A-D Results
4/8/1997 2:44 PM

Multiple Regression Analysis

Dependent variable: TNMCS_HRS

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	-832.911	373.966	-2.22724	0.0268
FLYING_HRS	-0.364756	0.328773	-1.10944	0.2683
POSS_HRS	0.117839	0.0058537	20.1306	0.0000
SORTIES	-0.51937	0.642954	-0.807787	0.4200

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	1.37646E11	3	4.5882E10	2484.97	0.0000
Residual	4.76366E9	258	1.84638E7		
Total (Corr.)	1.4241E11	261			

R-squared = 96.655 percent
R-squared (adjusted for d.f.) = 96.6161 percent
Standard Error of Est. = 4296.95
Mean absolute error = 3019.24
Durbin-Watson statistic = 0.62385

F-16A/D TNMCS

The StatAdvisor

The output shows the results of fitting a multiple linear regression model to describe the relationship between TNMCS_HRS and 3 independent variables. The equation of the fitted model is

TNMCS_HRS = -832.911 - 0.364756*FLYING_HRS + 0.117839*POSS_HRS - 0.51937*SORTIES

OK

Since the P-value in the ANOVA table is less than 0.01, there is a statistically significant relationship between the variables at the 99% confidence level.

The R-Squared statistic indicates that the model as fitted explains 96.655% of the variability in TNMCS_HRS. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 96.6161%. The standard error of the estimate shows the standard deviation of the residuals to be 4296.95. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 3019.24 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the DW value is less than 1.4, there may be some indication of serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0.4200, belonging to SORTIES. Since the P-value is greater or equal to 0.10, that term is not statistically significant at the 90% or higher confidence level. Consequently, you should consider removing SORTIES from the model.

(26)

Figure 32. MERLIN F-16 TNMCS Regression Forecasting Model (Reynolds, 1999)

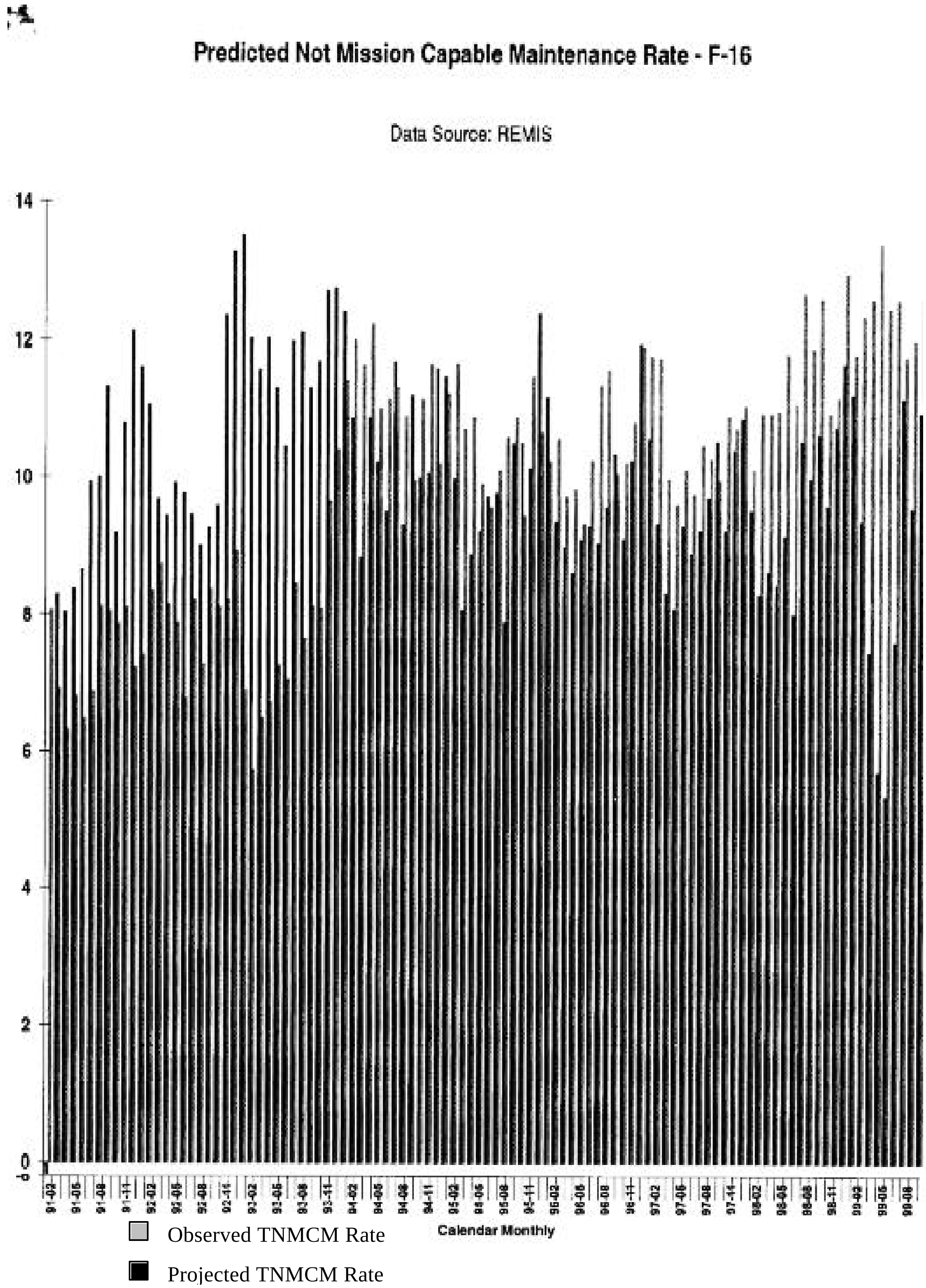


Figure 33. MERLIN TNMCM Regression Model Forecasts (DRC, 2000)

Appendix B: REMIS Variables

Table 12. REMIS Data Variables

EIMSURS Data		**PPS Data (per 5-digit Work Unit Code)**
TNMCM Hours	TNMCS Hours	Manhours Expended
Maintenance Downtime (per 5-digit Work Unit Code)	Supply Downtime (per 5-digit Work Unit Code)	Repair Hours Expended
Maintenance Reliability (per 5-digit Work Unit Code)	Supply Reliability (per 5-digit Work Unit Code)	Repair Actions Conducted
Possessed Hours	Number of Landing Status Code 3 Breaks (per 3-digit Work Unit Code)	Cannibalization Hours
Flying Hours	Aircraft Utilization Rate	Cannibalization Actions
Sorties	Average Sortie Duration	Manhours per Sortie
Mission Capable Hours	Average Possessed Acft	Manhours per Flying Hour
		8-Hour Fix Rate (ACC Data)

Table 13. Definitions of REMIS Data Variables

Variable	Description
TNMCM Hours	Number of hours recorded for aircraft not being mission capable for maintenance reasons (does not include partially mission capable for maintenance hours)
TNMCS Hours	Number of hours recorded for aircraft not being mission capable for supply reasons (does not include partially mission capable for supply hours)
MC Hours	Number of hours recorded for aircraft being fully mission capable or partially mission capable
Possessed Hours	Number of hours aircraft is possessed
Flying Hours	Number of flying hours recorded for aircraft
Sorties	Number of flights recorded for aircraft
Average Sortie Duration	Average sortie duration per aircraft
Aircraft Utilization Rate	Average number of sorties flown per aircraft
Code 3 Breaks	Number of debrief landing status code 3 breaks (grounding conditions)
Maintenance Reliability	Number of times a WUC is coded NMCM, NMCMA or PMCM
Supply Reliability	Number of times a WUC is coded NMCS, NMCSA or PMCS
Maintenance Downtime	Number of hours a WUC is coded NMCM, NMCMA or PMCM
Supply Downtime	Number of hours a WUC is coded NMCS, NMCSA or PMCS
Manhours Expended	Number of manhours expended on both on and off equipment WUCs
Repair Hours Expended	Number of repair hours expended on both on and off equipment WUCs
Repair Actions Conducted	Number of repair actions performed on both on and off equipment WUCs
Cannibalization Hours	Number of hours expended on cannibalization actions per WUC
Cannibalization Actions	Number of cannibalization actions performed per WUC
Manhours per Sortie	Total manhours/total sorties
Manhours per Flying Hour	Total manhours/total flying hours
8-Hour Fix Rate (ACC data)	Total number of code 3 breaks fixed in 8 hours or less
Average Possessed Aircraft	Average number of aircraft possessed by the Air Force

Table 14. Derived REMIS Data Variables

Derived REMIS Data Variables	
Total TNMCM hours of the top 25, 50, 100 and 200 work unit codes for each quarter	Total Supply Downtime of the top 25, 50, 100 and 200 work unit codes for each quarter
Total TNMCS hours of the top 25, 50, 100 and 200 work unit codes for each quarter	Total Manhours Expended of the top 25, 50, 100 and 200 work unit codes for each quarter
Total Maintenance Reliability hours of the top 25, 50, 100 and 200 work unit codes for each quarter	Total Repair Hours of the top 25, 50, 100 and 200 work unit codes for each quarter
Total Supply Reliability hours of the top 25, 50, 100 and 200 work unit codes for each quarter	Total Repair Actions of the top 25, 50, 100 and 200 work unit codes for each quarter
Total Maintenance Downtime hours of the top 25, 50, 100 and 200 work unit codes for each quarter	Total Cannibalization Hours of the top 25, 50, 100 and 200 work unit codes for each quarter
Average Manhours Expended per Sortie of the top 25, 50, 100 and 200 work unit codes for each quarter	Total Cannibalization Actions of the top 25, 50, 100 and 200 work unit codes for each quarter
Average Mean Time to Repair of the top 25, 50 100 and 200 work unit codes (based on repair actions) for each quarter	Average Manhours Expended per Flying Hour of the top 25, 50, 100 and 200 work unit codes for each quarter
Total TNMCM hours of the top 50 weighted/rank-ordered work unit codes for the period of FY92 – FY00	Average Mean Time to Repair of the top 25, 50 100 and 200 work unit codes (based on supply reliability) for each quarter
Total TNMCS hours of the top 50 weighted/rank-ordered work unit codes for the period of FY92 – FY00	Total Supply Reliability hours of the top 50 weighted/rank-ordered work unit codes for the period of FY92 – FY00
Total Maintenance Reliability hours of the top 50 weighted/rank-ordered work unit codes for the period of FY92 – FY00	Total Supply Downtime hours of the top 50 weighted/rank-ordered work unit codes for the period of FY92 – FY00
Total Maintenance Downtime hours of the top 50 weighted/rank-ordered work unit codes for the period of FY92 – FY00	Total Manhours Expended on the top 50 weighted/rank-ordered work unit codes for the period of FY92 – FY00
Total Repair hours of the top 50 weighted/rank-ordered work unit codes for the period of FY92 – FY00	Total Repair Actions of the top 50 weighted/rank-ordered work unit codes for the period of FY92 – FY00
Total Cannibalization Hours of the top 50 weighted/rank-ordered work unit codes for the period of FY92 – FY00	Total Cannibalization Actions of the top 50 weighted/rank-ordered work unit codes for the period of FY92 – FY00
Average Mean Time to Repair of the top 50 weighted/rank-ordered work unit codes (based on repair actions) for the period of FY92 – FY00	Average Mean Time to Repair of the top 50 weighted/rank-ordered work unit codes (based on supply reliability) for the period of FY92 – FY00

Appendix C: REMIS Data Queries and Sample Output

<u>Landing Status Code 3 Breaks by 3-digit WUC</u> (EIMSURS)

```
PAGE     1
  Debrief Summary                      PREPARED: 10/04/00
 FOR: RU100102              BY: REMISTALK, J041988

 BREAKS
  USER-INPUT SELECT ELEMENTS/OPTIONS WERE AS FOLLOWS:

      VERB USED IN THIS REPORT WAS: SUM
      REPORT SORTED BY:
                   YEAR
                   MONTH
                   SUBSYS_WUC

            * Equipment Designator: EQ 'F016C' 'F016D'

              Time Frame Window: From: 199001   To: 199412
PAGE     2
    BREAKS
 RemisTalk Report: J041988  Generated by:100102 on 10/04/00

 YEAR  MONTH  SUBSYS_WUC  NUM_LSC_3
 ----  -----  ----------  ---------
 1990    1                    0
              016             1
              041             0
              042             1
              043             0
```

<u>Maintenance Reliability (Number of Times 5-digit WUC coded NMCM)</u>* (EIMSURS)

```
PAGE     1
  Status Detail                         PREPARED: 10/04/00
  FOR: RU100102                      BY: REMISTALK, J334150

 NUMBER OF TIMES NMCM

  USER-INPUT SELECT ELEMENTS/OPTIONS WERE AS FOLLOWS:

      VERB USED IN THIS REPORT WAS: SUM
      REPORT SORTED BY: WUC

     * EQUIPMENT DESIGNATOR: EQ 'F016C' 'F016D'
```

* TYPE EQUIPMENT: EQ 'A'

Status Code: EQ 'C' 'D' 'M' 'N' 'G'
Time Frame Window: From: 199501 To: 200008

PAGE 2
NUMBER OF TIMES NMCM
RemisTalk Report: J334150 Generated by:100102 on 10/04/00

YEAR	MONTH	WUC	STATUS_CD COUNT
1994	11	03600	1
		27000	4
		27Z00	1
	12	01000	2

*Same query used for supply reliability variable except NMCS replaces NMCM

Various Utilization Data (EIMSURS)

PAGE 1.1
Inv/Stat/Util (Org/Geoloc smry) PREPARED: 10/04/00
FOR: RU100102 BY: REMISTALK, J922134

UTILIZATION AND STATUS DATA BY MONTH

USER-INPUT SELECT ELEMENTS/OPTIONS WERE AS FOLLOWS:

VERB USED IN THIS REPORT WAS: SUM
REPORT SORTED BY:
YEAR

MONTH ---------- ------

*EQUIPMENT DESIGNATOR: EQ ' F016C' ' F016D'

Time Frame Window: From: 199501 To: 200008

PAGE 2.1
UTILIZATION AND STATUS DATA BY MONTH
RemisTalk Report: J922134 Generated by: 100102 on 10/04/00

YEAR	MONTH	POSSESSED	FLYING_HOURS	SORTIES	MC_HOURS	TNMCM	TNMCS	AVERAGE_INV
1995	1	948,733.9	24,316.5	16760	755,305	153,550.9	77,773.6	1,275.22
	2	859,532.4	24,690.1	17055	683,401	141,564.0	73,619.6	1,279.04
	3	953,256.1	31,060.2	20282	760,154	147,184.7	88,525.1	1,281.31

YEAR	MONTH	UTIL_RMNTH	FLY_PER_SORT
1995	1	19.07	1.5
	2	19.30	1.4
	3	24.24	1.5

TNMCS and TNMCM Hours[1] and Maintenance and Supply Downtime[2] (EIMSURS)

```
PAGE     1
  Inv/Stat/Util (Summary)                PREPARED: 10/02/00
  FOR: RU100102                       BY: REMISTALK, J666094
```

STATUS – SUPPLY

```
  USER-INPUT SELECT ELEMENTS/OPTIONS WERE AS FOLLOWS:

      VERB USED IN THIS REPORT WAS: SUM
      REPORT SORTED BY:
                   CYEAR
                   CMONTH
                   WUC

            * EQUIPMENT DESIGNATOR: EQ 'F016C''F016D'

                  * TYPE EQUIPMENT: EQ 'A'

               Time Frame Window: From: 199501 To: 200008
PAGE     2
 STATUS - SUPPLY
 RemisTalk Report: J666094 Generated by: 100102 on 10/02/00
```

CYEAR	CMONTH	WUC	NMCS	NMCSA	PMCS	TNMCS
1995	01	.	.0	.0	.0	.0
		01000	.0	.0	.0	83.0
		03000	.0	.0	.0	116.5
		03100	.0	.0	.0	134.8

[1] Replace NMCS, NMCSA, PMCS and TNMCS with NMCM, NMCMA, PMCM and TNMCM to retrieve maintenance data instead of supply data.

[2] The sum of NMCS, NMCSA and PMCS represents downtime for supply and the sum of NMCM, NMCMA and PMCM represent downtime for maintenance per AFCSM 25-524 Volume 2, Sections 3.4.28 and 3.4.5.

Maintenance and Repair Data* **(PPS)**

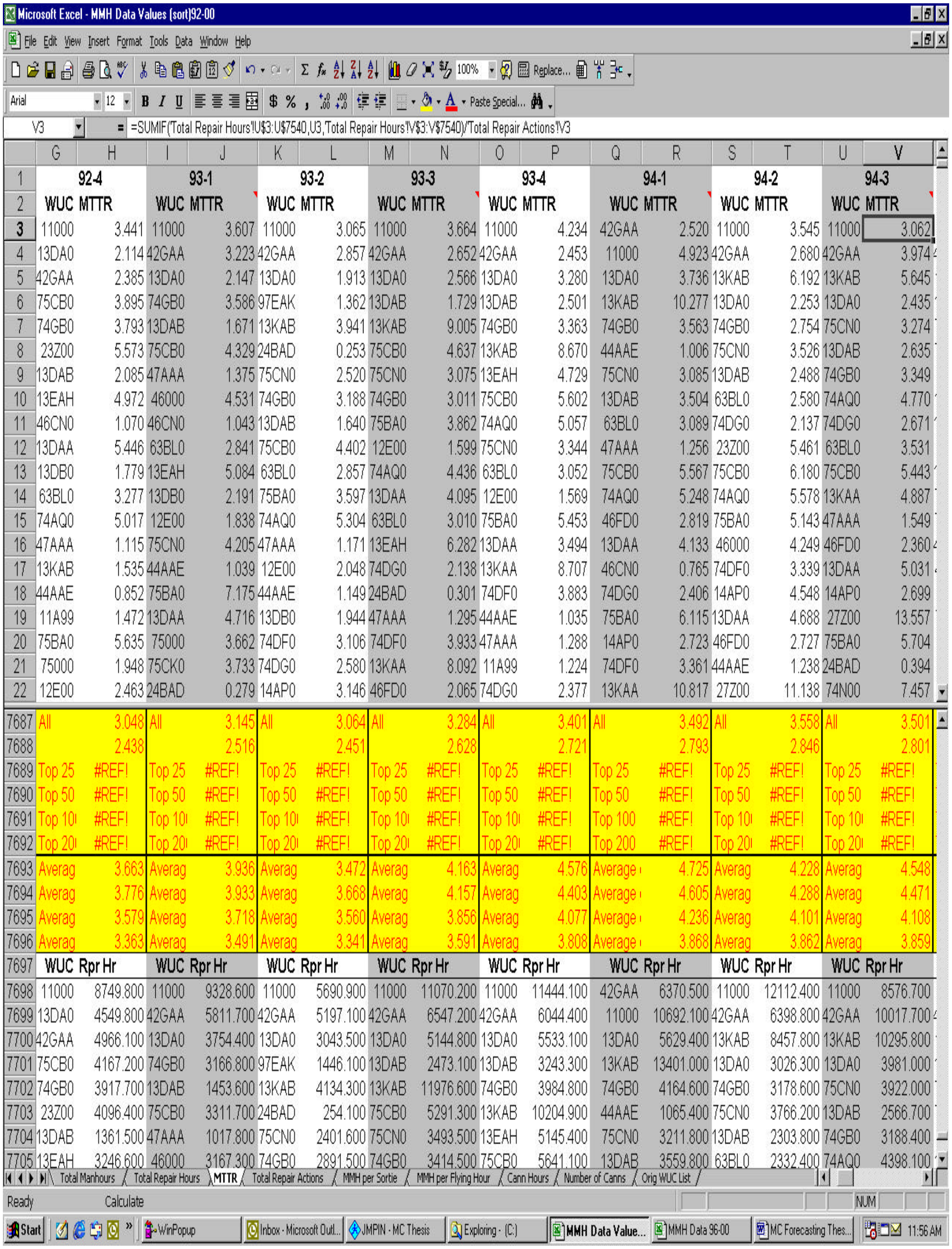
```
PAGE     1.1

  PPS (MDC CMD/Base) Summary           PREPARED: 10/03/00
  FOR: RU100102                        BY: REMISTALK, J021880

R AND M DATA

  USER-INPUT SELECT ELEMENTS/OPTIONS WERE AS FOLLOWS:

      VERB USED IN THIS REPORT WAS: SUM
      REPORT SORTED BY:
                   YEAR
                   MONTH
                   WORK_UNIT_CD

            * Type Equipment: EQ 'A'
            * Equipment Designator: EQ 'F016C' 'F016D'
              Time Frame Window: From: 199501   To: 200010
PAGE     2.1

R AND M DATA
RemisTalk Report: J021880  Generated by: 100102 on 10/03/00
```

YEAR	MONTH	WORK_UNIT_CD	TOTAL_MANHRS	TOT_REPR_HRS	TOT_REP_ACT	MMH_SORT
1995	01	.	38,704.80	.00	0	2.31
		01000	676.80	.00	0	.04
		01110	615.80	.00	0	.04
		01120	332.30	.00	0	.02
		01130	105.80	.00	0	.01

YEAR	MONTH	WORK_UNIT_CD	MMH_OPTIME	CANN_HOURS	NUM_CANNS	MTBF_TOTAL	MTTR
1995	01		1.59	.0	.0	.00	.00
		01000	.03	.0	.0	.00	.00
		01110	.03	.0	.0	.00	.00
		01120	.01	.0	.0	.00	.00
		01130	.00	.0	.0	.00	.00

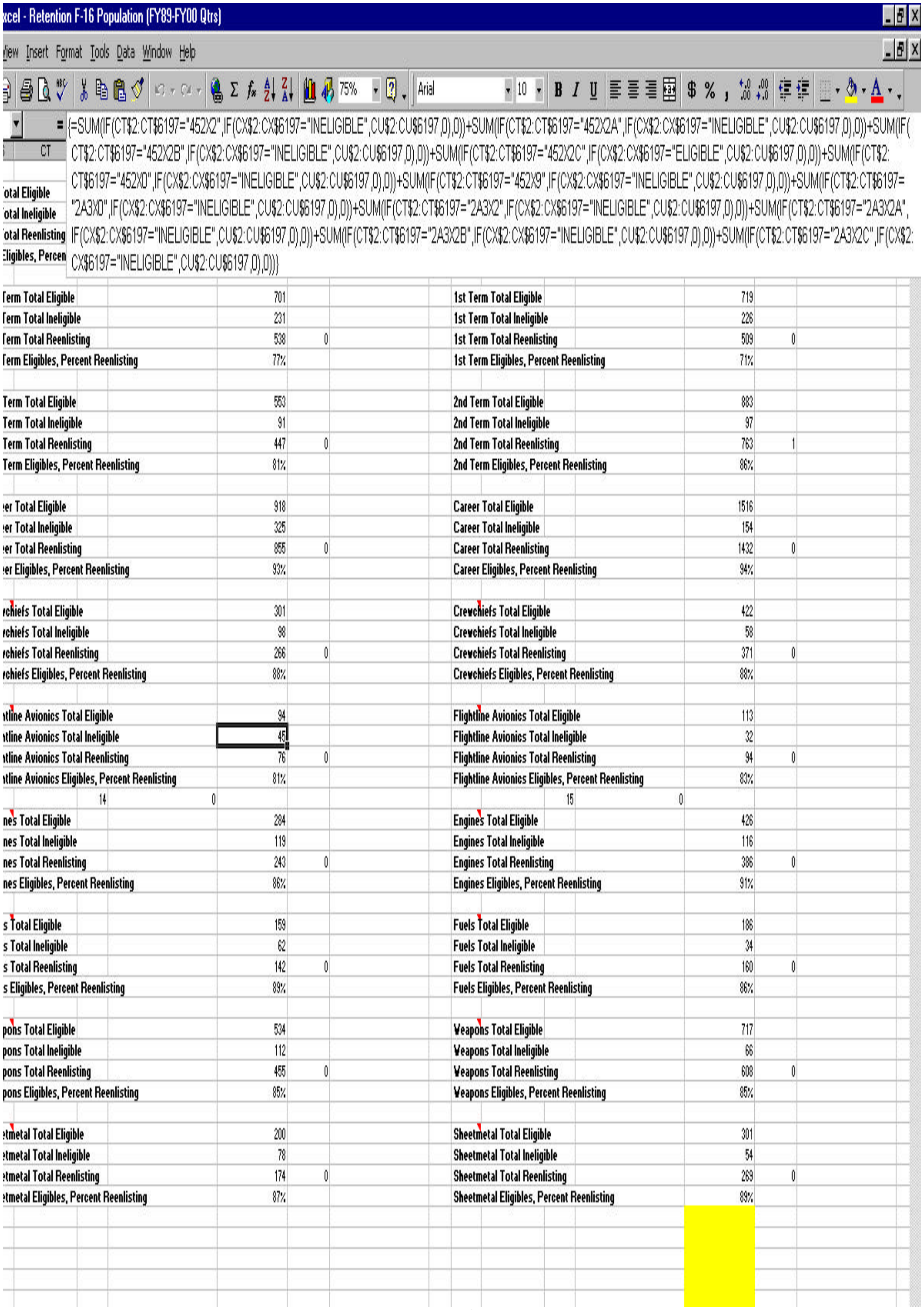
*A “. ” in the work unit code column represents Time Compliance Technical Orders accomplished for all work unit codes for the month for all F-16C/D aircraft.

Appendix D: Microsoft Excel® Algorithms



	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	92-4		93-1		93-2		93-3		93-4		94-1		94-2		94-3	
2	WUC	MTTR	WUC	MTTR	WUC	MTTR	WUC	MTTR	WUC	MTTR	WUC	MTTR	WUC	MTTR	WUC	MTTR
3	11000	3.441	11000	3.607	11000	3.065	11000	3.664	11000	4.234	42GAA	2.520	11000	3.545	11000	3.062
4	13DA0	2.114	42GAA	3.223	42GAA	2.857	42GAA	2.652	42GAA	2.453	11000	4.923	42GAA	2.680	42GAA	3.974
5	42GAA	2.385	13DA0	2.147	13DA0	1.913	13DA0	2.566	13DA0	3.280	13DA0	3.736	13KAB	6.192	13KAB	5.645
6	75CB0	3.895	74GB0	3.586	97EAK	1.362	13DAB	1.729	13DAB	2.501	13KAB	10.277	13DA0	2.253	13DA0	2.435
7	74GB0	3.793	13DAB	1.671	13KAB	3.941	13KAB	9.005	74GB0	3.363	74GB0	3.563	74GB0	2.754	75CN0	3.274
8	23Z00	5.573	75CB0	4.329	24BAD	0.253	75CB0	4.637	13KAB	8.670	44AAE	1.006	75CN0	3.526	13DAB	2.635
9	13DAB	2.085	47AAA	1.375	75CN0	2.520	75CN0	3.075	13EAH	4.729	75CN0	3.085	13DAB	2.488	74GB0	3.349
10	13EAH	4.972	46000	4.531	74GB0	3.188	74GB0	3.011	75CB0	5.602	13DAB	3.504	63BL0	2.580	74AQ0	4.770
11	46CN0	1.070	46CN0	1.043	13DAB	1.640	75BA0	3.862	74AQ0	5.057	63BL0	3.089	74DG0	2.137	74DG0	2.671
12	13DAA	5.446	63BL0	2.841	75CB0	4.402	12E00	1.599	75CN0	3.344	47AAA	1.256	23Z00	5.461	63BL0	3.531
13	13DB0	1.779	13EAH	5.084	63BL0	2.857	74AQ0	4.436	63BL0	3.052	75CB0	5.567	75CB0	6.180	75CB0	5.443
14	63BL0	3.277	13DB0	2.191	75BA0	3.597	13DAA	4.095	12E00	1.569	74AQ0	5.248	74AQ0	5.578	13KAA	4.887
15	74AQ0	5.017	12E00	1.838	74AQ0	5.304	63BL0	3.010	75BA0	5.453	46FD0	2.819	75BA0	5.143	47AAA	1.549
16	47AAA	1.115	75CN0	4.205	47AAA	1.171	13EAH	6.282	13DAA	3.494	13DAA	4.133	46000	4.249	46FD0	2.360
17	13KAB	1.535	44AAE	1.039	12E00	2.048	74DG0	2.138	13KAA	8.707	46CN0	0.765	74DF0	3.339	13DAA	5.031
18	44AAE	0.852	75BA0	7.175	44AAE	1.149	24BAD	0.301	74DF0	3.883	74DG0	2.406	14AP0	4.548	14AP0	2.699
19	11A99	1.472	13DAA	4.716	13DB0	1.944	47AAA	1.295	44AAE	1.035	75BA0	6.115	13DAA	4.688	27Z00	13.557
20	75BA0	5.635	75000	3.662	74DF0	3.106	74DF0	3.933	47AAA	1.288	14AP0	2.723	46FD0	2.727	75BA0	5.704
21	75000	1.948	75CK0	3.733	74DG0	2.580	13KAA	8.092	11A99	1.224	74DF0	3.361	44AAE	1.238	24BAD	0.394
22	12E00	2.463	24BAD	0.279	14AP0	3.146	46FD0	2.065	74DG0	2.377	13KAA	10.817	27Z00	11.138	74N00	7.457
7687	All	3.048	All	3.145	All	3.064	All	3.284	All	3.401	All	3.492	All	3.558	All	3.501
7688		2.438		2.516		2.451		2.628		2.721		2.793		2.846		2.801
7689	Top 25	#REF!	Top 25	#REF!	Top 25	#REF!	Top 25	#REF!	Top 25	#REF!	Top 25	#REF!	Top 25	#REF!	Top 25	#REF!
7690	Top 50	#REF!	Top 50	#REF!	Top 50	#REF!	Top 50	#REF!	Top 50	#REF!	Top 50	#REF!	Top 50	#REF!	Top 50	#REF!
7691	Top 10	#REF!	Top 10	#REF!	Top 10	#REF!	Top 10	#REF!	Top 10	#REF!	Top 100	#REF!	Top 10	#REF!	Top 10	#REF!
7692	Top 20	#REF!	Top 20	#REF!	Top 20	#REF!	Top 20	#REF!	Top 20	#REF!	Top 200	#REF!	Top 20	#REF!	Top 20	#REF!
7693	Averag	3.663	Averag	3.936	Averag	3.472	Averag	4.163	Averag	4.576	Average	4.725	Averag	4.228	Averag	4.548
7694	Averag	3.776	Averag	3.933	Averag	3.668	Averag	4.157	Averag	4.403	Average	4.605	Averag	4.288	Averag	4.471
7695	Averag	3.579	Averag	3.718	Averag	3.560	Averag	3.856	Averag	4.077	Average	4.236	Averag	4.101	Averag	4.108
7696	Averag	3.363	Averag	3.491	Averag	3.341	Averag	3.591	Averag	3.808	Average	3.868	Averag	3.862	Averag	3.859
7697	WUC	Rpr Hr	WUC	Rpr Hr	WUC	Rpr Hr	WUC	Rpr Hr	WUC	Rpr Hr	WUC	Rpr Hr	WUC	Rpr Hr	WUC	Rpr Hr
7698	11000	8749.800	11000	9328.600	11000	5690.900	11000	11070.200	11000	11444.100	42GAA	6370.500	11000	12112.400	11000	8576.700
7699	13DA0	4549.800	42GAA	5811.700	42GAA	5197.100	42GAA	6547.200	42GAA	6044.400	11000	10692.100	42GAA	6398.800	42GAA	10017.700
7700	42GAA	4966.100	13DA0	3754.400	13DA0	3043.500	13DA0	5144.800	13DA0	5533.100	13DA0	5629.400	13KAB	8457.800	13KAB	10295.800
7701	75CB0	4167.200	74GB0	3166.800	97EAK	1446.100	13DAB	2473.100	13DAB	3243.300	13KAB	13401.000	13DA0	3026.300	13DA0	3981.000
7702	74GB0	3917.700	13DAB	1453.600	13KAB	4134.300	13KAB	11976.600	74GB0	3984.800	74GB0	4164.600	74GB0	3178.600	75CN0	3922.000
7703	23Z00	4096.400	75CB0	3311.700	24BAD	254.100	75CB0	5291.300	13KAB	10204.900	44AAE	1065.400	75CN0	3766.200	13DAB	2566.700
7704	13DAB	1361.500	47AAA	1017.800	75CN0	2401.600	75CN0	3493.500	13EAH	5145.400	75CN0	3211.800	13DAB	2303.800	74GB0	3188.400
7705	13EAH	3246.600	46000	3167.300	74GB0	2891.500	74GB0	3414.500	75CB0	5641.100	13DAB	3559.800	63BL0	2332.400	74AQ0	4398.100

Figure 34. Grouping Monthly Work Unit Code Data into Quarters



Term Total Eligible	701		1st Term Total Eligible	719	
Term Total Ineligible	231		1st Term Total Ineligible	226	
Term Total Reenlisting	538	0	1st Term Total Reenlisting	509	0
Term Eligibles, Percent Reenlisting	77%		1st Term Eligibles, Percent Reenlisting	71%	
Term Total Eligible	553		2nd Term Total Eligible	883	
Term Total Ineligible	91		2nd Term Total Ineligible	97	
Term Total Reenlisting	447	0	2nd Term Total Reenlisting	763	1
Term Eligibles, Percent Reenlisting	81%		2nd Term Eligibles, Percent Reenlisting	86%	
er Total Eligible	918		Career Total Eligible	1516	
er Total Ineligible	325		Career Total Ineligible	154	
er Total Reenlisting	855	0	Career Total Reenlisting	1432	0
er Eligibles, Percent Reenlisting	93%		Career Eligibles, Percent Reenlisting	94%	
chiefs Total Eligible	301		Crewchiefs Total Eligible	422	
chiefs Total Ineligible	98		Crewchiefs Total Ineligible	58	
chiefs Total Reenlisting	266	0	Crewchiefs Total Reenlisting	371	0
chiefs Eligibles, Percent Reenlisting	88%		Crewchiefs Eligibles, Percent Reenlisting	88%	
tline Avionics Total Eligible	94		Flightline Avionics Total Eligible	113	
tline Avionics Total Ineligible	45		Flightline Avionics Total Ineligible	32	
tline Avionics Total Reenlisting	76	0	Flightline Avionics Total Reenlisting	94	0
tline Avionics Eligibles, Percent Reenlisting	81%		Flightline Avionics Eligibles, Percent Reenlisting	83%	
14 0			15 0		
nes Total Eligible	284		Engines Total Eligible	426	
nes Total Ineligible	119		Engines Total Ineligible	116	
nes Total Reenlisting	243	0	Engines Total Reenlisting	386	0
nes Eligibles, Percent Reenlisting	86%		Engines Eligibles, Percent Reenlisting	91%	
s Total Eligible	159		Fuels Total Eligible	186	
s Total Ineligible	62		Fuels Total Ineligible	34	
s Total Reenlisting	142	0	Fuels Total Reenlisting	160	0
s Eligibles, Percent Reenlisting	89%		Fuels Eligibles, Percent Reenlisting	86%	
pons Total Eligible	534		Weapons Total Eligible	717	
pons Total Ineligible	112		Weapons Total Ineligible	66	
pons Total Reenlisting	455	0	Weapons Total Reenlisting	608	0
pons Eligibles, Percent Reenlisting	85%		Weapons Eligibles, Percent Reenlisting	85%	
tmetal Total Eligible	200		Sheetmetal Total Eligible	301	
tmetal Total Ineligible	78		Sheetmetal Total Ineligible	54	
tmetal Total Reenlisting	174	0	Sheetmetal Total Reenlisting	269	0
tmetal Eligibles, Percent Reenlisting	87%		Sheetmetal Eligibles, Percent Reenlisting	89%	

Figure 35. Microsoft Excel® Matrix Algebra Function

Appendix E: Weighted Top 50 Work Unit Codes

Table 15. TNMCM Hours Weighted Top 50 Work Unit Codes

TNMCM Hours Weighted Top 50 WUCs		59.90%*
WUC	**Nomenclature**	**Hours**
0341A	PHASE 1	945,274.9
23000	TURBO FAN PWR PLANT	727,653.6
0341B	PHASE 2	848,921.1
27000	TURBOFAN POWR PLANT	561,826.9
46000	FUEL SYSTEM	563,411.6
11000	AIRFRAME	546,079.5
04112	ACCEPT INSPECTION	536,751.1
14000	FLIGHT CONTROL SYS	255,982.4
12000	CREW STATION SYSTEM	246,467.7
27Z00	TURBOFAN ENGINE LRU	286,538.7
13000	LANDING GEAR SYSTEM	230,387.4
23Z00	TURB FAN P/P ASMBLD (-220 & -229)	206,902.3
42000	ELECT POWER SYSTEM	148,226.5
74A00	FIRE CONT RADAR SET	131,591.6
75A00	GUN SYSTEM	134,673.9
14A00	PRIM FLT CONT ELECT	123,855.4
41000	ENVIR CONT SYSTEM	117,306.1
24D00	JET FUEL START SYS	114,942.5
46D00	FUEL TANKS INTERNAL	113,181.2
13E00	BRAKE SKID CONT SYS	120,328.0
46E00	FUEL INDICATING-CON	94,614.9
45000	HYD AND PNEU SYSTEM	89,377.3
74000	FIRE CONTROL SYSTEM	92,500.2
75000	WEAPONS DELIVERY	80,933.9
0412K	GUN INSP/LUBRICATN	76,177.6
46A00	ENGINE SUPPLY	88,603.1
04199	SPECIAL INSPECT NOC	115,775.0
24000	AUX POWER PLANT JFS	72,696.0
41A00	AIRCOND SUBSYSTEM	74,007.6
24A00	POWER SECTION EPU	70,140.8
12CA0	CANOPY ASSY	67,717.6
46F00	FUEL TANKS EXTERNAL	59,028.2
27100	ENG INST CTRLS AMS	71,373.8
14D00	LEADING EDGE FLAPS	58,865.0
13F00	NOSE WHL STEER SYS	55,489.8
42A00	AC GEN DRIVE ASSY	55,227.3
45A00	HYDRAULIC PWR SUPPL	50,841.8
74B00	HEAD UP DISPLAY SET	45,915.4
12C00	CANOPY SUB SYSTEM	48,788.0
12CAC	TRANSPARENCY, FWD (F-16C, BLK 30)	78,370.0

TNMCM Hours Weighted Top 50 WUCs		59.90%*
WUC	**Nomenclature**	**Hours**
13L00	BRAKE/SKID CONTROL	48,336.0
51F00	AIR DATA SYSTEM	40,661.7
12E00	EJECT SEAT ACES II F/A	46,822.0
24EA0	GEARBOX ACCESS DR	46,867.2
13A00	LANDING GR CONT SYS	35,299.3
51000	FLIGHT INSTRUMENTS	32,530.8
75D00	STORES MGT SYSTEM	34,332.4
14CB0	HORIZ STABILIZER	43,041.1
42AJ0	GEN 10 KVA/FLCS PMG	53,110.4
46AF0	PROPORTION FUEL FLO	48,539.6
*8,836,286 hrs out of 14,751,921 total hrs (36 Quarters)		

Table 16. TNMCS Hours Weighted Top 50 Work Unit Codes

TNMCS Weighted Top 50 WUCs		42.28%*
WUC	**Nomenclature**	**Hours**
0341A	PHASE 1	553,346.9
0341B	PHASE 2	464,039.4
23000	TURBO FAN PWR PLANT	290,825.4
46000	FUEL SYSTEM	194,250.8
11000	AIRFRAME	193,950.2
14000	FLIGHT CONTROL SYS	111,273.3
12000	CREW STATION SYSTEM	124,509.7
27000	TURBOFAN POWR PLANT	123,812.4
13000	LANDING GEAR SYSTEM	94,909.6
42000	ELECT POWER SYSTEM	81,870.0
46AF0	PROPORTION FUEL FLO	118,264.9
41000	ENVIR CONT SYSTEM	64,310.0
74000	FIRE CONTROL SYSTEM	57,692.2
12CA0	CANOPY ASSY	70,446.6
14CB0	HORIZ STABILIZER	61,588.3
42AA0	CONSTANT SPEED DRIV	106,897.2
42AJ0	GEN 10 KVA/FLCS PMG	98,148.2
04112	ACCEPT INSPECTION	78,040.8
14D00	LEADING EDGE FLAPS	52,283.0
74A00	FIRE CONT RADAR SET	47,624.7
24000	AUX POWER PLANT JFS	37,372.5
45000	HYD AND PNEU SYSTEM	46,876.9
75A00	GUN SYSTEM	34,976.9
46A00	ENGINE SUPPLY	42,499.1
42A00	AC GEN DRIVE ASSY	43,562.7
24EA0	GEARBOX ACCESS DR	49,104.6
14DA0	POWER DRIVE UN ASSY	65,087.0

TNMCS Weighted Top 50 WUCs		42.28%*
WUC	Nomenclature	Hours
14A00	PRIM FLT CONT ELECT	32,686.6
27Z00	TURBOFAN ENGINE LRU	43,892.2
45A99	NOC, HYD AND PNEU SYSTEM	50,962.8
24D00	JET FUEL START SYS	36,432.5
23Z00	TURB FAN P/P ASMBLD (-220 & -229)	112,239.2
45A00	HYDRAULIC PWR SUPPL	32,757.9
74B00	HEAD UP DISPLAY SET	31,144.0
12CAC	TRANSPARENCY, FWD (F-16C, BLK 30)	142,855.8
45AAA	NOC, HYDRAULIC PWR SUPPL	52,198.5
46A99	NOC, ENGINE SUPPLY	41,227.0
46E00	FUEL INDICATING-CON	28,903.2
74AQ0	PROG SIGNL PROCSSR	36,536.9
0412K	GUN INSP/LUBRICATN	21,049.6
46D00	FUEL TANKS INTERNAL	28,274.2
12E00	EJECT SEAT ACES II F/A	21,896.1
75000	WEAPONS DELIVERY	22,862.7
12C00	CANOPY SUB SYSTEM	30,424.8
13E00	BRAKE SKID CONT SYS	21,931.3
24A00	POWER SECTION EPU	19,317.3
14BC0	INTER SERVO ACT, FLAPERON	43,740.1
41AAB	VLV BLD AIR REG/SO7	33,756.1
47AD0	REGULTOR OXY BRTHNG	68,971.2
04199	SPECIAL INSPECT NOC	24,390.1
*4,286,013 hrs out of 10,137,416 total hrs (36 Quarters)		

Table 17. Manhours Weighted Top 50 Work Unit Codes

Manhours Weighted Top 50 WUCs		42.04%*
WUC	Nomenclature	Hours
TCTO	ALL TCTOs (all WUCs)	3,790,062.3
27Z00	TURBOFAN ENGINE LRU	744,388.8
23Z00	TURB FAN P/P ASMBLD (-220 & -229)	623,927.1
42GAA	BATTERY AIRCRAFT	453,830.8
11000	AIRFRAME	424,505.8
74AQ0	PROG SIGNL PROCSSR	306,269.1
0412L	PYL RKS&WP DISP INS	958,661.4
75CB0	LAUNCHER WING TIP	239,669.4
13DA0	MLG WHEEL&TIRE ASSY	227,234.8
75CN0	LNCR MSL WT LAU-129A	236,431.4
75BA0	PYLON WING WEAPONS	213,547.3
12E00	EJECT SEAT ACES II F/A	225,711.4
74N00	TARGETING POD	413,179.9

Manhours Weighted Top 50 WUCs		42.04%*
WUC	**Nomenclature**	**Hours**
46000	FUEL SYSTEM	194,685.5
74AP0	XMITTER DUAL MODE	193,321.0
74AN0	MODULAR LPRF	178,382.2
27000	TURBOFAN POWR PLANT	185,749.1
0341B	PHASE 2	620,931.5
0341A	PHASE 1	634,770.3
13KAB	TIRE ASSY MLG	232,575.4
14AP0	CMPTR DIG FLGT CNTR	163,021.7
74BQ0	DISPLAY UNIT	146,230.6
13EAH	BRAKE ASSY PN 2-1543 (BLOCK 30)	136,573.0
12CA0	CANOPY ASSY	156,462.2
74AM0	RADAR ANTENNA	138,339.4
75CK0	RACK EJECT TER-9/A	127,678.1
74A00	FIRE CONT RADAR SET	122,106.5
74KA0	MULTIFNCTN DISPLAY	129,976.1
74CC0	FIRE CNTL CMPTR ENH	125,735.7
04199	SPECIAL INSPECT NOC	738,396.9
42GC0	BATTERY A/C IN PRF	216,297.1
75000	WEAPONS DELIVERY	113,060.1
23000	TURBO FAN PWR PLANT	125,233.9
47AAA	CONVERTER LOX 5 LIT	122,201.9
13DAA	WHEEL ASSY MLG (BLOCK 30)	111,500.7
0412K	GUN INSP/LUBRICATN	392,605.0
74KB0	PRGMMBL DSPLY GNRTR	111,839.3
13KAA	WHEEL ASSY MLG (BLOCK 40 & 50)	119,528.3
75DJ0	ADVNCD CENTRL INTFC	101,355.6
74P00	NAVIGATIONAL SET	100,128.5
01000	GROUND HANDLING SRV	230,010.2
46FD0	TK 370 GAL EXT PYLN	96,609.8
74DG0	BATTERY INU	116,166.2
75DQ0	INTFC UNIT ENH CTRL	98,006.4
75BB0	PYLON CENTERLINE	92,350.6
46FA0	TANK 370 GALLON EXT	99,834.2
14A00	PRIM FLT CONT ELECT	83,987.9
74DF0	INERTIAL NAVIGTN UN	123,779.2
75A00	GUN SYSTEM	97,026.3
27EA0	AUGMENTOR ASSY	221,463.2
*15,855,339 hrs out of 37,717,532 hrs (36 Quarters)		

Table 18. Repair Hours Weighted Top 50 Work Unit Codes

Repair Hours Weighted Top 50 WUCs		39.26%*
WUC	**Nomenclature**	**Hours**
11000	AIRFRAME	360,226.1
42GAA	BATTERY AIRCRAFT	311,349.5
27Z00	TURBOFAN ENGINE LRU	391,712.9
23Z00	TURB FAN P/P ASMBLD (-220 & -229)	305,696.5
13DA0	MLG WHEEL&TIRE ASSY	213,503.2
74AQ0	PROG SIGNL PROCSSR	198,495.3
75CB0	LAUNCHER WING TIP	175,992.8
75CN0	LNCR MSL WT LAU-129A	164,396.2
75BA0	PYLON WING WEAPONS	146,564.4
13KAB	TIRE ASSY MLG	192,609.3
74N00	TARGETING POD	358,335.4
46000	FUEL SYSTEM	114,678.8
13EAH	BRAKE ASSY (BLOCK 30)	109,963.6
74AN0	MODULAR LPRF	102,966.6
74AP0	XMITTER DUAL MODE	118,888.4
75CK0	RACK EJECT TER-9/A	94,244.5
13KAA	WHEEL ASSY MLG (BLOCK 40 & 50)	104,794.5
13DAA	WHEEL ASSY MLG (BLOCK 30)	96,433.6
27000	TURBOFAN POWR PLANT	86,923.1
74BQ0	DISPLAY UNIT	85,897.4
14AP0	CMPTR DIG FLGT CNTR	87,690.0
74AM0	RADAR ANTENNA	83,645.8
74KA0	MULTIFNCTN DISPLAY	84,757.5
13DAB	TIRE MAIN LDG GEAR	68,324.8
13DB0	NLG WHEEL&TIRE ASSY	65,067.1
74CC0	FIRE CNTL CMPTR ENH	75,947.0
74P00	NAVIGATIONAL SET	66,310.3
75BB0	PYLON CENTERLINE	69,157.2
12E00	EJECT SEAT ACES II F/A	66,988.4
46FA0	TANK 370 GALLON EXT	69,231.5
46FD0	TK 370 GAL EXT PYLN	61,969.5
42GC0	BATTERY A/C IN PRF	109,003.4
46DA0	TANK WING	61,452.8
74KB0	PRGMMBL DSPLY GNRTR	69,028.9
75DJ0	ADVNCD CENTRL INTFC	55,818.7
75000	WEAPONS DELIVERY	52,032.7
47AAA	CONVERTER LOX 5 LIT	52,466.9
75DQ0	INTFC UNIT ENH CTRL	52,061.6
12CA0	CANOPY ASSY	52,412.0
23000	TURBO FAN PWR PLANT	54,766.9
74DF0	INERTIAL NAVIGTN UN	81,043.5
46FE0	TANK FUEL 300 GAL	45,948.3
12CAC	TRANSPARENCY, FWD (F-16C, BLK 30)	47,334.7

Repair Hours Weighted Top 50 WUCs		39.26%*
WUC	**Nomenclature**	**Hours**
74DG0	BATTERY INU	61,157.6
74GB0	RECORDER A-B VD TP	81,939.5
62CD0	RCVR/XMTR VHF RM MT	41,472.4
75A00	GUN SYSTEM	46,004.3
74BT0	PDU DEFRACTIVE HUD	41,837.2
46D00	FUEL TANKS INTERNAL	49,840.6
74BR0	ELCTRN CNTL WAC HUD (BLOCK 30)	42,062.8
*5,630,446 hrs out of 14,339,883 total hrs (36 Quarters)		

Table 19. Repair Actions Weighted Top 50 Work Unit Codes

Repair Actions Weighted Top 50 WUCs		32.68%*
WUC	**Nomenclature**	**Count**
11000	AIRFRAME	90,674
13DA0	MLG WHEEL&TIRE ASSY	77,334
42GAA	BATTERY AIRCRAFT	76,626
75CN0	LNCR MSL WT LAU-129A	45,386
13KAB	TIRE ASSY MLG	43,746
75CB0	LAUNCHER WING TIP	38,619
74AQ0	PROG SIGNL PROCSSR	33,762
47AAA	CONVERTER LOX 5 LIT	34,522
75BA0	PYLON WING WEAPONS	32,772
12E00	EJECT SEAT ACES II F/A	27,105
13DAB	TIRE MAIN LDG GEAR	28,122
23Z00	TURB FAN P/P ASMBLD (-220 & -229)	31,266
13DB0	NLG WHEEL&TIRE ASSY	23,922
42GC0	BATTERY A/C IN PRF	34,577
14AP0	CMPTR DIG FLGT CNTR	22,977
13DAA	WHEEL ASSY MLG (BLOCK 30)	22,751
13EAH	BRAKE ASSY (BLOCK 30)	21,223
46000	FUEL SYSTEM	20,166
13KAA	WHEEL ASSY MLG (BLOCK 40 & 50)	24,926
27Z00	TURBOFAN ENGINE LRU	26,587
74AN0	MODULAR LPRF	19,454
75CK0	RACK EJECT TER-9/A	18,386
46FD0	TK 370 GAL EXT PYLN	18,271
74DG0	BATTERY INU	20,919
74AP0	XMITTER DUAL MODE	18,283
75000	WEAPONS DELIVERY	17,929
12CA0	CANOPY ASSY	17,601
24EBA	SHAFT POWER TAKEOFF	15,142
74DF0	INERTIAL NAVIGTN UN	17,475

Repair Actions Weighted Top 50 WUCs		32.68%*
WUC	**Nomenclature**	**Count**
74BQ0	DISPLAY UNIT	15,386
74N00	TARGETING POD	23,279
11A99	NOC, NOSE SECTION	16,797
27000	TURBOFAN POWR PLANT	13,999
74KB0	PRGMMBL DSPLY GNRTR	13,852
75BB0	PYLON CENTERLINE	13,863
74AM0	RADAR ANTENNA	12,830
74CC0	FIRE CNTL CMPTR ENH	13,035
74GB0	RECORDER A-B VD TP	27,424
13000	LANDING GEAR SYSTEM	12,217
62CD0	RCVR/XMTR VHF RM MT	11,244
51BA0	IND HORIZ SITUATION	11,363
11GDA	COV ENG ACC LH 4301	11,637
46FE0	TANK FUEL 300 GAL	11,258
44AAE	LGHT WNGTIP NAV/FRM	15,473
74CE0	GEN AVIONICS COMPTR	11,958
74P00	NAVIGATIONAL SET	11,344
75DJ0	ADVNCD CENTRL INTFC	11,361
46FA0	TANK 370 GALLON EXT	12,246
11GDE	COV AFT ENG 4305	10,723
44AAH	LIGHT INLET NAV/FRM	10,941
*1,212,753 hrs out of 3,711,004 total hrs (36 Quarters)		

Table 20. Cann Hours Weighted Top 50 Work Unit Codes

Cann Hours Weighted Top 50 WUCs		38.87%*
WUC	**Nomenclature**	**Hours**
42AA0	CONSTANT SPEED DRIV	11,829.7
74AQ0	PROG SIGNL PROCSSR	13,479.5
46AFA	MOTOR HYDRAULIC FFP	14,888.2
42AJ0	GEN 10 KVA/FLCS PMG	12,908.5
74BQ0	DISPLAY UNIT	11,789.0
74AM0	RADAR ANTENNA	11,773.2
51BA0	IND HORIZ SITUATION	8,613.8
47AD0	REGULTOR OXY BRTHNG	9,856.4
74KA0	MULTIFNCTN DISPLAY	7,888.7
46CA0	VLV VNT/PRESS EX TK	11,931.8
41AAA	VLV B/A REG SHTF 13	7,202.1
74BU0	ELCTRN UN DIFF HUD	7,258.8
46AF0	PROPORTION FUEL FLO	9,850.4

Cann Hours Weighted Top 50 WUCs		38.87%*
WUC	**Nomenclature**	**Hours**
46EC0	TRANSMITTER FUEL FL	8,749.0
74CC0	FIRE CNTL CMPTR ENH	8,274.1
74AP0	XMITTER DUAL MODE	10,995.5
45A99	NOC, HYD AND PNEU SYSTEM	4,864.6
46A99	NOC, ENGINE SUPPLY	6,480.0
46CB0	VLV VNT/PRESS FL TK	7,740.8
46AN0	VALVE SHTF MOT OPER	5,442.0
14DAC	ACT ELECT/MECH LEF	5,342.5
41AAB	VLV BLD AIR REG/SO7	5,599.1
14AP0	CMPTR DIG FLGT CNTR	7,459.1
74BT0	PDU DEFRACTIVE HUD	6,918.0
46AB0	PUMP WING SCAVANGE	5,508.6
74JA0	DATA ENTRY DISPLAY	4,285.2
42AE0	GENERATOR 60 KVA	9,068.7
74AN0	MODULAR LPRF	12,349.2
74LA0	RCVR/XMTR RDR ALT	4,136.3
51FA0	COMPUTER CADC	4,685.9
46ED0	INDICATOR FUEL FLOW	4,094.6
74BR0	ELCTRN CNTL WAC HUD (BLOCK 30)	5,605.3
46BU0	VLV SO REF TRANSFER	6,203.6
46AQ0	DISC FILTER&ENG CPL	5,301.9
14FB0	ELECT COMPONENT ASY	3,758.1
41A99	NOC, AIRCOND SUBSYSTEM	3,839.3
74KB0	PRGMMBL DSPLY GNRTR	6,583.0
51AB0	ALTIMETER SERVOED	3,146.4
41AAS	EDCS SENSOR/CNTRLLR	5,624.5
46A00	ENGINE SUPPLY	3,953.6
42A99	NOC, AC GEN DRIVE ASSY	3,803.7
74DF0	INERTIAL NAVIGTN UN	5,052.5
41ABN	TURBINE AIR BEARING	3,730.5
42BD0	GEN CNTRL UN 10 KVA	3,119.8
44CB0	LIGHT CAUTION PANEL	2,577.0
24DC0	CONT JET FUEL START	2,560.2
75DQ0	INTFC UNIT ENH CTRL	5,191.8
14AA0	COMPUTER FLGHT CONT	2,819.9
74DK0	INU,RG LAS GY(H-423	2,613.9
13LAG	SENSOR WHEEL SPEED (BLOCK 40 & 50)	4,303.1
*341,051 hrs out of 877,433 total hrs (36 Quarters)		

Table 21. Cann Actions Weighted Top 50 Work Unit Codes

Cann Actions Weighted Top 50 WUCs		37.16%*
WUC	**Nomenclature**	**Count**
74AQ0	PROG SIGNL PROCSSR	2,691
51BA0	IND HORIZ SITUATION	1,892
74BQ0	DISPLAY UNIT	2,132
74KA0	MULTIFNCTN DISPLAY	1,532
74BU0	ELCTRN UN DIFF HUD	1,624
74AM0	RADAR ANTENNA	1,774
42AA0	CONSTANT SPEED DRIV	1,354
42AJ0	GEN 10 KVA/FLCS PMG	1,930
47AD0	REGULTOR OXY BRTHNG	1,827
74BT0	PDU DEFRACTIVE HUD	1,493
41AAA	VLV B/A REG SHTF 13	1,075
14AP0	CMPTR DIG FLGT CNTR	1,695
74AP0	XMITTER DUAL MODE	1,973
74CC0	FIRE CNTL CMPTR ENH	1,534
74LA0	RCVR/XMTR RDR ALT	882
45A99	NOC, HYD AND PNEU SYSTEM	777
74JA0	DATA ENTRY DISPLAY	747
46ED0	INDICATOR FUEL FLOW	733
14FB0	ELECT COMPONENT ASY	715
74BR0	ELCTRN CNTL WAC HUD (BLOCK 30)	1,146
74AN0	MODULAR LPRF	2,340
74KB0	PRGMMBL DSPLY GNRTR	1,297
46AFA	MOTOR HYDRAULIC FFP	798
41A99	NOC, AIRCOND SUBSYSTEM	628
51FA0	COMPUTER CADC	835
41AAB	VLV BLD AIR REG/SO7	746
14DAC	ACT ELECT/MECH LEF	549
51AB0	ALTIMETER SERVOED	566
46A99	NOC, ENGINE SUPPLY	517
24DC0	CONT JET FUEL START	575
42AE0	GENERATOR 60 KVA	1,057
42A99	NOC, AC GEN DRIVE ASSY	527
44CB0	LIGHT CAUTION PANEL	535
41AAS	EDCS SENSOR/CNTRLLR	821
42BD0	GEN CNTRL UN 10 KVA	553
231AB	INDICATOR FAN FTIT	458
46CA0	VLV VNT/PRESS EX TK	588
46AB0	PUMP WING SCAVANGE	383
46EC0	TRANSMITTER FUEL FL	512
74DK0	INU,RG LAS GY(H-423	504
46AN0	VALVE SHTF MOT OPER	348
76EG0	SIGNAL PROCESSER	519
13LAG	SENSOR WHEEL SPEED (BLOCK 40 & 50)	767
13EAG	SENSOR WHEEL SPEED (BLOCK 30)	1,151

Cann Actions Weighted Top 50 WUCs		37.16%*
WUC	**Nomenclature**	**Count**
14AA0	COMPUTER FLGHT CONT	509
46CB0	VLV VNT/PRESS FL TK	409
24D00	JET FUEL START SYS	286
71BA0	RECEIVER ILS	384
13EAF	CONT BOX ANTI SKID	298
24D99	NOC, JET FUEL START SYS	475
*49,461 actions out of 133,096 total actions (36 Quarters)		

Table 22. Maintenance Downtime Weighted Top 50 Work Unit Codes

Maintenance Downtime Weighted Top 50 WUCs		66.24%*
WUC	**Nomenclature**	**Hours**
23000	TURBO FAN PWR PLANT	510,302.8
46000	FUEL SYSTEM	414,442.6
27000	TURBOFAN POWR PLANT	428,022.9
0341A	PHASE 1	317,417.8
0341B	PHASE 2	323,985.8
11000	AIRFRAME	346,616.6
14000	FLIGHT CONTROL SYS	186,655.8
75000	WEAPONS DELIVERY	175,314.6
12000	CREW STATION SYSTEM	171,586.8
75A00	GUN SYSTEM	175,554.5
74A00	FIRE CONT RADAR SET	140,821.7
27Z00	TURBOFAN ENGINE LRU	199,723.2
13000	LANDING GEAR SYSTEM	150,286.4
23Z00	TURB FAN P/P ASMBLD (-220 & -229)	145,846.9
74000	FIRE CONTROL SYSTEM	102,706.0
13E00	BRAKE SKID CONT SYS	106,925.4
42000	ELECT POWER SYSTEM	92,902.1
41000	ENVIR CONT SYSTEM	88,266.8
14A00	PRIM FLT CONT ELECT	92,214.6
46E00	FUEL INDICATING-CON	75,583.4
46D00	FUEL TANKS INTERNAL	86,173.8
24D00	JET FUEL START SYS	76,198.9
45000	HYD AND PNEU SYSTEM	60,785.4
04199	SPECIAL INSPECT NOC	91,745.8
76E00	RAD THREAT WARN SET	76,958.4
04112	ACCEPT INSPECTION	385,169.6
0412K	GUN INSP/LUBRICATN	49,419.9
46F00	FUEL TANKS EXTERNAL	50,604.6
41A00	AIRCOND SUBSYSTEM	55,227.1
46A00	ENGINE SUPPLY	65,851.7

Maintenance Downtime Weighted Top 50 WUCs		66.24%*
WUC	**Nomenclature**	**Hours**
24A00	POWER SECTION EPU	51,548.8
24000	AUX POWER PLANT JFS	47,756.6
12CA0	CANOPY ASSY	49,697.3
13F00	NOSE WHL STEER SYS	46,643.4
74B00	HEAD UP DISPLAY SET	45,163.5
75D00	STORES MGT SYSTEM	42,803.4
51000	FLIGHT INSTRUMENTS	32,647.8
75C00	WEAPON RACK SYSTEM	39,593.1
51F00	AIR DATA SYSTEM	32,983.3
12C00	CANOPY SUB SYSTEM	42,624.1
14D00	LEADING EDGE FLAPS	34,967.4
74D00	INERTIAL NAVIG SET	25,848.8
63000	UHF COMMUNICATIONS	25,673.0
12CAC	TRANSPARENCY, FWD (F-16C, BLK 30)	71,845.1
45A00	HYDRAULIC PWR SUPPL	30,176.1
27100	ENG INST CTRLS AMS	57,824.4
42A00	AC GEN DRIVE ASSY	33,386.7
0341D	PHASE 4	177,832.4
12E00	EJECT SEAT ACES II F/A	28,183.4
74C00	FIRE CONT COMP SET1	23,966.1
*6,184,476.6 hrs out of 9,336,776 total hrs (36 Quarters)		

Table 23. Maintenance Reliability Weighted Top 50 Work Unit Codes

Maintenance Reliability Weighted Top 50 WUCs		56.85%*
WUC	**Nomenclature**	**Hours**
74A00	FIRE CONT RADAR SET	15,376
46000	FUEL SYSTEM	15,576
27000	TURBOFAN POWR PLANT	13,018
23000	TURBO FAN PWR PLANT	12,611
14000	FLIGHT CONTROL SYS	11,851
11000	AIRFRAME	9,364
13000	LANDING GEAR SYSTEM	9,385
12000	CREW STATION SYSTEM	8,829
75000	WEAPONS DELIVERY	7,034
42000	ELECT POWER SYSTEM	6,721
46E00	FUEL INDICATING-CON	5,929
74B00	HEAD UP DISPLAY SET	5,193
14A00	PRIM FLT CONT ELECT	5,149
13E00	BRAKE SKID CONT SYS	5,106
27Z00	TURBOFAN ENGINE LRU	5,705
0341A	PHASE 1	5,648

Maintenance Reliability Weighted Top 50 WUCs		56.85%*
WUC	**Nomenclature**	**Hours**
24D00	JET FUEL START SYS	4,889
75A00	GUN SYSTEM	4,634
41000	ENVIR CONT SYSTEM	4,748
74D00	INERTIAL NAVIG SET	4,671
45000	HYD AND PNEU SYSTEM	4,559
0341B	PHASE 2	5,158
75C00	WEAPON RACK SYSTEM	4,379
46F00	FUEL TANKS EXTERNAL	4,073
74000	FIRE CONTROL SYSTEM	4,270
13F00	NOSE WHL STEER SYS	3,906
63000	UHF COMMUNICATIONS	3,297
23Z00	TURB FAN P/P ASMBLD (-220 & -229)	3,895
46D00	FUEL TANKS INTERNAL	3,174
74C00	FIRE CONT COMP SET1	3,200
04112	ACCEPT INSPECTION	4,601
24A00	POWER SECTION EPU	3,045
41A00	AIRCOND SUBSYSTEM	3,281
75D00	STORES MGT SYSTEM	2,792
51000	FLIGHT INSTRUMENTS	2,616
63B00	COMM SET UHF	2,569
13L00	BRAKE/SKID CONTROL	2,857
46A00	ENGINE SUPPLY	2,657
51F00	AIR DATA SYSTEM	2,460
76E00	RAD THREAT WARN SET	2,582
74K00	MULTIFCTN DSPLY SET	2,328
42A00	AC GEN DRIVE ASSY	2,232
24000	AUX POWER PLANT JFS	2,049
27100	ENG INST CTRLS AMS	2,098
76C00	ECM POD SET	2,411
45A00	HYDRAULIC PWR SUPPL	2,106
75B00	EXTERNAL STORES	2,132
74J00	DATA ENTRY CP INTFC	1,794
13A00	LANDING GR CONT SYS	1,683
23100	ENG INST CT&MT SYS	1,684
*251,325 hrs out of 442,049 total hrs (36 Quarters)		

Table 24. Supply Downtime Weighted Top 50 Work Unit Codes

Supply Downtime Weighted Top 50 WUCs		33.41%*
WUC	**Nomenclature**	**Hours**
46000	FUEL SYSTEM	123,098.7
12000	CREW STATION SYSTEM	142,756.6
11000	AIRFRAME	100,942.9
74000	FIRE CONTROL SYSTEM	74,340.0
14000	FLIGHT CONTROL SYS	74,402.9
23000	TURBO FAN PWR PLANT	97,758.9
46AF0	PROPORTION FUEL FLO	78,865.8
42000	ELECT POWER SYSTEM	55,791.4
74A00	FIRE CONT RADAR SET	55,781.5
74B00	HEAD UP DISPLAY SET	51,668.9
41000	ENVIR CONT SYSTEM	54,142.0
27000	TURBOFAN POWR PLANT	47,930.7
76E00	RAD THREAT WARN SET	37,529.9
12CA0	CANOPY ASSY	87,580.7
13000	LANDING GEAR SYSTEM	39,134.1
45000	HYD AND PNEU SYSTEM	34,262.9
75000	WEAPONS DELIVERY	30,167.7
14DA0	POWER DRIVE UN ASSY	54,078.6
12C00	CANOPY SUB SYSTEM	59,295.3
74BQ0	DISPLAY UNIT	41,047.6
14CB0	HORIZ STABILIZER	39,920.9
42A00	AC GEN DRIVE ASSY	31,883.0
76000	PENETR AIDS AND ECM	26,876.4
14D00	LEADING EDGE FLAPS	36,827.2
75A00	GUN SYSTEM	28,029.5
24000	AUX POWER PLANT JFS	21,903.6
74AQ0	PROG SIGNL PROCSSR	30,096.0
74JA0	DATA ENTRY DISPLAY	34,606.2
45A99	NOC, HYD AND PNEU SYSTEM	28,384.1
14A00	PRIM FLT CONT ELECT	22,857.8
45AAA	NOC, HYDRAULIC PWR SUPPL	33,482.1
74KA0	MULTIFNCTN DISPLAY	27,595.3
24D00	JET FUEL START SYS	18,902.3
51BA0	IND HORIZ SITUATION	25,223.8
42AA0	CONSTANT SPEED DRIV	28,008.9
12CAG	TRANSPARENCY AFT (D-MODEL)	49,329.9
42AJ0	GEN 10 KVA/FLCS PMG	61,963.7
47AD0	REGULTOR OXY BRTHNG	48,248.3
41ABN	TURBINE AIR BEARING	20,163.0
24EA0	GEARBOX ACCESS DR	34,366.6
41A00	AIRCOND SUBSYSTEM	28,217.4
46A00	ENGINE SUPPLY	29,341.8
12CCB	ACTUATOR ASSEMBLY (D-MODEL)	31,497.5

Supply Downtime Weighted Top 50 WUCs		33.41%*
WUC	**Nomenclature**	**Hours**
14DL0	LEADING EDGE FLP LH	27,365.2
46CA0	VLV VNT/PRESS EX TK	33,781.2
74LA0	RCVR/XMTR RDR ALT	31,859.9
75D00	STORES MGT SYSTEM	10,517.8
45A00	HYDRAULIC PWR SUPPL	22,626.2
13E00	BRAKE SKID CONT SYS	14,677.3
*2,219,130 hrs out of 6,641,822.5 total hrs (36 Quarters)		

Table 25. Supply Reliability Weighted Top 50 Work Unit Codes

Supply Reliability Weighted Top 50 WUCs		46.78%*
WUC	**Nomenclature**	**Count**
46000	FUEL SYSTEM	11,980
12000	CREW STATION SYSTEM	6,358
23000	TURBO FAN PWR PLANT	8,975
11000	AIRFRAME	6,828
14000	FLIGHT CONTROL SYS	8,111
74A00	FIRE CONT RADAR SET	10,807
27000	TURBOFAN POWR PLANT	8,718
13000	LANDING GEAR SYSTEM	7,049
42000	ELECT POWER SYSTEM	5,048
74000	FIRE CONTROL SYSTEM	2,905
41000	ENVIR CONT SYSTEM	3,304
74B00	HEAD UP DISPLAY SET	3,683
75000	WEAPONS DELIVERY	4,499
14A00	PRIM FLT CONT ELECT	3,787
45000	HYD AND PNEU SYSTEM	3,450
24000	AUX POWER PLANT JFS	1,517
24D00	JET FUEL START SYS	3,732
13E00	BRAKE SKID CONT SYS	3,252
75A00	GUN SYSTEM	3,385
12CA0	CANOPY ASSY	1,244
76E00	RAD THREAT WARN SET	1,549
42AJ0	GEN 10 KVA/FLCS PMG	1,235
42A00	AC GEN DRIVE ASSY	1,744
46AF0	PROPORTION FUEL FLO	819
14D00	LEADING EDGE FLAPS	935
63000	UHF COMMUNICATIONS	2,171
12C00	CANOPY SUB SYSTEM	1,209
46D00	FUEL TANKS INTERNAL	2,242
51000	FLIGHT INSTRUMENTS	1,747
12CAC	TRANSPARENCY, FWD (F-16C, BLK 30)	1,450

Supply Reliability Weighted Top 50 WUCs		46.78%*
WUC	**Nomenclature**	**Count**
42AA0	CONSTANT SPEED DRIV	836
74AQ0	PROG SIGNL PROCSSR	829
14AP0	CMPTR DIG FLGT CNTR	1,303
75D00	STORES MGT SYSTEM	2,075
0341B	PHASE 2	4,164
76000	PENETR AIDS AND ECM	599
51BA0	IND HORIZ SITUATION	564
0341A	PHASE 1	4,564
14CB0	HORIZ STABILIZER	558
24A00	POWER SECTION EPU	2,146
74L00	RADAR ALTIMETER	592
12CCA	ACTUATOR ASSY, CANOPY (F-16C, BLK 30)	546
47AD0	REGULTOR OXY BRTHNG	733
74BQ0	DISPLAY UNIT	582
63BL0	R/T RT-1505/ARC-164 (CONTD)	604
13F00	NOSE WHL STEER SYS	2,707
74DF0	INERTIAL NAVIGTN UN	655
41A00	AIRCOND SUBSYSTEM	2,469
41AAA	VLV B/A REG SHTF 13	422
46A00	ENGINE SUPPLY	2,074
*152,755 incidents out of 326,531 total incidents (36 Quarters)		

Table 26. MTTR of Weighted Top 50 Repair Action Work Unit Codes

MTTR (Repair Actions) Weighted Top 50 WUCs		4.44 hrs*
WUC	**Nomenclature**	**Average**
11000	AIRFRAME	3.97
13DA0	MLG WHEEL&TIRE ASSY	2.76
42GAA	BATTERY AIRCRAFT	4.06
75CN0	LNCR MSL WT LAU-129A	3.62
13KAB	TIRE ASSY MLG	4.40
75CB0	LAUNCHER WING TIP	4.56
74AQ0	PROG SIGNL PROCSSR	5.88
47AAA	CONVERTER LOX 5 LIT	1.52
75BA0	PYLON WING WEAPONS	4.47
12E00	EJECT SEAT ACES II F/A	2.47
13DAB	TIRE MAIN LDG GEAR	2.43
23Z00	TURB FAN P/P ASMBLD (-220 & -229)	9.78
13DB0	NLG WHEEL&TIRE ASSY	2.72
42GC0	BATTERY A/C IN PRF	3.15
14AP0	CMPTR DIG FLGT CNTR	3.82
13DAA	WHEEL ASSY MLG (BLOCK 30)	4.24

MTTR (Repair Actions) Weighted Top 50 WUCs		4.44 hrs*
WUC	**Nomenclature**	**Average**
13EAH	BRAKE ASSY (BLOCK 30)	5.18
46000	FUEL SYSTEM	5.69
13KAA	WHEEL ASSY MLG (BLOCK 40 & 50)	4.20
27Z00	TURBOFAN ENGINE LRU	14.73
74AN0	MODULAR LPRF	5.29
75CK0	RACK EJECT TER-9/A	5.13
46FD0	TK 370 GAL EXT PYLN	3.39
74DG0	BATTERY INU	2.92
74AP0	XMITTER DUAL MODE	6.50
75000	WEAPONS DELIVERY	2.90
12CA0	CANOPY ASSY	2.98
24EBA	SHAFT POWER TAKEOFF	1.46
74DF0	INERTIAL NAVIGTN UN	4.64
74BQ0	DISPLAY UNIT	5.58
74N00	TARGETING POD	15.39
11A99	NOC, NOSE SECTION	2.34
27000	TURBOFAN POWR PLANT	6.21
74KB0	PRGMMBL DSPLY GNRTR	4.98
75BB0	PYLON CENTERLINE	4.99
74AM0	RADAR ANTENNA	6.52
74CC0	FIRE CNTL CMPTR ENH	5.83
74GB0	RECORDER A-B VD TP	2.99
13000	LANDING GEAR SYSTEM	2.38
62CD0	RCVR/XMTR VHF RM MT	3.69
51BA0	IND HORIZ SITUATION	1.80
11GDA	COV ENG ACC LH 4301	2.12
46FE0	TANK FUEL 300 GAL	4.08
44AAE	LGHT WNGTIP NAV/FRM	1.30
74CE0	GEN AVIONICS COMPTR	2.95
74P00	NAVIGATIONAL SET	5.85
75DJ0	ADVNCD CENTRL INTFC	4.91
46FA0	TANK 370 GALLON EXT	5.65
11GDE	COV AFT ENG 4305	2.25
44AAH	LIGHT INLET NAV/FRM	1.67
*4.44 hrs per action (Top 50) versus 3.88 hrs per action for all WUCs (36 Quarters)		

Table 27. MTTR of Weighted Top 50 Supply Reliability Work Unit Codes

MTTR (Supply Reliability) Weighted Top 50 WUCs		4.01 hrs*
WUC	**Nomenclature**	**Count**
46000	FUEL SYSTEM	5.68674
12000	CREW STATION SYSTEM	2.036771
23000	TURBO FAN PWR PLANT	3.938648
11000	AIRFRAME	3.972761
14000	FLIGHT CONTROL SYS	2.611322
74A00	FIRE CONT RADAR SET	2.763794
27000	TURBOFAN POWR PLANT	6.209236
13000	LANDING GEAR SYSTEM	2.378735
42000	ELECT POWER SYSTEM	2.245425
74000	FIRE CONTROL SYSTEM	4.873047
41000	ENVIR CONT SYSTEM	2.075748
74B00	HEAD UP DISPLAY SET	2.241339
75000	WEAPONS DELIVERY	2.902153
14A00	PRIM FLT CONT ELECT	3.649125
45000	HYD AND PNEU SYSTEM	2.640552
24000	AUX POWER PLANT JFS	3.188011
24D00	JET FUEL START SYS	2.95538
13E00	BRAKE SKID CONT SYS	3.45093
75A00	GUN SYSTEM	4.933966
12CA0	CANOPY ASSY	2.977785
76E00	RAD THREAT WARN SET	2.381958
42AJ0	GEN 10 KVA/FLCS PMG	2.955811
42A00	AC GEN DRIVE ASSY	3.346113
46AF0	PROPORTION FUEL FLO	9.247401
14D00	LEADING EDGE FLAPS	3.140343
63000	UHF COMMUNICATIONS	1.86897
12C00	CANOPY SUB SYSTEM	2.98003
46D00	FUEL TANKS INTERNAL	9.912609
51000	FLIGHT INSTRUMENTS	2.100059
12CAC	TRANSPARENCY, FWD (F-16C, BLK 30)	11.17966
42AA0	CONSTANT SPEED DRIV	8.466967
74AQ0	PROG SIGNL PROCSSR	5.879252
14AP0	CMPTR DIG FLGT CNTR	3.816425
75D00	STORES MGT SYSTEM	3.747121
0341B	PHASE 2	0
76000	PENETR AIDS AND ECM	2.48222
51BA0	IND HORIZ SITUATION	1.795063
0341A	PHASE 1	0
14CB0	HORIZ STABILIZER	5.364062
24A00	POWER SECTION EPU	3.916155
74L00	RADAR ALTIMETER	1.876199
12CCA	ACTUATOR ASSY, CANOPY (F-16C, BLK 30)	4.222887

MTTR (Supply Reliability) Weighted Top 50 WUCs		4.01 hrs*
WUC	**Nomenclature**	**Count**
47AD0	REGULTOR OXY BRTHNG	2.111463
74BQ0	DISPLAY UNIT	5.582829
63BL0	R/T RT-1505/ARC-164 (CONTD)	3.270631
13F00	NOSE WHL STEER SYS	2.439042
74DF0	INERTIAL NAVIGTN UN	4.637682
41A00	AIRCOND SUBSYSTEM	2.562425
41AAA	VLV B/A REG SHTF 13	3.203274
46A00	ENGINE SUPPLY	5.087194
*4.01 hrs per action (Top 50) versus 3.86 hrs per action for all WUCs (36 Quarters)		

Table 28. Code 3 Breaks Weighted Top 5 Work Unit Codes (3-Digit)

Code 3 Breaks Weighted Top 5 WUCs		33.91%*
WUC	**Nomenclature**	**Count**
74A	FIRE CONT RADAR SET	15,123
74D	INERTIAL NAVIG SET	5,547
46E	FUEL INDICATING-CON	4,395
74B	HEAD UP DISPLAY SET	3,908
75C	WEAPON RACK SYSTEM	3,895
*32,868 breaks out of 96,934 total breaks (36 Quarters)		

Appendix F: Partial Work Unit Code Listing

MDS	WUC	NOMENCLATURE		MDS	WUC	NOMENCLATURE
F016C	01000	GROUND HANDLING SRV		F016C	01420	TAPE DEV REPRO ANYL
F016C	01110	GROUND HANDLING		F016C	01430	ECM
F016C	01120	PARK & PRETAXI		F016C	01440	PHOTOGRAPHIC
F016C	01130	RUNUP		F016C	01450	INU AUTO CALIBRATN
F016C	01160	MOORING		F016C	01460	AGE
F016C	01210	FLYING FLT MECH DTY		F016C	01470	780 EQUIP PKUP/DEL
F016C	01300	SERVICE		F016C	01471	LOAD/UNLD SRVL EQPT
F016C	01310	FUEL (INC RE & DE)		F016C	01480	POD/PYLON & EXT TNK
F016C	01311	FUEL TANK PURGING		F016C	02000	AIRCRAFT CLEANING
F016C	01320	OIL		F016C	02100	WASHING
F016C	01330	OXYGEN		F016C	02110	CLEAN & TREAT EQPMT
F016C	01340	AIR		F016C	02120	FRESH WATER RINSE
F016C	01350	SUPRSNT EXPLSN FUEL		F016C	02300	GR SNOW FRST ICE RM
F016C	01360	HYDRAULIC OIL		F016C	02400	CLEANING
F016C	01370	ARMAMENT		F016C	02500	DECONTAMINATION
F016C	01372	BOMBS		F016C	03000	LOOK PHASE OF SCHEDULED INSPECTIONS
F016C	01373	ROCKETS, MISSILES AND FLARES		F016C	03100	PREFLIGHT INSPECT
F016C	01375	R/R R/XMTR FRQ CHGS		F016C	03101	END OF RUNWAY INSP
F016C	01376	BALLAST		F016C	03108	WLKAROUND BEFOREFLT
F016C	01377	IFF/SIF R/XMTR C/C		F016C	03109	DAILY WALKAROUND
F016C	01378	DESICCANT		F016C	03110	QUICK TURNARND INSP
F016C	01381	COM & ELECT EQ RECN		F016C	03115	LAUNCH-RECVERY INSP
F016C	01390	MISCELLANEOUS		F016C	03200	THRUFLIGHT INSPECT
F016C	01399	LUBRICATION		F016C	03210	POSTFLIGHT INSPECT
F016C	0139A	HYDRAZINE		F016C	03400	PHASED INSPECTION
F016C	0139B	RAIN REPELLANT		F016C	0341A	PHASE 1
F016C	0139C	NITROGEN		F016C	0341B	PHASE 2

Source: REMIS Data Base

Appendix G: D041 Variables

Table 29. D041 Data Variables and Derived Data Variables

D041 Variables	
Variable	**Description**
Order and Ship Time	Amount of time in days it takes for an item to be received by the customer from the time the order is place
Base Repair Cycle Time	Amount of time (in days) to repair an unserviceable item at base level (for those items authorized base-level repair)
Depot Repair Cycle Time	Time it takes (in days) for depot to repair an unserviceable item
Serviceable Inventory Level	Quantity of serviceable items (per NSN) on the shelf
Unserviceable Inventory Level	Quantity of unserviceable items (per NSN) awaiting repair
Failures	Total number of failures (per NSN) at each level of maintenance

D041 Derived Data Variables	
Total quantity of Unserviceable Inventory of the top 25, 50, 100 and 200 NSNs for each quarter	Total quantity of Serviceable Inventory of the top 25, 50, 100 and 200 NSNs for each quarter
Average Order and Ship Time of the top 25, 50, 100 and 200 NSNs for each quarter	Average Depot Repair Cycle Time of the top 25, 50, 100 and 200 NSNs for each quarter
Average Base Repair Cycle Time of the top 25, 50, 100 and 200 NSNs for each quarter	Total Unserviceable Inventory of the top 50 weighted/rank-ordered NSNs for the period of FY92 – FY00
Total Serviceable Inventory of the top 50 weighted/rank-ordered NSNs for the period of FY92 – FY00	Average Order and Ship Time of the top 50 weighted/rank-ordered NSNs for the period of FY92 – FY00
Average Base Repair Cycle Time of the top 50 weighted/rank-ordered NSNs for the period of FY92 – FY00	Average Depot Repair Cycle Time of the top 50 weighted/rank-ordered NSNs for the period of FY92 – FY00
Serviceable Inventory per Aircraft	Unserviceable Inventory per Aircraft

Appendix H: Weighted Top 50 National Identification Item Numbers

Table 30. Serviceable Inventory of Weighted Top 50 NIINs

Serviceable Inventory	Weighted Top 50 NIINs	29.38%*
NIIN	**Nomenclature**	**Count**
11316156	TWT B5OUTP	531,396
13129286	CABLE ASSY	434,821
10807580	PCB CUR	304,561
13129285	CABLE ASSY	211,744
12737820	SLIP RING	214,998
13113806	CABLE ASSY	182,542
3651964	TWTDR Q119	169,481
1114655	TORQUE MTR	117,707
11920855	W8/501	136,094
7319272	SEAL,#5BRG	104,593
12409021	LVPS FDP	107,432
11802941	PWR SUPPLY	160,186
12348673	POWR SUPP	175,739
13131813	CABLE ASSY	116,477
12413118	BD LVPS	147,032
12874583	HUB ASSY,M	77,646
4670627	BDAY Q119	111,901
11951084	MANIFOLD	122,551
11798314	MICRO CKT	69,779
4670634	BDAY Q119	82,741
12677701	CASE ASSY	71,330
763050	ACTUATOR	59,744
12289279	SLEEVE,OR	73,064
11802935	WING BOX	74,881
13663768	DISK	90,322
11909266	SHROUD	53,056
12058472	SHROUD FAN	63,194
13323439	SEAL ASSY	73,323
13173318	BUSHING SL	51,062
12149911	RP INTFC C	74,113
12129020	9TH STATOR	55,055
11796908	MICRO CKT	49,248
12903233	A1A5 CCA	49,621
12051297	CIRCUIT CD	61,348
10121938	WASHER SP	51,229
11559148	BOARD ASS	62,302
13696022	HARNESS AS	46,550
11751901	PCB	46,705
13206432	SWITCH	62,300
11856632	MATRIX	63,258

Serviceable Inventory Weighted Top 50 NIINs		29.38%*
NIIN	**Nomenclature**	**Count**
14282576	COVER ASSY	68,923
846111	CKT CD AY	55,380
10621019	CLUTCH ASY	44,031
13201448	CORRELATOR	45,106
13650119	CHASSIS,EL	34,945
13449149	COVER,RETA	40,549
12301348	VALVE KIT	31,461
14346916	VANE	79,862
13386519	DUCT,EXH	28,053
13226274	BAFFLE	33,676
		*5,723,112 items out of 17,946,910 items

Table 31. Unserviceable Inventory of Weighted Top 50 NIINs

Unserviceable Inventory Weighted Top 50 NIINs		53.76%*
NIIN	**Nomenclature**	**Count**
11559148	DIVSEGMENT	506,608
11802935	CONSEALINR	689,756
13131813	CONVNOZSEG	487,973
3651964	BLADE SE 2	561,352
12903233	EXT NOZ SG	265,354
11802941	CONVLINER	319,381
12677701	BLADE SE 1	350,596
12447181	HEAT STK 5	79,676
12348673	BLADE SE 3	202,997
11951084	RING SEG 3	106,836
13206432	DIV SEAL	194,773
11549125	AMP DETECT	65,247
7319272	M53 INIT	68,010
1114655	EJECTOR LH	80,691
11798314	RING SEG 4	107,151
7076478	GYRO	53,892
4670634	5TH VANE	387,128
10807580	IGV VANE	142,495
13114795	DIV SEAL	67,106
846111	LAUNCHER	42,551
11372472	BEARING #4	41,720
13173318	WHEEL MLG	43,206
13908587	SPRAYBAR	57,650
10550435	INU BATTRY	44,485
10124864	ADAPTER	38,770
10039017	NOZZSUPPRT	40,161

Unserviceable Inventory Weighted Top 50 NIINs		53.76%*
NIIN	**Nomenclature**	**Count**
12413118	VANE ASY 4	62,548
11906884	SEAL PRIM	39,073
13696022	BLADE SET	49,933
13323439	CAST BAL	50,758
4670627	4TH VANE	131,467
12051318	1 STG VANE	53,313
12058472	IN VAR VAN	43,083
12409021	ACTUATOR	37,379
5678852	CONVERTER	34,133
13663768	2ND BLADE	47,876
11029078	CKT CD AY	38,113
12051132	AUG LINER	26,610
12737820	KIT-1C	29,781
10121938	REC TRANS	32,992
11316156	TANK 370GL	35,673
12051298	4 VAR VANE	31,084
9242827	ACCELEROME	32,289
763050	CLOCK ACFT	33,218
11851885	TWT	33,213
3456121	BEARING #2	30,049
13129286	BLADE,LPT1	29,059
14282576	CONV SEAL	46,264
12543054	SEE6432PT	54,595
12906821	BK40 ROTOR	23,307
*6,071,375 items out of 11,294,367 total items		

Table 32. Part Failures of Weighted Top 50 NIINs

Parts Failures Weighted Top 50 NIINs		39.72%*
NIIN	**Nomenclature**	**Count**
013173318	WHEEL MLG	66,807
003651964	BLADE SE 2	91,044
011802935	CONSEALINR	50,342
012058472	IN VAR VAN	65,270
013131813	CONVNOZSEG	50,571
011559148	DIVSEGMENT	46,509
011802941	CONVLINER	44,987
012413118	VANE ASY 4	61,029
013206432	DIV SEAL	51,371
013663768	2ND BLADE	99,137
013201448	WHEEL, LAN	27,761
012051318	1 STG VANE	42,013

Parts Failures Weighted Top 50 NIINs		39.72%*
NIIN	**Nomenclature**	**Count**
010512886	AVTR AB+R	29,560
012677701	BLADE SE 1	74,293
012348673	BLADE SE 3	57,558
012051298	4 VAR VANE	37,702
010121938	REC TRANS	23,291
012051297	5 VAR VANE	37,550
000763050	CLOCK ACFT	22,926
004670627	4TH VANE	30,926
010621019	REC/TRANSM	20,833
004670634	5TH VANE	30,026
012149911	VANE ASY 3	28,953
011951084	RING SEG 3	21,046
005678852	CONVERTER	15,593
013304860	HW WHEEL	24,963
011798314	RING SEG 4	21,968
013323439	CAST BAL	24,964
013114795	DIV SEAL	17,192
011126380	REC TRANS	12,996
013129286	BLADE,LPT1	34,872
012562380	INU LN39	12,049
014282576	CONV SEAL	24,437
011549125	AMP DETECT	11,281
012986838	BRAKE MLG	11,094
013014588	R/T N232	27,188
011003892	MAU-12D/A	8,023
012330011	MLPRF	10,229
010807580	IGV VANE	16,806
013405205	LOOP CLAMP	42,013
014434089	3STG BLADE	37,027
012774737	ACTUATOR-2	55,342
003479686	SEAL ASSEM	17,161
014433622	4STG BLADE	24,655
013227746	AMRIU	8,846
012543054	SEE6432PT	6,661
012121021	BUSHING	40,958
012293821	MOD TER-9A	7,169
000613386	KIT-1A	4,860
013123525	RECEIVER T	11,108
*1,640,960 failures out of 4,131,200 total failures		

Table 33. Average Order and Ship Time of Weighted Top 50 NIINs

Order and Ship Time of Weighted Top 50 NIINs		
NIIN	**Nomenclature**	**Avg**
11244734	ADAPTR ECM	66.54
10390024	PWB ALQ131	70.31
10722569	CHASALQ131	65.00
12733873	A15 CARD	63.63
10550254	CHASALQ131	54.03
12775573	A1A15 CCA	54.89
11544989	MOD16KQ131	53.43
10774362	PCB MMO	52.71
10939985	CKT CRD AY	49.00
12610299	PNLPOWECON	49.00
10557331	CHAS LQ131	47.63
11521626	BD ASY 131	48.20
12863684	A1A13 CCA	47.11
12220639	CONVERT131	40.69
10783321	PCB BOARD	40.00
10722567	CHASALQ131	42.14
13119083	DIS CNTRL	35.94
10783299	PCB	41.06
12663365	ACS DOOR	42.03
10697856	PORT CAP	32.21
12765370	COUPLER,AM	31.49
2499339	HTSNK Q119	33.11
10569508	CBLEALQ131	32.31
10706733	MOD ALQ131	31.71
11163884	SS AMP8001	33.59
11721469	SOLSTATAMP	26.94
12775595	AMPLIFIER	27.77
10779326	PCB HEAT S	33.14
10789142	POWER SUPP	32.00
10568526	CBLEALQ131	29.06
12877013	A1A9 CCA	38.37
11832540	CCA 184	26.20
10776673	UNIT CONTR	29.71
11679515	HANGER PIS	34.10
10790009	PCB CRSOVR	26.71
11185378	A12 CARD	34.60

Order and Ship Time of Weighted Top 50 NIINs		
NIIN	Nomenclature	Avg
10671990	COUPLER	24.20
10723480	CABLE ASS	35.51
12663363	ACS DOOR	28.23
10330027	FLTR LQ131	30.46
12827048	DOOR ACCES	35.00
10535401	ANT ALQ131	36.71
10788250	PRINTED CI	36.20
10715584	PIN AY DBM	20.80
10735359	PWB ALQ131	24.46
11444990	BD ALQ 131	35.20
10780454	PRINTED CI	20.86
12775594	AMPLIFIER	25.74
10460986	PWB ALQ131	33.51
10390645	SWITCH	29.79

Table 34. Average Base Repair Cycle Time of Weighted Top 50 NIINs

Base Repair Cycle Time of Weighted Top 50 NIINs		
NIIN	Nomenclature	Avg
12344033	SIMULATOR	40.8
10996792	CCA	40.9697
11009286	111NTD CKT	29.63636
10999779	PRNTD CKT	23.71429
12437750	013368059	31.11429
10714803	STRUT TENS	24.77143
10779338	PCB PRGM	19.70588
10738818	LINK AXLE	21.28571
10710536	PIN ASSY	21.2
10767384	PCB	29.74286
10740957	LINK ASSY	19.97143
5642041	DUAL RECVR	18.68571
12404805	DRAG BRACE	18.4
846111	LAUNCHER	16.14286
620511	F16 PUMP	10.6
10428314	MODULE	15.82857
12564253	ANTEN ASSY	16.91304
10761668	CKDCDPWRSU	12.77143
10710968	COLLAR AY	15.31429
11251559	ACTUATOR	6.628571
12916174	TRAN MICRO	24.63636
11083415	CIRCUIT CD	19.76923
10710969	COLLAR ASY	15.14286
12524093	NLG DB	17.76

Base Repair Cycle Time of Weighted Top 50 NIINs		
NIIN	**Nomenclature**	**Avg**
37459	BDAYALQ119	4.028571
11201731	WIRINGBD#1	22.22222
11987521	CCA	15.35294
13559061	STDCHASSIS	15.68421
37463	BDAY LQ119	5.057143
11480668	FUEL NOZZL	5.48
10773397	PANEL ASSY	7.085714
37464	PWRSUPP119	4.314286
37506	BDAYALQ119	3.5625
3217636	BDAY Q119	10.85714
618893	BTFY VALVE	6.263158
76945	OSCAY Q119	3.914286
10798320	PCB PWR SW	13.58333
13136672	HPT NOZ AY	13.29412
76949	MICROWA119	4.2
10994321	CKT CD AY	7.114286
11945732	REC ASSY	52
76950	DRCONTQ119	3.727273
13216826	CCA	11.48276
37461	BDAYALQ119	4
11950675	A/C FWD TR	15.48276
77072	COLD PLATE	3.6
11631733	CANOPY AY	15.74286
10564953	CCA ALR69	13.85294
11963706	PSP-25/32	10.57143
854793	BOARD101V8	8.058824

Table 35. Average Depot Repair Cycle Time of Weighted Top 50 NIINs

Depot Repair Cycle Time of Weighted Top 50 NIINs		
NIIN	**Nomenclature**	**Avg**
7319272	M53 INIT	408.97
12077162	CUP-2 ASSY	242.17
12756318	POSTSELECT	240.06
11414817	SCOPE	233.69
11933057	PUMPGEARBX	306.00
12084483	PREDICTOR1	207.06
12759548	MIXER RF	225.71
12696977	VIDEO PROC	203.34
12077165	REC CONT A	201.57
12777782	OSCILLATOR	200.17
2640407	SIMULATOR	220.86
10549843	VALVE	255.57

Depot Repair Cycle Time of Weighted Top 50 NIINs		
NIIN	**Nomenclature**	**Avg**
12084482	PREDICTOR2	225.94
10865950	CIRCUIT CD	174.63
10820337	BD3 MIN CO	165.44
10808332	POWER SUP	196.14
11730443	MICRO MEAS	198.11
10611870	RECEIVER	173.06
13073714	PWR SENSOR	165.97
11585969	GU-D-TAC	176.49
10814159	POWER SPLY	197.17
10571731	S012257171	209.09
11587450	DATATR PCB	198.51
12696978	CCA RP A15	124.29
10358490	COOLRLQ131	180.63
10865951	CIRCUIT CD	133.37
11524363	CRYOENGINE	185.63
10789074	PRINTED CI	173.20
10767331	EXTDR ASSY	171.34
10796321	PCB	205.20
11873233	MIXER AMP	132.49
11896130	16K MEM	208.60
12775594	AMPLIFIER	176.46
13368059	MSI	169.00
12566544	ANTE POLAR	112.29
10897375	PRINT CIR	171.06
10045337	CONTROL A	120.57
12077027	VAC. PUMP	152.57
10824806	MON RF PWR	168.80
10856697	POWER SUPL	166.80
12100039	AMP IF LOG	173.89
12765370	COUPLER,AM	165.29
12474406	AMP HF	159.06
10851473	POWER SUPP	134.09
10827354	RECT ASSY	173.69
12815382	WIRE HARN	132.58
12862352	COMPTR ASY	170.00
12953895	AMPLIFIER	167.74
10573391	IFR RECPTL	73.40
11168858	B4,TWTOUTP	202.63

Appendix I: D041 SAS® Data Extraction Program and Sample Output

```
data mds;
  infile 'd:\oliver\f016.txt';
  input niin $ 5-13;

proc sort;
  by niin;

data type01;
  infile 'f:\ddb\ddb01' lrecl=690;
  input niin $ 9-17 soss96 $ 3-4 brcs96 52-54 drcs96 55-57 osts96 75-76;

proc sort;
  by niin;

data type42;
  infile 'f:\ddb\ddb42';
  input type $ 1-2 nsn $ 5-19 serbd 20-25 serc 26-31 seri 32-37 unserb 38-43 unsercs 44-
49
        unserca 50-55 unseri 56-61 unserd 62-67 toc 68-73 unsero 74-79 unserwd 80-85
        unserdi 86-91 dotm 92-97 serwb 98-103 serwd 104-109 sero 110-115 niin $ 9-17 alc
$ 3-4;
  if serc eq . then delete;
  unss96 = unserb + unsercs + unserca + unseri + unserd + unsero + unserwd + unserdi +
toc;
  sers96 = serbd + serc + seri + serwb + serwd + sero;

proc sort;
  by niin;

data oliver.sep96;
  merge mds(in=a) type01(in=b) type42(in=c);
  by niin;
  if a and b;
  keep niin soss96 brcs96 osts96 drcs96 unss96 sers96;
run;
```

Sample Output from D041

NIIN	SOS Jun00	BRC Jun00	DRC Jun00	OST Jun00	UNS Jun00	SER Jun00	SOS Mar00	BRC Mar00	DRC Mar00	OST Mar00	UNS Mar00	SER Mar00
37459	WR	4	34	9	0	1	WR	4	18	9	0	1
37461	WR	0	34	8	7	64	WR	1	53	8	8	67
37463	WR	4	35	9			WR	4	37	9		
37464	WR	4	32	9	335	292	WR	4	34	9	330	301
37506	WR	1	33	11	425	71	WR	1	39	11	419	77
Source: D041 Data System												

SOS = Source of Supply (managing depot…WR = Warner Robbins)

BRC = Base Repair Cycle
DRC = Depot Repair Cycle
OST = Order and Ship Time
UNS = Unserviceable Inventory
SER = Serviceable Inventory

Appendix J: Personnel Data Variables

Table 36. Personnel Data Variables

Personnel Data Variables	
Total F-16 Enlisted Maintenance Personnel Assigned*	3-levels per Aircraft
F-16 Enlisted Maintenance Personnel Assigned in Each Skill Level (1, 3, 5, 7, 9 and 0)*	5-levels per Aircraft
Number of F-16 Enlisted Maintenance Personnel Assigned in Each Grade (E-1 – E-9)*	7-levels per Aircraft
Total Number of F-16 Crewchiefs*	Amn per Aircraft (E1 – E4)
Total Number of F-16 Crewchiefs in Each Skill Level (1, 3, 5, 7, 9 and 0)*	NCOs per Aircraft (E5 – E6)
Total Number of Personnel in F-16 Flightline Avionics*	SNCOs per Aircraft (E7 – E9)
Total Number of Personnel in F-16 Flightline Avionics in Each Skill Level (1, 3, 5, 7, 9 and 0)*	Crew Chiefs per Aircraft #
Total Number of Engine Personnel*	Flightline Avionics personnel per Aircraft #
Total Number of Engine Personnel in Each Skill Level (1, 3, 5, 7, 9 and 0)*	Fuels personnel per Aircraft #
Total Number of Fuels Personnel*	Engines personnel per Aircraft #
Total Number of Fuels Personnel in Each Skill Level (1, 3, 5, 7, 9 and 0)*	Weapons personnel per Aircraft #
Total Number of Weapons Personnel*	Structures personnel per Aircraft #
Total Number of Weapons Personnel in Each Skill Level (1, 3, 5, 7, 9 and 0)*	Percent Eligible Crewchiefs Reenlisting of Total Crewchiefs
Total Number of Structures Personnel*	Percent Eligible Flightline Avionics Reenlisting of total Flightline Avionics
Total Number of Structures Personnel in Each Skill Level (1, 3, 5, 7, 9 and 0)*	Percent Eligible Engines Reenlisting of total Engines
Percent of Personnel Eligible and Ineligible for Reenlistment (total and by grade (E1 – E9)) @	Percent Eligible Fuels Reenlisting of total Fuels
Percent of Eligible Personnel Reenlisting (total and by grade (E1 – E9)) @	Percent Eligible Weapons Reenlisting of total Weapons
Percent of Reenlistment Eligible and Ineligible Personnel Separating (total and by grade (E1 – E9)) @	Percent Eligible Structures Reenlisting of total Structures
Percent Eligibles Reenlisting (First Term, Second Term and Career Term)	Total Maintenance Officer (4024 and 21A3) (Flightline)
Percent Eligible and Ineligible Separating (First Term, Second Term and Career Term)	Total Maintenance Officer (staff) by grade (O-1 - O-6) (4016 and 21A4)
Ratio of F-16 Maintenance Personnel to Maintenance Officers (4024 and 21A3)	Total Maintenance Officer (staff) (4016 and 21A4)
Total Maintenance Officer (flightline) by grade (O-1 - O-6) (4024 and 21A3) and by total CGOs and FGOs	Ratio of 3-Levels to 5, 7 and 9-Levels in total and by AFSC
	Enlisted Maintainers per Aircraft

* Also analyzed by the ratio of number of personnel assigned versus number of personnel authorized

\# Analyzed by total number assigned (crewchiefs, weapons, etc.) and by personnel assigned in each skill level (3-lvl crewchiefs, 3-lvl weapons, 5-lvl crewchiefs, etc.)

@ Out of total F-16 Maintenance Personnel

Appendix K: Personnel Data System Data Retrieval Programs

AFSC Data Retrieval Program (SAS®) for the Personnel Data System

(officer and enlisted)

```
********************************************************************
* PROGRAM: AFIT.SAS                                                *
* POC: RONALD HESS   AFPC/DPSART  DSN:665-3540                     *
* DIRECTORY: D:\SASDATA\AFIT                                       *
* DATE CREATED:   18 OCT 2000                                      *
*                                                                  *
* PURPOSE: Creates files for AFIT student's thesis-- Does a count  *
*   of maintenance troops (OFF&ENL, by Grade & Skill Level).       *
*   This files are quarterly files (ie. 9103, 9106, 9109,...)      *
*   The required data will be Air Force or can be modified for ACC *
*   This program runs for Enlisted/All Air Force                   *
*                                                                  *
* DATE REVISED:   24 OCT 2000                                      *
*                                                                  *
* CHANGES MADE:  Incorporated both Enlisted & Officer file builds  *
*      into 1 program using the same macro.                        *
*                                                                  *
* RUNNING INSTRUCTION:                                             *
*   1.  Run this program to create both officer and enlisted files *
*   2.  Run File_Xport.SAS File                                    *
*   3.  Will create these XLS spreadsheets in D:\SASDATA\          *
*           a. enl_all_grade.xls                                   *
*                                                                  *
*           b. enl_all_level.xls                                   *
*                                                                  *
*           c. off_all_grade.xls                                   *
*                                                                  *
*           d. off_all_level.xls                                   *
*                                                                  *
*      ############################NOTE########################    *
*   To run this program to only pick up ACC command troops:        *
*     1. Change (%do I=91 %to 100)  to (%do I=94 %to 100) in this  *
*         program as well as in File_Xport                         *
*     2. Add statement to the selection line:                      *
*                 AND SUBSTR(EFA,3,2) = '1C'                       *
*                                                                  *
*     3. Change OUTFILE= "D:\SasData\AFIT\enl_all_grade.xls"       *
*                                                                  *
*     4. Will create theses XLS spreadsheets in D:\SASDATA\        *
*           a. enl_acc_grade.xls                                   *
*           b. enl_acc_level.xls                                   *
*           c. off_acc_grade.xls                                   *
*           d. off_acc_level.xls                                   *
*                                                                  *
*                                                                  *
********************************************************************;
*';*";*/;RUN;
OPTIONS OBS = MAX NODATE NONUMBER NOCENTER ;
LIBNAME AFIT 'c:\AFIT';
```

```
%macro do_multi;
    %do I=95 %to 100;
        %do J=6 %to 12 %by 3;
                  %let G = &I;
            %if %length(&J) = 1 %then %let J = 0&J;
                  %if %length(&I) = 3 %then %let G = %substr(&I,2,2);
            %let file1 = enlhist.aae&G&J;
                  %let file2 = offhist.bae&G&J;
                %if %substr(&file1,14,2) = 09 %then %do;
                    %let file1 = enlhist.aae&G.fy;
                              %let file2 = offhist.bae&G.fy;
                        %end;
                %if %substr(&file1,14,2) = 12 %then %do;
                    %let file1 = enlhist.aae&G.cy;
                              %let file2 = offhist.bae&G.cy;
                        %end;

data afit.AA&G&J(keep = asc ahk4 xbk afsc level aku51 filedate);
    set &file1;
    IF AHB IN ('A','K','P','W','B','F','S') AND
          AQF <= '39' AND
          AQT ^= '3' AND
          AAW NOT IN ('B30','B31');

    filedate = "AA&G&J";

/* If changes are needed for AFSCs, this is where they can be added */
/* Code split up to allow for AFSC conversions in 1993 */

      IF &I < 93 or (&I = 93 AND &J < 12) THEN
            IF SUBSTR(XBK,2,2) IN ('45','46');
      ELSE
            IF SUBSTR(XBK,2,2) IN ('2A','2W');

      /***************************************/
      /*Create AFSC and Skill Level Variables*/
      /* Again based on old or new AFSC      */
      /***************************************/

afsc=substr(xbk,2,3)||'X'||substr(xbk,6,2); /* Duty AFSC ie) 3C0X2 */
      level=substr(xbk,5,1);        /* Skill Level (0,1,3,5,7,9) */
run;

data afit.BA&G&J(keep = ahk4 xoy afsc level filedate);
    set &file2;
    IF AHB IN ('A','K','P','W','B','F','S') AND
          AQF <= '39' AND
          AQT ^= '3' AND
          AAW NOT IN ('B30','B31');

    filedate = "BA&G&J";            /*Variable to identify Quarter */

      /**********************************************/
      /*Selection criteria based on old or new AFSC */
      /**********************************************/
```

```
      IF (&I < 93) OR (&I = 93 AND &J < 12) THEN
            IF SUBSTR(XOY,2,2) = '40';

      IF (&I = 93 AND &J = 12) OR (&I > 93) THEN
            IF SUBSTR(XOY,2,3) IN ('21A','21M');


      /**************************************/
      /*Create AFSC and Skill Level Variables*/
      /* Again based on old or new AFSC      */
      /**************************************/

      IF (&I < 93) OR (&I = 93 AND &J < 12) THEN
            afsc=substr(xoy,2,2)||'XX';     /* Control AFSC ie) 21XX */
            level=substr(xoy,5,1);          /* Skill Level (1,3,4) */
      IF (&I = 93 AND &J = 12) OR (&I > 93) THEN
            afsc=substr(xoy,2,3)||'X';      /* Control AFSC ie) 21XX */
            level=substr(xoy,5,1);          /* Skill Level (1,3,4) */
run;
%end;
%end;
%mend do_multi ;
%do_multi;
```

AFSC Data Export Program – Exports SAS® Data to Microsoft Excel®

(officer and enlisted)

```
********************************************************************
*                                                                  *
* PROGRAM: File_Xport.SAS                                          *
* POC: RONALD HESS   AFPC/DPSART  DSN:665-3540                     *
* DIRECTORY: D:\SASDATA\AFIT                                       *
* DATE CREATED:   18 OCT 2000                                      *
*                                                                  *
* PURPOSE: Takes files that were created in AFIT.SAS and runs      *
*   frequencies against each file and creates an output file.      *
*   Then it merges all frequency files into one and exports it to  *
*   a spreadsheet in D:\SASDATA\AFIT directory (see filename below)*
*                                                                  *
*                                                                  *
* RUNNING INSTRUCTION: Make sure to run AFIT.SAS first             *
*                                                                  *
********************************************************************;
*';*";*/;RUN;
OPTIONS OBS = MAX NODATE NONUMBER NOCENTER ;
LIBNAME AFIT 'J:\dpsart\sascode\AFIT\';
%macro do_multi;
    %do I=89 %to 100;
        %do J=3 %to 12 %by 3;
                  %let G = &I;
            %if %length(&J) = 1 %then %let J = 0&J;
                  %if %length(&I) = 3 %then %let G = %substr(&I,2,2);
                  %let file1 = afit.aa&G&J;
                  %let file2 = afit.ba&G&J;
```

```
/****************************************************************/
/*  This PROC FREQs will build the Enlisted count files         */
/****************************************************************/

proc freq data=&file1 noprint;
      table filedate*afsc*ahk4 / nocum nopercent out=aagrade&G&J;
      format ahk4 $ahk4_f.;
run;
proc freq data=&file1 noprint;
      table filedate*afsc*level / nocum nopercent out=aalevel&G&J;
run;
proc freq data=&file1 noprint;
     table filedate*afsc*level*ahk4 / nocum nopercent out=aalevgr&G&J;
run;

/****************************************************************/
/*  This PROC FREQs will build the Officer count files          */
/****************************************************************/

proc freq data=&file2 noprint;
      table filedate*afsc*ahk4 / nocum nopercent out=bagrade&G&J;
      format ahk4 $ahk4_f.;
run;
proc freq data=&file2 noprint;
      table filedate*afsc*level / nocum nopercent out=balevel&G&J;
run;
proc freq data=&file2 noprint;
      table filedate*afsc*level*ahk4 / nocum nopercent out=balevgr&G&J;
run;
%end;
%end;
%mend do_multi ;
%do_multi;
data aagrade;
      set aagrade8909 aagrade9009
            aagrade9103 aagrade9106 aagrade9109 aagrade9112
            aagrade9203 aagrade9206 aagrade9209 aagrade9212
            aagrade9303 aagrade9306 aagrade9309 aagrade9312
            aagrade9403 aagrade9406 aagrade9409 aagrade9412
            aagrade9506 aagrade9509 aagrade9512
            aagrade9603 aagrade9606 aagrade9609 aagrade9612
            aagrade9703 aagrade9706 aagrade9709 aagrade9712
            aagrade9803 aagrade9806 aagrade9809 aagrade9812
            aagrade9903 aagrade9906 aagrade9909 aagrade9912
            aagrade0003 aagrade0006 aagrade0009;
run;
data aalevel;
      set aalevel8909 aalevel9009
            aalevel9103 aalevel9106 aalevel9109 aalevel9112
            aalevel9203 aalevel9206 aalevel9209 aalevel9212
            aalevel9303 aalevel9306 aalevel9309 aalevel9312
            aalevel9403 aalevel9406 aalevel9409 aalevel9412
            aalevel9506 aalevel9509 aalevel9512
            aalevel9603 aalevel9606 aalevel9609 aalevel9612
            aalevel9703 aalevel9706 aalevel9709 aalevel9712
```

```
            aalevel9803 aalevel9806 aalevel9809 aalevel9812
            aalevel9903 aalevel9906 aalevel9909 aalevel9912
            aalevel0003 aalevel0006 aalevel0009;
run;
data aalevgr;
      set aalevgr8909 aalevgr9009
            aalevgr9103 aalevgr9106 aalevgr9109 aalevgr9112
            aalevgr9203 aalevgr9206 aalevgr9209 aalevgr9212
            aalevgr9303 aalevgr9306 aalevgr9309 aalevgr9312
            aalevgr9403 aalevgr9406 aalevgr9409 aalevgr9412
            aalevgr9506 aalevgr9509 aalevgr9512
            aalevgr9603 aalevgr9606 aalevgr9609 aalevgr9612
            aalevgr9703 aalevgr9706 aalevgr9709 aalevgr9712
            aalevgr9803 aalevgr9806 aalevgr9809 aalevgr9812
            aalevgr9903 aalevgr9906 aalevgr9909 aalevgr9912
            aalevgr0003 aalevgr0006 aalevgr0009;
run;

data bagrade;
      set bagrade8909 bagrade9009
            bagrade9103 bagrade9106 bagrade9109 bagrade9112
            bagrade9203 bagrade9206 bagrade9209 bagrade9212
            bagrade9303 bagrade9306 bagrade9309 bagrade9312
            bagrade9403 bagrade9406 bagrade9409 bagrade9412
            bagrade9503 bagrade9506 bagrade9509 bagrade9512
            bagrade9603 bagrade9606 bagrade9609 bagrade9612
            bagrade9703 bagrade9706 bagrade9709 bagrade9712
            bagrade9803 bagrade9806 bagrade9809 bagrade9812
            bagrade9903 bagrade9906 bagrade9909 bagrade9912
            bagrade0003 bagrade0006 bagrade0009;
run;
data balevel;
      set balevel8909 balevel9009
            balevel9103 balevel9106 balevel9109 balevel9112
            balevel9203 balevel9206 balevel9209 balevel9212
            balevel9303 balevel9306 balevel9309 balevel9312
            balevel9403 balevel9406 balevel9409 balevel9412
            balevel9503 balevel9506 balevel9509 balevel9512
            balevel9603 balevel9606 balevel9609 balevel9612
            balevel9703 balevel9706 balevel9709 balevel9712
            balevel9803 balevel9806 balevel9809 balevel9812
            balevel9903 balevel9906 balevel9909 balevel9912
            balevel0003 balevel0006 balevel0009;
run;
data balevgr;
      set balevgr8909 balevgr9009
            balevgr9103 balevgr9106 balevgr9109 balevgr9112
            balevgr9203 balevgr9206 balevgr9209 balevgr9212
            balevgr9303 balevgr9306 balevgr9309 balevgr9312
            balevgr9403 balevgr9406 balevgr9409 balevgr9412
            balevgr9503 balevgr9506 balevgr9509 balevgr9512
            balevgr9603 balevgr9606 balevgr9609 balevgr9612
            balevgr9703 balevgr9706 balevgr9709 balevgr9712
            balevgr9803 balevgr9806 balevgr9809 balevgr9812
            balevgr9903 balevgr9906 balevgr9909 balevgr9912
```

```
            balevgr0003 balevgr0006 balevgr0009;
run;

PROC EXPORT DATA= WORK.aagrade
            OUTFILE=
"J:\dpsart\sascode\AFIT\afit_freq\enl_all_grade.xls"
            DBMS=EXCEL2000 REPLACE;
RUN;
PROC EXPORT DATA= WORK.aalevel
            OUTFILE=
"J:\dpsart\sascode\AFIT\afit_freq\enl_all_level.xls"
            DBMS=EXCEL2000 REPLACE;
RUN;
PROC EXPORT DATA= WORK.aalevgr
            OUTFILE=
"J:\dpsart\sascode\AFIT\afit_freq\enl_all_lev_grd.xls"
            DBMS=EXCEL2000 REPLACE;
RUN;
PROC EXPORT DATA= WORK.bagrade
            OUTFILE=
"J:\dpsart\sascode\AFIT\afit_freq\off_all_grade.xls"
            DBMS=EXCEL2000 REPLACE;
RUN;
PROC EXPORT DATA= WORK.balevel
            OUTFILE=
"J:\dpsart\sascode\AFIT\afit_freq\off_all_level.xls"
            DBMS=EXCEL2000 REPLACE;
RUN;
PROC EXPORT DATA= WORK.balevgr
            OUTFILE=
"J:\dpsart\sascode\AFIT\afit_freq\off_all_lev_grd.xls"
            DBMS=EXCEL2000 REPLACE;
RUN;
```

Sample Output of PDS AFSC Data

Quarter	AFSC	Skill Level	Grade	Count	Percent of Total
AA8909	451X0	0	38	13	0.010775505
AA8909	451X0	0	39	141	0.116872783
AA8909	451X4	7	36	170	0.140910447
AA8909	451X4	7	37	82	0.067968569
AA8909	451X4A	1	32	1	0.000828885
AA8909	451X4A	1	34	1	0.000828885
AA8909	451X4A	3	31	1	0.000828885
AA8909	451X4A	3	32	4	0.00331554
AA8909	451X4A	3	33	41	0.033984284
Source: AFPC Personnel Data System					

Note: A translation table (from the PDS) for the following data field is required to translate its data field codes: Grade = AHK4

Appendix L: AFSC Listing (Enlisted and Officer)

Enlisted AFSC (FY90 – FY94)	Enlisted AFSC Duty Title (FY90 – FY94)
451X0	Avionic Systems Manager
451X5	F-16/A-10 Avionics Test Station and Component Specialist
451X9	Avionic Test Station and Component Superintendent
452X0	Aircraft Manager
452X2	F-16 Avionic Systems
452X2A	F-16 Avionic Systems Attack Control Systems
452X2B	F-16 Avionic Systems Instrument and flight Control Systems
452X2C	F-16 Avionic Systems Comm/Nav and Penetration Aids Systems
452X4B	Tactical A ircraft Maintenance, F-16 (Crewchief)
452X5	Tactical Electrical and Environmental Systems
452X9	Tactical Aircraft Superintendent
453X9	Aircraft Avionic Superintendent (31 Oct 92 – 31 Oct 93)
454X0	Systems Manager or Aerospace Propulsion Superintendent
454X0A	Aerospace Propulsion, Jet Engines
454X1	Aerospace Ground Equipment
454X2	Aircrew Egress Systems
454X3	Aircraft Fuel Systems
454X4	Aircraft Pneudraulic Systems
454X9	Aircraft Systems Superintendent
455X9	Conventional Avionic Superintendent
456X1	Electronic Warfare Systems
456X1B	Electronic Warfare Systems, Tactical
456X9	Offensive/Defensive Avionic Superintendent
458X0	Aircraft Metals Technology
458X1	Nondestructive Inspection
458X2	Aircraft Structural Maintenance
458X3	Fabrication and Parachute
458X9	Aircraft Fabrication Superintendent
462X0	Weapons Maintenance Manager or Aircraft Armament Systems Superintendent
462X0F	Aircraft Armament Systems, F-16
Source: Air Force Personnel Center PDS Enlisted AFSC Historical File	

Enlisted AFSC (FY94 – FY00)	Enlisted AFSC Duty Title (FY94 – FY00)
2A0X0	Avionics CEM
2A0X1B	Avionics Test Station and Components (F-16/F-117/A-10/B-1B/C-17)
2A1X0	Avionic Superintendent
2A1X1	Avionic Sensor Maintenance
2A1X7	Electronic Warfare Systems
2A2X0	Electronic Warfare/Offensive Avionic Superintendent (1 Nov 93 – 30 Oct 94)
2A2X2	Electronic Warfare Systems (1 Nov 93 – 30 Oct 94) Electronic Warfare Superintendent (1 Nov 93 – 30 Oct 94)
2A3X0	Tactical Aircraft Chief Enlisted Manager (CEM) or Tactical Aircraft Superintendent
2A3X2	F-16, F-117, CV-22 Avionic Systems
2A3X2A	F-16, F-117, CV-22 Avionic Systems, Attack Control
2A3X2B	F-16, F-117, CV-22 Avionic Systems, Instrument and Flight Controls
2A3X2C	F-16, F-117, CV-22 Avionic Systems, Comm/Nav and Penetration Aids
2A3X3B	Tactical Aircraft Maintenance, F-16 (Crewchief)
2A4X0	Aircraft Avionic Superintendent
2A6X0	Aerospace Propulsion CEM or Aerospace Ground Equipment CEM or Aircraft Systems CEM or Aircraft Systems Superintendent or Aircraft Fabrication CEM
2A6X1	Aerospace Propulsion Superintendent
2A6X1A	Aerospace Propulsion Jet Engines
2A6X1D	Aerospace Propulsion F100 Jet Engines
2A6X1E	Aerospace Propulsion F110 Jet Engines
2A6X2	Aerospace Ground Equipment
2A6X3	Aircrew Egress Systems
2A6X4	Aircraft Fuel Systems
2A6X5	Aircraft Hydraulic Systems
2A6X6	Aircraft Electrical and Environmental Systems
2A7X0	Aircraft Fabrication Superintendent
2A7X1	Aircraft Metals Technology
2A7X2	Nondestructive Inspection
2A7X3	Aircraft Structural Maintenance
2A7X4	Survival Equipment
2W1X0	Aircraft Armament CEM
2W1X1	Aircraft Armament Systems or Aircraft Armament Systems Superintendent
2W1X1F	Aircraft Armament Systems, F-16
	Source: AFMAN 36-2108, Attch 11

Officer AFSC	Officer AFSC Duty Title
401X	Maintenance Staff Officer (FY76 – FY93)
409X	Aerospace Maintenance Director (FY76 – FY93)
402X	Aircraft Maintenance and Munitions Officer (FY71 – FY93)
21AX	Aircraft Maintenance and Munitions Officer (Flightline {X=3} and Staff {X=4}) (FY94 – FY00)
	Source: Air Force Personnel Center PDS Officer AFSC Historical File

Appendix M: Personnel Data System Retention Data Retrieval Programs

Retention Data Retrieval Program (SAS®) for the Personnel Data System

```
DATA AFIT.REEN_SEPS89(KEEP = ACA7 AHK4 AQJ ATQ1 TEFFDT XBS XRC ADU
ASJ12);
      SET ENLHIST.AKA89FY;
            IF AHB IN ('A','K','P','W','B','F','S') AND
                  SUBSTR(ACA7,1,2) IN ('45','46');
RUN;
DATA AFIT.REEN_SEPS90(KEEP = ACA7 AHK4 AQJ ATQ1 TEFFDT XBS XRC ADU
ASJ12);
      SET ENLHIST.AKA90FY;
            IF AHB IN ('A','K','P','W','B','F','S') AND
                  SUBSTR(ACA7,1,2) IN ('45','46');
RUN;
DATA AFIT.REEN_SEPS91(KEEP = ACA7 AHK4 AQJ ATQ1 TEFFDT XBS XRC ADU
ASJ12);
      SET ENLHIST.AKA91FY;
            IF AHB IN ('A','K','P','W','B','F','S') AND
                  SUBSTR(ACA7,1,2) IN ('45','46');
RUN;
DATA AFIT.REEN_SEPS92(KEEP = ACA7 AHK4 AQJ ATQ1 TEFFDT XBS XRC ADU
ASJ12);
      SET ENLHIST.AKA92FY;
            IF AHB IN ('A','K','P','W','B','F','S') AND
                  SUBSTR(ACA7,1,2) IN ('45','46');
RUN;
DATA AFIT.REEN_SEPS93(KEEP = ACA7 AHK4 AQJ ATQ1 TEFFDT XBS XRC ADU
ASJ12);
      SET ENLHIST.AKA93FY;
            IF AHB IN ('A','K','P','W','B','F','S') AND
                  SUBSTR(ACA7,1,2) IN ('45','46');
RUN;
DATA AFIT.REEN_SEPS94(KEEP = ACA7 AHK4 AQJ ATQ1 TEFFDT XBS XRC ADU
ASJ12);
      SET ENLHIST.AKA94FY;
            IF AHB IN ('A','K','P','W','B','F','S') AND
                  SUBSTR(ACA7,1,2) IN ('2A','2W');
RUN;
DATA AFIT.REEN_SEPS95(KEEP = ACA7 AHK4 AQJ ATQ1 TEFFDT XBS XRC ADU
ASJ12);
      SET ENLHIST.AKA95FY;
            IF AHB IN ('A','K','P','W','B','F','S') AND
                  SUBSTR(ACA7,1,2) IN ('2A','2W');
RUN;
DATA AFIT.REEN_SEPS96(KEEP = ACA7 AHK4 AQJ ATQ1 TEFFDT XBS XRC ADU
ASJ12);
      SET ENLHIST.AKA96FY;
            IF AHB IN ('A','K','P','W','B','F','S') AND
                  SUBSTR(ACA7,1,2) IN ('2A','2W');
RUN;
DATA AFIT.REEN_SEPS97(KEEP = ACA7 AHK4 AQJ ATQ1 TEFFDT XBS XRC ADU
ASJ12);
```

```
      SET ENLHIST.AKA97FY;
            IF AHB IN ('A','K','P','W','B','F','S') AND
                  SUBSTR(ACA7,1,2) IN ('2A','2W');
RUN;
DATA AFIT.REEN_SEPS98(KEEP = ACA7 AHK4 AQJ ATQ1 TEFFDT XBS XRC ADU
ASJ12);
      SET ENLHIST.AKA98FY;
            IF AHB IN ('A','K','P','W','B','F','S') AND
                  SUBSTR(ACA7,1,2) IN ('2A','2W');
RUN;
DATA AFIT.REEN_SEPS99(KEEP = ACA7 AHK4 AQJ ATQ1 TEFFDT XBS XRC ADU
ASJ12);
      SET ENLHIST.AKA99FY;
            IF AHB IN ('A','K','P','W','B','F','S') AND
                  SUBSTR(ACA7,1,2) IN ('2A','2W');
RUN;
DATA AFIT.REEN_SEPS00(KEEP = ACA7 AHK4 AQJ ATQ1 TEFFDT XBS XRC ADU
ASJ12);
      FORMAT TEFFDT Z4.;
      SET ENLHIST.AKA00FY;
            IF AHB IN ('A','K','P','W','B','F','S') AND
                  SUBSTR(ACA7,1,2) IN ('2A','2W');
RUN;
```

Retention Data Export Program – Exports Data to Microsoft Excel®

```
PROC EXPORT DATA= AFIT.REEN_SEPS89
            OUTFILE= "c:\reen_sepsFY89.xls"
            DBMS=EXCEL2000 REPLACE;
RUN;
PROC EXPORT DATA= AFIT.REEN_SEPS90
            OUTFILE= "c:\reen_sepsFY90.xls"
            DBMS=EXCEL2000 REPLACE;
RUN;
PROC EXPORT DATA= AFIT.REEN_SEPS91
            OUTFILE= "c:\reen_sepsFY91.xls"
            DBMS=EXCEL2000 REPLACE;
RUN;
PROC EXPORT DATA= AFIT.REEN_SEPS92
            OUTFILE= "c:\reen_sepsFY92.xls"
            DBMS=EXCEL2000 REPLACE;
RUN;
PROC EXPORT DATA= AFIT.REEN_SEPS93
            OUTFILE= "c:\reen_sepsFY93.xls"
            DBMS=EXCEL2000 REPLACE;
RUN;
PROC EXPORT DATA= AFIT.REEN_SEPS94
            OUTFILE= "c:\reen_sepsFY94.xls"
            DBMS=EXCEL2000 REPLACE;
RUN;
PROC EXPORT DATA= AFIT.REEN_SEPS95
            OUTFILE= "c:\reen_sepsFY95.xls"
            DBMS=EXCEL2000 REPLACE;
RUN;
PROC EXPORT DATA= AFIT.REEN_SEPS96
            OUTFILE= "c:\reen_sepsFY96.xls"
```

```
            DBMS=EXCEL2000 REPLACE;
RUN;
PROC EXPORT DATA= AFIT.REEN_SEPS97
            OUTFILE= "c:\\reen_sepsFY97.xls"
            DBMS=EXCEL2000 REPLACE;
RUN;
PROC EXPORT DATA= AFIT.REEN_SEPS98
            OUTFILE= "c:\reen_sepsFY98.xls"
            DBMS=EXCEL2000 REPLACE;
RUN;
PROC EXPORT DATA= AFIT.REEN_SEPS99
            OUTFILE= "c:\reen_sepsFY99.xls"
                  DBMS=EXCEL2000 REPLACE;
RUN;
PROC EXPORT DATA= AFIT.REEN_SEPS00
            OUTFILE= "c:\reen_sepsFY00.xls"
            DBMS=EXCEL2000 REPLACE;
RUN;
```

Sample Output of PDS Retention Data

Grade	Control AFSC	Reenlist/ Separate	Reenlist/ Extend	Eligibility	Enlistment Category	Reenlist Term	Effective Date	Duty AFSC
36	2A7X1	2	900	1M	4	4	9408	2A771
38	2A3X0	2	900	1M	4	4	9401	2A390
35	2A1X1	2	900	1M	2	4	9405	2A151
38	2A5X0	2	900	1M	4	3	9406	2A590
37	2A6X2	2	900	1K	4	3	9406	2A672
35	2W1X1	2	900	1M	2	4	9401	2W151
37	2W2X1	2	900	1K	4	5	9409	2W271
36	2A3X3A	3	RBE	2V	4	5	9312	2A373A
37	2A6X4	3	RBE	2V	4	4	9409	2A674
37	2A3X3A	2	900	1K	4	4	9408	2A373A

Source: AFPC Personnel Data System

Note: Translation tables (from the PDS) for the following data fields may be necessary to translate some data field codes:

Grade = AHK4
Control AFSC = ACA7
Reenlist/Separate = XRC
Reenlist/Extend = ASJ12
Eligibility = AQJ
Enlistment Category = ADU
Reenlistment Term = ATQ1
Effective Date = TEFFDT
Duty AFSC = XBS

Appendix N: HAF Manpower Data System Authorization Data Retrieval Program

Manpower Authorization Data Retrieval Program (IBM Standard Query Language)

```
select cmd,afsc,grd,rgr,
q4_1994,0,0,0,0,0
from AS02D17.hCMDB_sep_1994 a
where fct not in ('x','u','v','y')
  and mnt like '__xxx'
  and (afsc like '45%' or afsc like '46%' or afsc like '040%'
  or afsc like '2a%' or afsc like '2w%' or afsc like '021a%'
  or afsc like '021m%')

Union All

select cmd,afsc,grd,rgr,
0,q4_1993,0,0,0,0
from AS02D17.hCMDB_sep_1993 a
where fct not in ('x','u','v','y')
  and mnt like '__xxx'
  and ((afsc like '45%' or afsc like '46%' or afsc like '040%')
  or pec = '00027133m')

Union All

select cmd,afsc,grd,rgr,
0,0,q4_1992,0,0,0
from AS02D17.hCMDB_sep_1992 a
where fct not in ('x','u','v','y')
  and mnt like '__xxx'
  and (afsc like '45%' or afsc like '46%' or afsc like '040%')

Union All

select cmd,afsc,grd,rgr,
0,0,0,q4_1991,0,0
from AS02D17.hCMDB_sep_1991 a
where fct not in ('x','u','v','y')
  and mnt like '__xxx'
  and (afsc like '45%' or afsc like '46%' or afsc like '040%')

Union All

select cmd,afsc,grd,rgr,
0,0,0,0,q4_1990,0
from AS02D17.hCMDB_sep_1990 a
where fct not in ('x','u','v','y')
  and mnt like '__xxx'
  and (afsc like '45%' or afsc like '46%' or afsc like '040%')

Union All

select cmd,afsc,grd,rgr,
0,0,0,0,0,q4_1989
```

```
from AS02D17.hCMDB_sep_1989
where fct not in ('x','u','v','y')
  and mnt like '__xxx'
  and (afsc like '45%' or afsc like '46%' or afsc like '040%')
   order by 1,2,3,4

select cmd,afsc,grd,rgr,
q4_1995,0,0,0,0,0
from AS02D17.hCMDB_sep_1995 a
where fct not in ('x','u','v','y')
  and mnt like '__xxx'
  and (afsc like '2a%' or afsc like '2w%' or afsc like '021a%' or
   afsc like '021m%' or afsc like '45%' or afsc like '46%' or afsc
   like '040%')

Union All

select cmd,afsc,grd,rgr,
0,q4_1996,0,0,0,0
from AS02D17.hCMDB_sep_1996 a
where fct not in ('x','u','v','y')
  and mnt like '__xxx'
  and (afsc like '2a%' or afsc like '2w%' or afsc like '021a%' or
   afsc like '021m%' or afsc like '45%' or afsc like '46%' or afsc
   like '040%')

Union All

select cmd,afsc,grd,rgr,
0,0,q4_1997,0,0,0
from AS02D17.hCMDB_sep_1997 a
where fct not in ('x','u','v','y')
  and mnt like '__xxx'
  and (afsc like '2a%' or afsc like '2w%' or afsc like '021a%' or
   afsc like '021m%' or afsc like '45%' or afsc like '46%' or afsc
   like '040%')

Union All

select cmd,afsc,grd,rgr,
0,0,0,q4_1998,0,0
from AS02D17.hCMDB_sep_1998 a
where fct not in ('x','u','v','y')
  and mnt like '__xxx'
and (afsc like '2a%' or afsc like '2w%' or afsc like '021a%' or
  afsc like '021m%' or afsc like '45%' or afsc like '46%' or afsc
  like '040%')

Union All

select cmd,afsc,grd,rgr,
0,0,0,0,q4_1999,0
from AS02D17.hCMDB_sep_1999 a
where fct not in ('x','u','v','y')
```

```
  and mnt like '__xxx'
  and (afsc like '2a%' or afsc like '2w%' or afsc like '021a%' or
   afsc like '021m%' or afsc like '45%' or afsc like '46%' or afsc
   like '040%')

Union All

select cmd,afsc,grd,rgr,
0,0,0,0,0,q4_2000
from AS02D17.CMDB_sep_2000
where fct not in ('x','u','v','y')
  and mnt like '__xxx'
  and (afsc like '2a%' or afsc like '2w%' or afsc like '021a%' or
   afsc like '021m%' or afsc like '45%' or afsc like '46%' or afsc
   like '040%')
   order by 1,2,3,4
```

Sample Output of MDS Annual Authorization Data

CMD	AFSC	GRD	REQ GRADE	SUM Q4 1994	SUM Q4 1993	SUM Q4 1992	SUM Q4 1991	SUM Q4 1990	SUM Q4 1989
AAC	4016	LTC	LTC	0	0	0	0	4	4
AAC	4016	MAJ	LTC	0	0	0	0	4	4
AAC	4016	MAJ	MAJ	0	0	0	0	10	12
AAC	4024	CIV	CIV	0	0	0	0	1	1
AAC	4024	CPT	CPT	0	0	0	0	12	14
AAC	4024	CPT	MAJ	0	0	0	0	5	5
AAC	4024	LT	LT	0	0	0	0	5	5
AAC	4054A	CPT	CPT	0	0	0	0	2	3
AAC	4054A	CPT	MAJ	0	0	0	0	1	1
AAC	4054A	LT	CPT	0	0	0	0	1	1
AAC	4054B	CPT	CPT	0	0	0	0	0	1
AAC	4054B	LT	CPT	0	0	0	0	1	0
AAC	4096	COL	COL	0	0	0	0	2	2
AAC	4096	LTC	COL	0	0	0	0	1	1
AAC	4096	LTC	LTC	0	0	0	0	2	2
AAC	45100	CMS	CMS	0	0	0	0	2	2
AAC	45134A	A1C	A1C	0	0	0	0	4	4
AAC	45134B	A1C	A1C	0	0	0	0	5	5
AAC	45134B	A1C	SGT	0	0	0	0	7	7
AAC	45135	A1C	A1C	0	0	0	0	3	3
AAC	45154A	SGT	SGT	0	0	0	0	10	10
AAC	45154A	SSG	SSG	0	0	0	0	3	3
AAC	45154B	SGT	SGT	0	0	0	0	5	5
									Source: HAF Manpower Data System

Appendix O: Variable Analysis Results

Table 37. Retention Variable Analysis

Retention Variables	MC Rate L0	MC Rate L1	MC Rate L2	MC Rate L3	MC Rate L4
Ttl Rnlst	0.673	0.693	0.626	0.588	0.533
E3 Ttl Rnlst	0.404	0.449	0.398	0.407	0.310
E4 Ttl Rnlst	0.257	0.355	0.336	0.329	0.108
E5 Ttl Rnlst	0.279	0.322	0.288	0.315	0.401
E6 Ttl Rnlst	0.384	0.453	0.387	0.381	0.382
E7 Ttl Rnlst	0.569	0.473	0.374	0.313	0.260
E8 Ttl Rnlst	0.291	0.256	0.193	0.183	0.167
E9 Ttl Rnlst	0.479	0.376	0.349	0.411	0.371
1st Term Ttl Rnlst/(E1 - E4)	0.568	0.640	0.627	0.571	0.391
2nd Term Ttl Rnlst/(E5 - E6)	0.494	0.482	0.446	0.486	0.500
Career Ttl Rnlst/(E7 - E9)	0.091	0.126	0.055	0.045	0.071
Crewchiefs Ttl Rnlst	0.856	0.841	0.785	0.750	0.743
Flightline Avionics Ttl Rnlst	0.009	-0.056	-0.104	-0.107	-0.129
Engines Ttl Rnlst	0.205	0.276	0.208	0.204	0.100
Fuels Ttl Rnls t	0.435	0.381	0.380	0.372	0.295
Weapons Ttl Rnlst	0.580	0.642	0.645	0.639	0.560
Sheetmetal Ttl Rnlst	0.479	0.464	0.301	0.286	0.236
Ttl Elgbl Seprt	0.805	0.789	0.784	0.808	0.705
E3 Ttl Elgbl Seprt	0.651	0.710	0.668	0.687	0.629
E4 Ttl Elgbl Seprt	0.728	0.720	0.717	0.766	0.659
E5 Ttl Elgbl Seprt	0.131	0.165	0.226	0.207	0.302
E6 Ttl Elgbl Seprt	-0.189	-0.110	-0.070	-0.004	-0.006
E7 Ttl Elgbl Seprt	-0.372	-0.313	-0.294	-0.142	-0.194
E8 Ttl Elgbl Seprt	-0.139	-0.036	-0.082	0.004	-0.044
E9 Ttl Elgbl Seprt	0.188	0.203	0.202	0.198	0.115
1st Term Ttl Elgbl Seprt/(E1 - E4)	0.799	0.799	0.791	0.813	0.721
2nd Term Ttl Elgbl Seprt/(E5 - E6)	0.623	0.612	0.620	0.658	0.590
Career Ttl Elgbl Seprt/(E7 - E9)	-0.465	-0.387	-0.363	-0.289	-0.301
Crewchiefs Ttl Elgbl Seprt	0.771	0.788	0.774	0.768	0.722

Retention Variables	MC Rate L0	MC Rate L1	MC Rate L2	MC Rate L3	MC Rate L4
Flightline Avionics Ttl Elgbl Seprt	0.299	0.260	0.237	0.261	0.105
Engines Ttl Elgbl Seprt	0.424	0.473	0.499	0.547	0.371
Fuels Ttl Elgbl Seprt	0.265	0.357	0.383	0.392	0.292
Weapons Ttl Elgbl Seprt	0.791	0.775	0.736	0.748	0.713
Sheetmetal Ttl Elgbl Seprt	0.257	0.249	0.301	0.345	0.301
Ttl InElgbl	0.716	0.727	0.793	0.778	0.633
E1, E2, and E3 Ttl InElgbl	0.548	0.515	0.550	0.558	0.403
E4 Ttl InElgbl	0.750	0.776	0.847	0.847	0.751
E5 Ttl InElgbl	0.565	0.596	0.636	0.607	0.457
E6 Ttl InElgbl	0.393	0.488	0.604	0.692	0.614
E7 Ttl InElgbl	0.668	0.638	0.746	0.740	0.692
E8 Ttl InElgbl	0.530	0.504	0.632	0.663	0.574
E9 Ttl InElgbl	0.725	0.615	0.600	0.602	0.508
1st Term Ttl InElgbl/(E1 - E4)	0.624	0.615	0.669	0.671	0.545
2nd Term Ttl InElgbl/(E5 - E6)	0.637	0.644	0.718	0.706	0.580
Career Ttl InElgbl/(E7 - E9)	0.661	0.689	0.762	0.754	0.608
Crewchiefs Ttl InElgbl	0.819	0.793	0.808	0.771	0.683
Flightline Avionics Ttl InElgbl	0.787	0.748	0.786	0.791	0.682
Engines Ttl InElgbl	0.755	0.794	0.835	0.819	0.722
Fuels Ttl InElgbl	0.645	0.677	0.735	0.711	0.593
Weapons Ttl InElgbl	0.616	0.628	0.702	0.686	0.538
Sheetmetal Ttl InElgbl	0.640	0.649	0.727	0.753	0.616
Ttl Seprt	0.767	0.771	0.820	0.814	0.674
E1, E2 and E3 Ttl Seprt	0.580	0.555	0.585	0.596	0.443
E4 Ttl Seprt	0.765	0.772	0.802	0.832	0.727
E5 Ttl Seprt	0.581	0.615	0.661	0.630	0.490
E6 Ttl Seprt	0.250	0.358	0.468	0.575	0.536
E7 Ttl Seprt	0.564	0.553	0.671	0.712	0.650
E8 Ttl Seprt	0.412	0.432	0.525	0.584	0.489
E9 Ttl Seprt	0.703	0.613	0.608	0.607	0.498
1st Term Ttl Seprt/(E1 - E4)	0.754	0.749	0.766	0.781	0.667
2nd Term Ttl Seprt/(E5 - E6)	0.691	0.693	0.744	0.757	0.646

Retention Variables	MC Rate L0	MC Rate L1	MC Rate L2	MC Rate L3	MC Rate L4
Career Ttl Seprt/(E7 - E9)	0.585	0.630	0.710	0.719	0.573
Crewchiefs Ttl Seprt	0.819	0.807	0.812	0.785	0.710
Flightline Avionics Ttl Seprt	0.757	0.710	0.736	0.747	0.595
Engines Ttl Seprt	0.733	0.775	0.817	0.814	0.697
Fuels Ttl Seprt	0.604	0.661	0.709	0.693	0.567
Weapons Ttl Seprt	0.762	0.763	0.793	0.789	0.676
Sheetmetal Ttl Seprt	0.604	0.606	0.682	0.713	0.591
1st Term Reenlistment Rate	-0.566	-0.519	-0.493	-0.588	-0.578
2nd Term Reenlistment Rate	-0.431	-0.409	-0.435	-0.416	-0.310
Career Reenlistment Rate	0.510	0.435	0.381	0.311	0.336

Table 38. Enlisted Maintainers Assigned Variable Analysis

Enlisted Maintenance Personnel Assigned	MC Rate L0	MC Rate L1	MC Rate L2	MC Rate L3	MC Rate L4
Total (All AFSCs)	0.824	0.814	0.808	0.815	0.839
1 - levels	0.533	0.538	0.533	0.576	0.627
3 - levels	-0.758	-0.769	-0.725	-0.677	-0.636
5 - levels	0.821	0.820	0.820	0.837	0.871
7 - levels	0.876	0.863	0.842	0.824	0.816
9 - levels	0.886	0.854	0.820	0.813	0.791
0 - levels	0.815	0.847	0.828	0.726	0.745
1, 3 and 5 levels	0.728	0.717	0.722	0.750	0.795
E-1	0.265	0.257	0.240	0.226	0.188
E-2	0.405	0.308	0.219	0.168	0.104
E-3	-0.575	-0.550	-0.504	-0.426	-0.298
E-4	0.838	0.848	0.850	0.851	0.854
E-5	0.592	0.580	0.592	0.617	0.664
E-6	0.886	0.881	0.870	0.857	0.851
E-7	0.714	0.689	0.654	0.631	0.619
E-8	0.896	0.892	0.859	0.800	0.789
E-9	0.905	0.900	0.887	0.858	0.842

Enlisted Maintenance Personnel Assigned	MC Rate L0	MC Rate L1	MC Rate L2	MC Rate L3	MC Rate L4
Amn	0.753	0.741	0.736	0.758	0.790
NCO	0.834	0.827	0.830	0.837	0.863
SNCO	0.818	0.804	0.774	0.743	0.734
Crewchiefs	0.909	0.887	0.859	0.832	0.833
1-level	0.760	0.740	0.723	0.736	0.786
3-level	-0.739	-0.788	-0.796	-0.812	-0.822
5-level	0.884	0.882	0.874	0.889	0.920
7-level	0.910	0.896	0.864	0.841	0.829
9-level	0.936	0.901	0.854	0.821	0.797
0-level	0.871	0.868	0.835	0.766	0.759
Flightline Avionics	0.823	0.801	0.765	0.738	0.762
1-level	0.402	0.315	0.197	0.204	0.237
3-level	-0.849	-0.832	-0.762	-0.681	-0.603
5-level	0.648	0.597	0.502	0.516	0.540
7-level	0.698	0.688	0.672	0.666	0.710
9-level	0.936	0.901	0.854	0.821	0.797
0-level	0.871	0.868	0.835	0.766	0.759
Fuels	0.899	0.875	0.840	0.795	0.788
1-level	0.212	0.234	0.253	0.306	0.306
3-level	-0.589	-0.603	-0.616	-0.628	-0.619
5-level	0.756	0.734	0.738	0.745	0.773
7-level	0.916	0.894	0.855	0.819	0.803
9-level	0.857	0.825	0.783	0.739	0.718
0-level	0.852	0.834	0.800	0.747	0.734
Engines	0.918	0.900	0.878	0.863	0.868
1-level	0.573	0.575	0.567	0.596	0.638
3-level	0.678	0.674	0.679	0.701	0.742
5-level	0.875	0.866	0.863	0.867	0.887
7-level	0.882	0.860	0.828	0.804	0.793
9-level	0.883	0.851	0.807	0.767	0.744
0-level	0.852	0.834	0.800	0.747	0.734

Enlisted Maintenance Personnel Assigned	MC Rate L0	MC Rate L1	MC Rate L2	MC Rate L3	MC Rate L4
Weapons	0.924	0.911	0.900	0.888	0.884
1-level	0.695	0.667	0.620	0.562	0.471
3-level	-0.860	-0.901	-0.915	-0.907	-0.897
5-level	0.920	0.921	0.924	0.922	0.925
7-level	0.932	0.917	0.893	0.868	0.850
9-level	0.858	0.815	0.787	0.766	0.710
0-level	0.673	0.692	0.681	0.577	0.630
Strucutres	0.945	0.925	0.898	0.868	0.860
1-level	0.081	0.150	0.167	0.225	0.280
3-level	0.647	0.672	0.720	0.741	0.732
5-level	0.786	0.761	0.732	0.735	0.784
7-level	0.888	0.867	0.832	0.800	0.772
9-level	0.849	0.797	0.757	0.759	0.744
0-level	0.852	0.834	0.800	0.747	0.734
Ratio of 3 to 5 lvls	-0.882	-0.892	-0.879	-0.869	-0.873
Ratio of 3 to 5 lvls (CC)	-0.822	-0.855	-0.853	-0.871	-0.895
Ratio of 3 to 5 lvls (F/L Avn)	-0.852	-0.832	-0.754	-0.689	-0.629
Ratio of 3 to 5 lvls (Fuels)	-0.656	-0.643	-0.639	-0.649	-0.649
Ratio of 3 to 5 lvls (Engines)	0.263	0.295	0.343	0.401	0.482
Ratio of 3 to 5 lvls (Wpns)	-0.891	-0.917	-0.918	-0.908	-0.901
Ratio of 3 to 5 lvls (Strctr)	0.019	0.093	0.202	0.284	0.320
Ratio of 3 to 7 lvls	-0.905	-0.902	-0.872	-0.841	-0.823
Ratio of 3 to 7 lvls (CC)	-0.853	-0.880	-0.869	-0.864	-0.866
Ratio of 3 to 7 lvls (F/L Avn)	-0.901	-0.883	-0.819	-0.747	-0.690
Ratio of 3 to 7 lvls (Fuels)	-0.759	-0.757	-0.752	-0.750	-0.734
Ratio of 3 to 7 lvls (Engines)	0.297	0.332	0.391	0.464	0.557
Ratio of 3 to 7 lvls (Wpns)	-0.897	-0.919	-0.915	-0.900	-0.889
Ratio of 3 to 7 lvls (Strctr)	-0.051	0.017	0.122	0.205	0.278
Ratio of 3 to 5 and 7 lvls	-0.896	-0.901	-0.880	-0.862	-0.858
Ratio of 3 to 5 and 7 lvls (CC)	-0.837	-0.867	-0.861	-0.871	-0.885
Ratio of 3 to 5 and 7 lvls (F/L Avn)	-0.871	-0.851	-0.777	-0.709	-0.649

Enlisted Maintenance Personnel Assigned	MC Rate L0	MC Rate L1	MC Rate L2	MC Rate L3	MC Rate L4
Ratio of 3 to 5 and 7 lvls (Fuels)	-0.696	-0.687	-0.682	-0.688	-0.683
Ratio of 3 to 5 and 7 lvls (Engines)	0.273	0.306	0.358	0.421	0.506
Ratio of 3 to 5 and 7 lvls (Wpns)	-0.894	-0.918	-0.918	-0.906	-0.897
Ratio of 3 to 5 and 7 lvls (Strctr)	-0.003	0.069	0.177	0.260	0.308

Table 39. Enlisted Maintainers Assigned per Aircraft Variable Analysis

Enlisted Maintenance Personnel Assigned per Acft	MC Rate L0	MC Rate L1	MC Rate L2	MC Rate L3	MC Rate L4
Total (All AFSCs) per Aircraft	0.912	0.899	0.893	0.886	0.890
Total (All AFSCs) (A v A)	0.557	0.509	0.440	0.372	0.340
1 - lvls per Acft	0.627	0.631	0.628	0.667	0.717
3 - lvls per Acft	0.102	0.068	0.179	0.247	0.307
5 - lvls per Acft	0.897	0.889	0.887	0.888	0.900
7 - lvls per Acft	0.921	0.907	0.890	0.869	0.855
9 - lvls per Acft	0.933	0.905	0.878	0.863	0.838
0 - lvls per Acft	0.865	0.879	0.864	0.793	0.796
1, 3 and 5 lvls per Acft	0.889	0.877	0.878	0.883	0.899
E-1 per Acft	0.435	0.427	0.408	0.391	0.350
E-2 per Acft	0.605	0.529	0.466	0.447	0.427
E-3 per Acft	-0.162	-0.100	0.016	0.168	0.351
E-4 per Acft	0.918	0.918	0.915	0.905	0.898
E-5 per Acft	0.819	0.808	0.818	0.827	0.852
E-6 per Acft	0.906	0.899	0.889	0.872	0.861
E-7 per Acft	0.892	0.871	0.846	0.824	0.810
E-8 per Acft	0.932	0.922	0.895	0.846	0.830
E-9 per Acft	0.903	0.894	0.883	0.855	0.838
Amn (E1 -E4) per Acft	0.902	0.888	0.882	0.883	0.891
NCO (E5 - E6) per Acft	0.894	0.885	0.886	0.882	0.889
SNCO (E7 - E9) per Acft	0.921	0.905	0.881	0.852	0.836

Enlisted Maintenance Personnel Assigned per Acft	MC Rate L0	MC Rate L1	MC Rate L2	MC Rate L3	MC Rate L4
Crewchiefs per Acft	0.902	0.884	0.864	0.839	0.833
1-lvl per Acft	0.778	0.759	0.745	0.754	0.797
3-lvl per Acft	-0.480	-0.533	-0.526	-0.545	-0.555
5-lvl per Acft	0.897	0.891	0.884	0.884	0.897
7-lvl per Acft	0.917	0.903	0.877	0.853	0.838
9-lvl per Acft	0.935	0.905	0.865	0.833	0.808
0-lvl per Acft	0.876	0.871	0.844	0.785	0.775
Flightline Avionics per Acft	0.855	0.836	0.812	0.787	0.793
1-lvl per Acft	0.479	0.396	0.282	0.287	0.315
3-lvl per Acft	-0.748	-0.732	-0.652	-0.563	-0.474
5-lvl per Acft	0.869	0.836	0.783	0.774	0.775
7-lvl per Acft	0.827	0.816	0.801	0.786	0.797
9-lvl per Acft	0.935	0.905	0.865	0.833	0.808
0-lvl per Acft	0.876	0.871	0.844	0.785	0.775
Fuels per Acft	0.899	0.877	0.850	0.811	0.801
1-lvl per Acft	0.249	0.271	0.289	0.343	0.345
3-lvl per Acft	-0.500	-0.523	-0.540	-0.557	-0.547
5-lvl per Acft	0.817	0.800	0.803	0.801	0.815
7-lvl per Acft	0.932	0.913	0.884	0.852	0.832
9-lvl per Acft	0.861	0.832	0.794	0.751	0.730
0-lvl per Acft	0.857	0.841	0.811	0.760	0.747
Engines per Acft	0.920	0.903	0.885	0.866	0.865
1-lvl per Acft	0.627	0.630	0.622	0.647	0.683
3-lvl per Acft	0.743	0.735	0.735	0.746	0.776
5-lvl per Acft	0.911	0.900	0.897	0.892	0.899
7-lvl per Acft	0.922	0.902	0.875	0.850	0.834
9-lvl per Acft	0.885	0.856	0.817	0.779	0.756
0-lvl per Acft	0.857	0.841	0.811	0.760	0.747
Weapons per Acft	0.915	0.901	0.893	0.877	0.867
1-lvl per Acft	0.743	0.716	0.675	0.617	0.530

Enlisted Maintenance Personnel Assigned per Acft	MC Rate L0	MC Rate L1	MC Rate L2	MC Rate L3	MC Rate L4
3-lvl per Acft	-0.803	-0.856	-0.876	-0.872	-0.863
5-lvl per Acft	0.915	0.911	0.913	0.905	0.902
7-lvl per Acft	0.927	0.912	0.894	0.869	0.849
9-lvl per Acft	0.919	0.884	0.860	0.836	0.787
0-lvl per Acft	0.832	0.838	0.828	0.755	0.776
Strucutres per Acft	0.934	0.914	0.893	0.865	0.853
1-lvl per Acft	0.184	0.242	0.264	0.316	0.371
3-lvl per Acft	0.728	0.743	0.778	0.786	0.773
5-lvl per Acft	0.881	0.857	0.832	0.825	0.850
7-lvl per Acft	0.929	0.908	0.880	0.848	0.819
9-lvl per Acft	0.922	0.884	0.855	0.844	0.821
0-lvl per Acft	0.857	0.841	0.811	0.760	0.747

Table 40. Enlisted Maintainers Authorized versus Assigned Variable Analysis

Enlisted Authorized versus Assigned	MC Rate L0	MC Rate L1	MC Rate L2	MC Rate L3	MC Rate L4
Total (All AFSCs) (A v A)	0.557	0.509	0.440	0.372	0.340
1 - levels	0.467	0.475	0.464	0.510	0.560
3 - levels	-0.901	-0.905	-0.884	-0.865	-0.858
5 - levels	0.688	0.710	0.725	0.768	0.825
7 - levels	0.819	0.807	0.767	0.714	0.661
9 - levels	0.827	0.772	0.716	0.693	0.623
0 - levels	0.299	0.357	0.338	0.191	0.238
1, 3 and 5 levels	-0.852	-0.837	-0.791	-0.726	-0.670
E-1	0.034	0.031	0.028	0.006	-0.037
E-2	0.142	0.015	-0.112	-0.231	-0.372
E-3	-0.738	-0.733	-0.724	-0.709	-0.675
E-4	0.755	0.792	0.810	0.802	0.760
E-5	-0.547	-0.530	-0.487	-0.448	-0.401

Enlisted Authorized versus Assigned	MC Rate L0	MC Rate L1	MC Rate L2	MC Rate L3	MC Rate L4
E-6	0.746	0.771	0.776	0.761	0.744
E-7	0.221	0.159	0.059	-0.041	-0.160
E-8	0.789	0.781	0.707	0.566	0.503
E-9	0.513	0.522	0.512	0.462	0.430
Amn	-0.675	-0.684	-0.666	-0.602	-0.568
NCO	0.259	0.333	0.411	0.454	0.507
SNCO	0.523	0.479	0.383	0.255	0.142
Crewchiefs	0.499	0.502	0.489	0.454	0.454
1-level	0.701	0.678	0.658	0.679	0.740
3-level	-0.872	-0.896	-0.886	-0.884	-0.893
5-level	-0.063	-0.009	0.026	0.155	0.224
7-level	0.730	0.737	0.705	0.692	0.657
9-level	0.906	0.863	0.807	0.776	0.735
0-level	0.799	0.808	0.773	0.672	0.662
Flightline Avionics	0.099	0.088	0.067	0.045	0.083
1-level	0.294	0.206	0.086	0.098	0.131
3-level	-0.926	-0.903	-0.835	-0.761	-0.705
5-level	-0.506	-0.505	-0.527	-0.496	-0.508
7-level	-0.652	-0.626	-0.583	-0.535	-0.520
9-level	0.933	0.891	0.842	0.810	0.762
0-level	0.859	0.867	0.836	0.742	0.722
Fuels	0.767	0.736	0.690	0.626	0.606
1-level	0.115	0.142	0.165	0.221	0.213
3-level	-0.777	-0.759	-0.740	-0.723	-0.710
5-level	-0.793	-0.772	-0.705	-0.608	-0.564
7-level	-0.613	-0.581	-0.543	-0.483	-0.483
9-level	0.840	0.803	0.756	0.710	0.681
0-level	0.805	0.792	0.759	0.698	0.684
Engines	0.890	0.869	0.839	0.812	0.805
1-level	0.442	0.448	0.437	0.474	0.520
3-level	0.091	0.135	0.207	0.296	0.402

Enlisted Authorized versus Assigned	MC Rate L0	MC Rate L1	MC Rate L2	MC Rate L3	MC Rate L4
5-level	-0.551	-0.556	-0.560	-0.558	-0.586
7-level	-0.647	-0.643	-0.651	-0.663	-0.706
9-level	0.802	0.756	0.698	0.649	0.605
0-level	0.738	0.723	0.687	0.617	0.607
Weapons	0.691	0.687	0.681	0.661	0.634
1-level	0.585	0.554	0.493	0.435	0.330
3-level	-0.906	-0.929	-0.930	-0.918	-0.908
5-level	0.776	0.817	0.849	0.870	0.886
7-level	0.769	0.778	0.745	0.702	0.665
9-level	0.413	0.340	0.297	0.253	0.133
0-level	-0.605	-0.552	-0.532	-0.622	-0.547
Strucutres	0.878	0.849	0.807	0.755	0.722
1-level	-0.201	-0.113	-0.104	-0.030	0.024
3-level	-0.183	-0.118	-0.015	0.064	0.092
5-level	-0.393	-0.436	-0.487	-0.492	-0.469
7-level	-0.352	-0.386	-0.431	-0.462	-0.559
9-level	-0.755	-0.785	-0.777	-0.745	-0.784
0-level	0.783	0.768	0.733	0.670	0.659

Table 41. Maintenance Officers Assigned Variable Analysis

Maintenance Officers Assigned (Flightline and Staff)	MC Rate L0	MC Rate L1	MC Rate L2	MC Rate L3	MC Rate L4
Maintainers per O1 (F/L)	0.775	0.736	0.762	0.773	0.775
Maintainers per O2 (F/L)	0.647	0.756	0.851	0.882	0.863
Maintainers per O3 (F/L)	-0.919	-0.929	-0.955	-0.962	-0.942
Maintainers per O4 (F/L)	0.769	0.697	0.639	0.606	0.563
Maintainers per O5 (F/L)	0.684	0.672	0.620	0.538	0.533
Maintainers per Total F/L Mx Officer	-0.193	-0.234	-0.305	-0.317	-0.338
Maintainers per CGO (O1 -O3)	-0.713	-0.734	-0.756	-0.731	-0.713
Maintainers per FGO (O4 - O5)	0.700	0.647	0.616	0.583	0.543

Maintenance Officers Assigned (Flightline and Staff)	MC Rate L0	MC Rate L1	MC Rate L2	MC Rate L3	MC Rate L4
O1 (F/L)	-0.538	-0.507	-0.569	-0.610	-0.610
O2 (F/L)	-0.339	-0.487	-0.617	-0.676	-0.672
O3 (F/L)	0.898	0.907	0.933	0.944	0.941
O4 (F/L)	-0.545	-0.473	-0.409	-0.375	-0.323
O5 (F/L)	-0.100	-0.057	-0.015	-0.004	0.016
O6 (F/L)	0.052	0.078	0.098	0.121	0.118
Total F/L	0.545	0.580	0.640	0.661	0.695
O1 (staff)	-0.151	-0.096	-0.042	0.013	0.033
O2 (staff)	-0.699	-0.632	-0.626	-0.608	-0.593
O3 (staff)	-0.597	-0.590	-0.581	-0.543	-0.566
O4 (staff)	0.869	0.848	0.820	0.792	0.760
O5 (staff)	0.935	0.938	0.936	0.922	0.902
O6 (staff)	0.850	0.873	0.906	0.926	0.931
Total Staff	0.897	0.890	0.877	0.863	0.834
Total (all)	0.861	0.877	0.900	0.904	0.904

Table 42. Maintenance Officers Authorized versus Assigned Variable Analysis

Maintenance Officer Authorized versus Assigned	MC Rate L0	MC Rate L1	MC Rate L2	MC Rate L3	MC Rate L4
O2 (F/L)	0.424	0.497	-0.738	-0.768	-0.667
O3 (F/L)	-0.332	-0.329	0.589	0.625	0.424
O4 (F/L)	-0.049	0.113	-0.199	-0.184	-0.371
O5 (F/L)	0.107	-0.020	-0.088	-0.016	-0.067
O6 (F/L)	0.449	-0.274	0.069	0.063	0.052
Total F/L	0.104	-0.303	0.468	0.374	0.389
O2 (staff)	0.328	-0.226	0.072	0.098	0.063
O3 (staff)	0.681	-0.359	0.281	0.338	0.310
O4 (staff)	-0.100	-0.770	0.693	0.684	0.696
O5 (staff)	0.611	-0.028	-0.046	-0.058	-0.103
O6 (staff)	-0.411	-0.738	0.567	0.539	0.568
Total Staff	-0.348	0.209	-0.313	-0.276	-0.381
Total (all)	0.029	0.277	-0.321	-0.358	-0.445

Table 43. Aircraft Utilization Variable Analysis

Utilization Variables	MC Rate L0	MC Rate L1	MC Rate L2	MC Rate L3	MC Rate L4
Possessed Hours	-0.872	-0.859	-0.833	-0.814	-0.815
Average Aircraft Inventory	-0.874	-0.863	-0.854	-0.834	-0.816
Flying Hours	-0.397	-0.477	-0.489	-0.396	-0.383
Sorties	-0.217	-0.352	-0.361	-0.247	-0.259
Quarterly UTE Rate	0.429	0.332	0.316	0.399	0.410
Average Sortie Duration	-0.440	-0.409	-0.421	-0.400	-0.358
8-hr Fix Rate (ACC)	0.821	0.782	0.770	0.735	0.789
TNMCM Rate	-0.990	-0.938	-0.908	-0.863	-0.815
TNMCS Rate	-0.943	-0.900	-0.865	-0.861	-0.843

Table 44. Reliability and Maintainability Variable Analysis

Reliability and Maintainability Variables	MC Rate L0	MC Rate L1	MC Rate L2	MC Rate L3	MC Rate L4
Supply Reliability All	-0.777	0.812	-0.751	-0.754	-0.772
Mx Reliability All	-0.899	0.866	-0.896	-0.854	-0.901
Breaks All	-0.623	0.532	-0.673	-0.610	-0.642
Supply Downtime All	-0.716	0.794	-0.699	-0.755	-0.735
Mx Downtime All	-0.903	0.722	-0.821	-0.767	-0.913
TNMCM Hours All	-0.987	0.903	-0.908	-0.866	-0.986
TNMCS Hours All	-0.955	0.995	-0.882	-0.875	-0.951
Supply Reliability Top 25 (sum)	-0.770	0.797	-0.739	-0.732	-0.769
Mx Reliability Top 25 (sum)	-0.900	0.809	-0.876	-0.805	-0.907
Breaks Top 25 (sum)	-0.454	0.354	-0.546	-0.472	-0.497
Supply Downtime Top 25 (sum)	-0.578	0.614	-0.582	-0.650	-0.611
Mx Downtime Top 25 (sum)	-0.813	0.592	-0.728	-0.655	-0.843
TNMCM Hours Top 25 (sum)	-0.922	0.769	-0.814	-0.758	-0.921
TNMCS Hours Top 25 (sum)	-0.939	0.953	-0.833	-0.824	-0.951
Supply Reliability Top 50 (sum)	-0.762	0.789	-0.733	-0.729	-0.760
Mx Reliability Top 50 (sum)	-0.886	0.802	-0.873	-0.807	-0.890

Reliability and Maintainability Variables	MC Rate L0	MC Rate L1	MC Rate L2	MC Rate L3	MC Rate L4
Breaks Top 50 (sum)	-0.567	0.472	-0.633	-0.565	-0.588
Supply Downtime Top 50 (sum)	-0.638	0.691	-0.630	-0.693	-0.661
Mx Downtime Top 50 (sum)	-0.825	0.608	-0.745	-0.675	-0.851
TNMCM Hours Top 50 (sum)	-0.944	0.805	-0.843	-0.789	-0.942
TNMCS Hours Top 50 (sum)	-0.948	0.973	-0.850	-0.841	-0.954
Supply Reliability Top 100 (sum)	-0.762	0.792	-0.735	-0.733	-0.759
Mx Reliability Top 100 (sum)	-0.890	0.816	-0.882	-0.822	-0.893
Supply Downtime Top 100 (sum)	-0.674	0.742	-0.655	-0.718	-0.693
Mx Downtime Top 100 (sum)	-0.852	0.643	-0.770	-0.707	-0.869
TNMCM Hours Top 100 (sum)	-0.965	0.845	-0.873	-0.822	-0.963
TNMCS Hours Top 100 (sum)	-0.953	0.985	-0.859	-0.854	-0.953
Supply Reliability Top 200 (sum)	-0.769	0.801	-0.742	-0.742	-0.765
Mx Reliability Top 200 (sum)	-0.900	0.841	-0.894	-0.842	-0.902
Supply Downtime Top 200 (sum)	-0.692	0.770	-0.671	-0.733	-0.711
Mx Downtime Top 200 (sum)	-0.875	0.677	-0.794	-0.735	-0.890
TNMCM Hours Top 200 (sum)	-0.979	0.876	-0.893	-0.846	-0.978
TNMCS Hours Top 200 (sum)	-0.952	0.993	-0.868	-0.864	-0.950

Table 45. Derived Reliability and Maintainability Variable Analysis

Reliability and Maintainability Variables	MC Rate L0	MC Rate L1	MC Rate L2	MC Rate L3	MC Rate L4
Supply Reliability per F/H	-0.784	-0.756	-0.741	-0.754	-0.770
Mx Reliability per F/H	-0.889	-0.830	-0.829	-0.835	-0.802
Breaks per F/H	-0.603	-0.608	-0.621	-0.586	-0.609
Supply Downtime per F/H	-0.667	-0.620	-0.615	-0.705	-0.746
Mx Downtime per F/H	-0.843	-0.759	-0.724	-0.697	-0.659
Supply Reliability per Acft	-0.774	-0.757	-0.747	-0.748	-0.755
Mx Reliability per Acft	-0.846	-0.836	-0.854	-0.804	-0.739
Breaks per Acft	-0.459	-0.510	-0.535	-0.461	-0.481
Supply Downtime per Acft	-0.631	-0.610	-0.615	-0.688	-0.725

Mx Downtime per Acft	-0.876	-0.811	-0.783	-0.720	-0.665
Supply Reliability per Sortie	-0.789	-0.759	-0.748	-0.758	-0.767
Mx Reliability per Sortie	-0.924	-0.863	-0.866	-0.860	-0.809
Breaks per Sortie	-0.639	-0.635	-0.651	-0.613	-0.620
Supply Downtime per Sortie	-0.697	-0.647	-0.647	-0.729	-0.760
Mx Downtime per Sortie	-0.876	-0.790	-0.761	-0.729	-0.681
Supply Reliability per M ntnr	-0.799	-0.782	-0.770	-0.770	-0.773
Mx Reliability per Mntnr	-0.897	-0.887	-0.888	-0.860	-0.827
Breaks per Mntnr	-0.764	-0.785	-0.788	-0.734	-0.737
Supply Downtime per Mntnr	-0.797	-0.776	-0.765	-0.807	-0.832
Mx Downtime per Mntnr	-0.962	-0.915	-0.882	-0.838	-0.800

Table 46. Work Unit Code Variable Analysis

Work Unit Code Variables	**MC Rate L0**	**MC Rate L1**	**MC Rate L2**	**MC Rate L3**	**MC Rate L4**
Manhours (all)	-0.774	0.870	-0.797	-0.777	-0.754
Repair Hours (all)	-0.534	0.597	-0.599	-0.564	-0.529
Repair Actions (all)	-0.021	0.097	-0.085	-0.099	-0.077
MMH per Sortie (avg all)	-0.773	0.871	-0.774	-0.767	-0.751
MMH per Flying Hour (avg all)	-0.758	0.860	-0.758	-0.756	-0.735
Cann Hours (all)	-0.579	0.744	-0.529	-0.505	-0.541
Cann Actions (all)	-0.461	0.655	-0.401	-0.386	-0.414
MTTR (Repair Actions) (avg all)	-0.613	0.601	-0.615	-0.549	-0.595
MTTR (NMCS Count) (Repair Actions) (avg all)	-0.613	0.601	-0.615	-0.549	-0.595
Manhours Top 25	-0.765	0.870	-0.792	-0.762	-0.745
Repair Hours Top 25	-0.381	0.447	-0.457	-0.413	-0.392
Repair Actions Top 25	0.057	0.031	0.035	0.053	0.020
MMH per Sortie Top 25 (avg)	-0.769	0.875	-0.778	-0.757	-0.747
MMH per Flying Hour Top 25 (avg)	-0.762	0.871	-0.771	-0.754	-0.739
Cann Hours Top 25	-0.615	0.767	-0.587	-0.562	-0.583
Cann Actions Top 25	-0.505	0.696	-0.463	-0.454	-0.473
MTTR (Repair Actions) Top 25 (avg)	-0.530	0.487	-0.557	-0.499	-0.510

Work Unit Code Variables	MC Rate L0	MC Rate L1	MC Rate L2	MC Rate L3	MC Rate L4
MTTR (NMCS Count) (Rpr Actns) Top 25 (avg)	-0.647	0.684	-0.658	-0.650	-0.633
Manhours Top 50	-0.763	0.866	-0.791	-0.764	-0.742
Repair Hours Top 50	-0.388	0.445	-0.476	-0.432	-0.405
Repair Actions Top 50	0.019	0.064	-0.018	-0.008	-0.023
MMH per Sortie Top 50 (avg)	-0.766	0.870	-0.775	-0.758	-0.743
MMH per Flying Hour Top 50 (avg)	-0.757	0.865	-0.766	-0.753	-0.733
Cann Hours Top 50	-0.617	0.775	-0.578	-0.555	-0.582
Cann Actions Top 50	-0.487	0.685	-0.431	-0.419	-0.446
MTTR (Repair Actions) Top 50 (avg)	-0.505	0.455	-0.527	-0.459	-0.483
MTTR (NMCS Count) (Rpr Actns) Top 50 (avg)	-0.639	0.657	-0.628	-0.622	-0.674
Manhours Top 100	-0.762	0.864	-0.790	-0.766	-0.741
Repair Hours Top 100	-0.427	0.485	-0.511	-0.472	-0.440
Repair Actions Top 100	0.001	0.080	-0.045	-0.043	-0.044
MMH per Sortie Top 100 (avg)	-0.764	0.867	-0.771	-0.758	-0.739
MMH per Flying Hour Top 100 (avg)	-0.752	0.859	-0.760	-0.751	-0.727
Cann Hours Top 100	-0.599	0.763	-0.549	-0.526	-0.561
Cann Actions Top 100	-0.468	0.668	-0.403	-0.389	-0.422
MTTR (Repair Actions) Top 100 (avg)	-0.527	0.488	-0.544	-0.472	-0.503
MTTR (NMCS Count) (Rpr Actns) Top 100 (avg)	-0.642	0.648	-0.630	-0.617	-0.630
Manhours Top 200	-0.763	0.864	-0.791	-0.769	-0.743
Repair Hours Top 200	-0.461	0.522	-0.538	-0.500	-0.468
Repair Actions Top 200	-0.004	0.083	-0.062	-0.068	-0.058
MMH per Sortie Top 200 (avg)	-0.764	0.866	-0.771	-0.760	-0.740
MMH per Flying Hour Top 200 (avg)	-0.751	0.857	-0.758	-0.752	-0.726
Cann Hours Top 200	-0.578	0.743	-0.524	-0.501	-0.539
Cann Actions Top 200	-0.454	0.653	-0.390	-0.376	-0.407
MTTR (Repair Actions) Top 200 (avg)	-0.564	0.534	-0.569	-0.498	-0.536
MTTR (NMCS Count) (Rpr Actns) Top 200 (avg)	-0.652	0.652	-0.650	-0.623	-0.643

Table 47. Derived Work Unit Code Variable Analysis

Work Unit Code Variables	MC Rate L0	MC Rate L1	MC Rate L2	MC Rate L3	MC Rate L4
MMH per Mntnr	-0.792	-0.807	-0.804	-0.792	-0.729
MMH per Acft	-0.721	-0.747	-0.746	-0.721	-0.654
MMH per Sortie	-0.773	-0.778	-0.774	-0.773	-0.705
MMH per F/H	-0.758	-0.767	-0.758	-0.758	-0.707
Repair Hrs per Mntnr	-0.691	-0.730	-0.730	-0.691	-0.679
Repair Hrs per Acft	-0.351	-0.421	-0.422	-0.351	-0.351
Repair Hrs per Sortie	-0.530	-0.561	-0.563	-0.530	-0.520
Repair Hrs per F/H	-0.466	-0.505	-0.498	-0.466	-0.467
Repair Actns per Mntnr	-0.306	-0.363	-0.349	-0.306	-0.310
Repair Actns per Acft	0.194	0.119	0.137	0.194	0.169
Repair Actns per Sortie	0.026	-0.026	-0.009	0.026	0.005
Repair Actns per F/H	0.103	0.046	0.071	0.103	0.073
Cann Hrs per Mntnr (minutes)	-0.700	-0.696	-0.649	-0.700	-0.615
Cann Hrs per Acft	-0.431	-0.435	-0.375	-0.431	-0.328
Cann Actns per Mntnr	-0.614	-0.618	-0.553	-0.614	-0.523
Cann Actns per Acft	-0.300	-0.314	-0.236	-0.300	-0.196
Cann Actns per Sortie	-0.418	-0.413	-0.338	-0.418	-0.314
Cann Actns per F/H	-0.365	-0.363	-0.283	-0.365	-0.264
MTTR	-0.613	-0.604	-0.615	-0.613	-0.570
Cann Hrs as pct of MMH	0.480	0.521	0.588	0.480	0.515
Pct Avlbl MMH Reported	-0.798	-0.810	-0.801	-0.798	-0.737
Repair Hrs as pct of MMH	0.642	0.658	0.667	0.642	0.645

Table 48. Weighted Work Unit Code Variable Analysis

Weighted Work Unit Code Variables	MC Rate L0	MC Rate L1	MC Rate L2	MC Rate L3	MC Rate L4
TNMCS Hours Weighted Top 50	-0.911	0.903	-0.847	-0.838	-0.932
TNMCM Hours Weighted Top 50	-0.942	0.833	-0.877	-0.834	-0.959
Supply Reliability Weighted Top 50	-0.767	0.795	-0.735	-0.733	-0.766
Mx Reliability Weighted Top 50	-0.892	0.809	-0.884	-0.818	-0.902
Supply Downtime Weighted Top 50	-0.699	0.690	-0.558	-0.568	-0.707
Mx Downtime Weighted Top 50	-0.845	0.832	-0.857	-0.851	-0.840
Cann Hours Weighted Top 50	-0.697	0.829	-0.653	-0.614	-0.667
Cann Actions Weighted Top 50	-0.581	0.761	-0.528	-0.504	-0.541
Cann Hours Weighted Top 50	-0.697	0.829	-0.653	-0.614	-0.667
Code 3 Breaks Weighted Top 50	-0.563	0.463	-0.630	-0.561	-0.588
Repair Hours Weighted Top 50	-0.505	0.523	-0.603	-0.578	-0.537
Repair Actions Weighted Top 50	0.075	0.008	0.017	0.005	0.014
Manhours Weighted Top 50	-0.792	0.886	-0.839	-0.814	-0.778
Serv Inv Weighted Top 50	0.403	-0.467	0.367	0.315	0.351
Unserv Inv Weighted Top 50	0.439	-0.523	0.355	0.382	0.367
Rep parts Failures Weighted Top 50	-0.448	0.406	-0.542	-0.496	-0.563
Avg OST Weighted Top 50	0.587	-0.701	0.588	0.575	0.620
Avg DRC Weighted Top 50	0.154	-0.182	-0.108	-0.229	-0.129
Avg BRC Weighted Top 50	0.405	-0.532	0.329	0.268	0.342
Avg MTTR (Repair Actions) Weighted Top 50	-0.681	0.608	-0.703	-0.647	-0.666
Avg MTTR (TNMCS) of Top 50	-0.499	0.508	-0.521	-0.503	-0.479
Top 50 TNMCS Hours (pct)	-0.423	0.302	-0.459	-0.452	-0.577
Top 50 TNMCM Hours (pct)	-0.048	-0.068	-0.172	-0.191	-0.277
Top 50 NMCS Reliability (pct)	-0.755	0.737	-0.683	-0.651	-0.759
Top 50 NMCM Reliability (pct)	-0.390	0.188	-0.457	-0.367	-0.522
Top 50 Supply Downtime (pct)	-0.060	-0.074	0.110	0.138	-0.071
Top 50 Mx Downtime (pct)	-0.815	0.771	-0.807	-0.799	-0.827
Top 50 Cann Hours (pct)	-0.694	0.614	-0.640	-0.546	-0.678
Top 50 Cann Actions (pct)	-0.465	0.430	-0.406	-0.377	-0.454

Weighted Work Unit Code Variables	MC Rate L0	MC Rate L1	MC Rate L2	MC Rate L3	MC Rate L4
Top 50 Cann Hours (pct)	-0.694	0.614	-0.640	-0.546	-0.678
Top 50 Code 3 Breaks (pct)	0.871	-0.858	0.805	0.807	0.872
Top 50 Repair Hours (pct)	0.123	-0.295	0.048	0.007	-0.002
Top 50 Repair Actions (pct)	0.494	-0.493	0.539	0.560	0.459
Top 50 Manhours (pct)	-0.388	0.360	-0.602	-0.619	-0.560
Top 50 Serv Inv NIINs (pct)	0.244	-0.260	0.062	-0.038	0.022
Top 50 Unserv Inv NIINs (pct)	0.548	-0.606	0.550	0.559	0.626
Top 50 Part Failure NIINs (pct)	0.531	-0.560	0.526	0.458	0.556

Table 49. Derived Weighted WUC and NIIN Variable Analysis

Weighted Work Unit Code Variables	MC Rate L0	MC Rate L1	MC Rate L2	MC Rate L3	MC Rate L4
Avg MTTR (Rpr Actns) Wtd Top 50	-0.681	-0.678	-0.703	-0.647	-0.684
Avg MTTR (NMCS Cnt) Wtd Top 50	-0.499	-0.483	-0.521	-0.503	-0.515
Top 50 TNMCS Hrs (pct)	-0.423	-0.470	-0.459	-0.452	-0.449
Top 50 TNMCM Hrs (pct)	-0.048	-0.160	-0.172	-0.191	-0.210
Top 50 NMCS Rlblty (pct)	-0.755	-0.731	-0.683	-0.651	-0.707
Top 50 NMCM Rlblty (pct)	-0.390	-0.463	-0.457	-0.367	-0.447
Top 50 Supply DT (pct)	-0.060	-0.003	0.110	0.138	0.078
Top 50 Mx DT (pct)	-0.815	-0.829	-0.807	-0.799	-0.788
Top 50 Cann Hrs (pct)	-0.694	-0.649	-0.640	-0.546	-0.548
Top 50 Cann Actns (pct)	-0.465	-0.440	-0.406	-0.377	-0.452
Top 50 Cann Hrs (pct)	-0.694	-0.649	-0.640	-0.546	-0.548
Top 5 Code 3 Breaks (pct)	0.888	0.904	0.882	0.870	0.845
Top 50 Rpr Hrs (pct)	0.124	0.079	0.048	0.007	-0.068
Top 50 Rpr Actns (pct)	0.494	0.474	0.539	0.560	0.564
Top 50 MMH (pct)	-0.387	-0.473	-0.602	-0.619	-0.713
Top 50 Serv Inv NIINs (pct)	0.244	0.161	0.062	-0.038	-0.246
Top 50 Unserv Inv NIINs (pct)	0.548	0.625	0.550	0.559	0.537
Top 50 Part Failure NIINs (pct)	0.531	0.565	0.526	0.458	0.410
Top 50 Mx DT per Mntnr	-0.857	-0.869	-0.866	-0.861	-0.885
Top 50 Cann Hrs per Mntnr	-0.769	-0.757	-0.723	-0.689	-0.690
Top 50 Cann Actns per Mntnr	-0.682	-0.684	-0.628	-0.605	-0.624
Top 50 Rpr Hrs per Mntnr	-0.678	-0.731	-0.739	-0.714	-0.707
Top 50 Rpr Actns per Mntnr	-0.235	-0.303	-0.276	-0.280	-0.234
Top 50 MMH per Mntnr	-0.809	-0.830	-0.840	-0.816	-0.763
Top 50 NMCS Rlblty per Sortie	-0.779	-0.750	-0.733	-0.738	-0.759

Weighted Work Unit Code Variables	MC Rate L0	MC Rate L1	MC Rate L2	MC Rate L3	MC Rate L4
Top 50 NMCM Rlblty per Sortie	-0.914	-0.862	-0.861	-0.821	-0.800
Top 50 Cann Actns per Sortie	-0.558	-0.548	-0.481	-0.470	-0.485
Top 5 Code 3 Breaks per Sortie	0.015	-0.012	-0.088	-0.061	-0.089
Top 50 Rpr Hrs per Sortie	-0.500	-0.555	-0.571	-0.568	-0.558
Top 50 Rpr Actns per Sortie	0.121	0.065	0.094	0.062	0.111
Top 50 MMH per Sortie	-0.799	-0.812	-0.826	-0.813	-0.758
Top 50 Supply DT per Acft	-0.611	-0.543	-0.449	-0.463	-0.530
Top 50 Mx DT per Acft	-0.843	-0.858	-0.860	-0.855	-0.882
Top 50 Cann Hrs per Acft	-0.607	-0.598	-0.555	-0.514	-0.503
Top 50 Cann Actns per Acft	-0.470	-0.478	-0.408	-0.385	-0.392
Top 5 Code 3 Breaks per Acft	0.368	0.284	0.209	0.273	0.236
Top 50 Rpr Hrs per Acft	-0.332	-0.429	-0.445	-0.419	-0.411
Top 50 Rpr Actns per Acft	0.282	0.205	0.235	0.224	0.269
Top 50 MMH per Acft	-0.753	-0.788	-0.804	-0.779	-0.718
Top 50 Serv Inv NIINs per Acft	0.590	0.659	0.598	0.545	0.493
Top 50 Unserv Inv NIINs per Acft	0.610	0.634	0.575	0.607	0.595
Top 50 Part Failure NIINs per Acft	-0.376	-0.398	-0.470	-0.418	-0.370
Top 50 NMCS Rlblty per F/H	-0.775	-0.748	-0.726	-0.734	-0.761
Top 50 NMCM Rlblty per F/H	-0.893	-0.845	-0.838	-0.806	-0.801
Top 50 Supply DT per F/H	-0.644	-0.559	-0.467	-0.502	-0.567
Top 50 Mx DT per F/H	-0.855	-0.851	-0.844	-0.854	-0.892
Top 50 Cann Actns per F/H	-0.519	-0.512	-0.439	-0.429	-0.447
Top 5 Code 3 Breaks per F/H	0.150	0.113	0.043	0.064	0.023
Top 50 Rpr Hrs per F/H	-0.441	-0.504	-0.512	-0.514	-0.513
Top 50 Rpr Actns per F/H	0.197	0.136	0.172	0.138	0.177
Top 50 MMH per F/H	-0.793	-0.811	-0.821	-0.812	-0.767
Top 50 NMCS Rlblty per Acft	-0.766	-0.749	-0.732	-0.729	-0.748
Top 50 NMCM Rlblty per Acft	-0.866	-0.856	-0.864	-0.783	-0.761

Table 50. D041 Variable Analysis

D041 Variables	MC Rate L0	MC Rate L1	MC Rate L2	MC Rate L3	MC Rate L4
Serv Inv (all)	-0.222	0.240	-0.122	-0.068	-0.053
Unserv Inv (all)	0.033	-0.112	-0.040	-0.015	-0.084
OST (avg all)	0.836	-0.919	0.847	0.832	0.828
BRC (avg all)	0.182	-0.230	0.089	0.063	0.198
DRC (avg all)	0.797	-0.857	0.773	0.758	0.815
Rep Item Failures (all)	-0.568	0.539	-0.549	-0.495	-0.575
Serv Inv Top 25 (sum)	-0.210	0.230	-0.098	-0.040	-0.034
Unserv Inv Top 25 (sum)	0.391	-0.497	0.322	0.362	0.320
OST Top 25 (avg)	0.620	-0.639	0.618	0.635	0.602
BRC Top 25 (avg)	0.252	-0.342	0.183	0.133	0.218
DRC Top 25 (avg)	-0.044	0.028	-0.139	-0.237	-0.114
Rep Itm Failures Top 25 (sum)	-0.566	0.527	-0.538	-0.486	-0.563
Serv Inv Top 50 (sum)	-0.226	0.247	-0.122	-0.065	-0.064
Unserv Inv Top 50 (sum)	0.333	-0.435	0.261	0.297	0.250
OST Top 50 (avg)	0.764	-0.805	0.747	0.749	0.752
BRC Top 50 (avg)	0.164	-0.258	0.090	0.041	0.124
DRC Top 50 (avg)	0.088	-0.141	0.003	-0.104	0.024
Rep Itm Failures Top 50 (sum)	-0.569	0.534	-0.539	-0.486	-0.565
Serv Inv Top 100 (sum)	-0.237	0.260	-0.138	-0.084	-0.086
Unserv Inv Top 100 (sum)	0.263	-0.358	0.186	0.218	0.166
OST Top 100 (avg)	0.821	-0.871	0.790	0.779	0.810
BRC Top 100 (avg)	0.119	-0.208	0.039	-0.010	0.074
DRC Top 100 (avg)	0.095	-0.221	-0.019	-0.089	0.000
Rep Itm Failures Top 100 (sum)	-0.569	0.538	-0.538	-0.486	-0.564
Serv Inv Top 200 (sum)	-0.239	0.262	-0.142	-0.089	-0.088
Unserv Inv Top 200 (sum)	0.210	-0.298	0.132	0.162	0.104
OST Top 200 (avg)	0.853	-0.907	0.815	0.798	0.843
BRC Top 200 (avg)	0.093	-0.177	0.016	-0.034	0.051
DRC Top 200 (avg)	0.129	-0.271	0.061	0.019	0.036
Rep Itm Failures Top 200 (sum)	-0.570	0.540	-0.540	-0.487	-0.566

Appendix P: Explanatory Model Variable Data Points

Quarter	MC Rate	Avg Acft Inv	8-hr Fix Rate (ACC)	7-lvls (assgn)	Ratio of 3 to 7 lvls	Ratio of 3 to 5 and 7 lvls	Maintainers per Acft	TNMCM Hours Wtd Top 50
97-3	78.07%	1302.4	81.23%	9157	0.89	0.28	29.67	268025.2
94-1	81.12%	1202.4	89.49%	11825	0.64	0.22	37.29	221363.2
96-1	80.90%	1292.0	85.08%	9654	0.83	0.27	31.03	246355.4
98-1	75.75%	1299.4	77.70%	8876	0.90	0.29	28.93	294192.8
96-4	78.18%	1300.8	79.86%	9528	0.87	0.29	30.27	286948.8
97-1	78.31%	1303.8	81.46%	9395	0.89	0.29	29.95	258767.5
96-3	81.36%	1297.3	80.08%	9514	0.86	0.28	30.52	238873.5
93-3	84.79%	1142.1	90.22%	11261	0.64	0.22	36.97	159008.3
00-1	75.82%	1276.6	78.05%	8484	0.95	0.31	28.02	294578.8
94-3	80.01%	1249.0	87.19%	11210	0.73	0.24	35.40	227459.4
99-3	75.85%	1278.1	80.21%	8336	0.97	0.30	28.38	315265.4
96-2	81.31%	1293.4	82.00%	9661	0.82	0.26	31.05	242401.2
98-3	77.05%	1296.3	80.05%	8599	0.91	0.29	28.44	299566.9
97-4	76.20%	1301.0	77.44%	8855	0.92	0.29	29.21	288314.1
95-1	78.75%	1270.3	84.17%	10633	0.78	0.26	33.44	310889.4
95-4	81.03%	1287.9	81.24%	9754	0.83	0.27	31.33	246617.4
93-2	86.59%	1130.6	88.90%	11560	0.62	0.22	37.91	141102.1
97-2	78.18%	1303.7	81.31%	9302	0.87	0.28	29.94	281562.9
93-4	82.08%	1162.7	88.19%	11098	0.62	0.21	35.80	193964.7
95-2	79.62%	1278.5	88.28%	10248	0.78	0.26	32.41	280366.0
99-2	75.88%	1279.7	78.61%	8560	0.92	0.29	28.65	341401.0
94-4	81.01%	1264.7	88.50%	10898	0.76	0.25	34.38	240914.7
00-2	76.79%	1274.8	75.32%	8637	0.93	0.31	28.25	272225.5
98-4	75.75%	1291.3	75.96%	8535	0.94	0.30	28.51	339583.6
94-2	80.41%	1226.5	90.20%	11734	0.67	0.22	36.82	218124.6
99-4*	76.20%	1276.7	75.45%	8350	0.97	0.31	28.24	283968.2
95-3*	80.19%	1284.6	86.32%	9862	0.79	0.25	31.45	245464.9
93-1*	85.60%	1121.0	89.53%	11514	0.59	0.21	37.98	139440.7
98-2*	75.58%	1297.2	76.72%	8886	0.86	0.27	28.88	302333.5
99-1*	75.73%	1284.6	78.79%	8554	0.93	0.30	28.43	375326.7
00-3*	78.69%	1272.9	80.00%	8556	0.98	0.33	28.00	244641.5
00-4*	76.32%	1270.6	76.92%	8570	0.96	0.32	27.87	250833.8

Table title: **Explanatory Model Data Points**

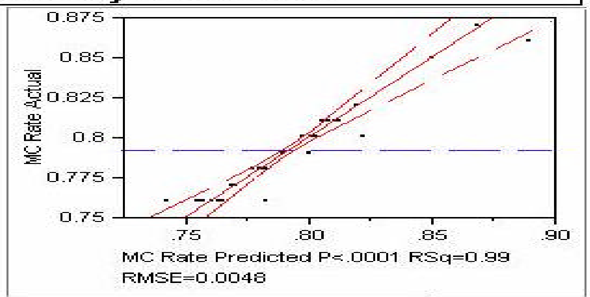
*This quarter's data randomly selected and removed from model building process and used for sensitivity analysis

Explanatory Model Data Points									
Quarter	Mx Reliability Wtd Top 50	Cann Hrs Wtd Top 50	O3 (F/L) (L3)	3-lvls (assgn)	5-lvls (assgn)	Total Maintainers (L1)	Crewchiefs	Maintainers per O3 (F/L) (L3)	Total Maintainers (L3)
97-3	7411	13067.2	518	8108	19455	38640	6031	76.0	39371
94-1	6168	7381.1	696	7570	23077	44842	6066	61.6	42862
96-1	7326	6740.6	632	8002	20330	40092	5930	65.6	41440
98-1	7573	12803.7	491	7991	18822	37598	5882	79.5	39039
96-4	7865	10144.1	589	8313	19572	39371	5443	68.1	40092
97-1	6938	10610.1	555	8367	19330	39047	5403	72.4	40161
96-3	7751	8093.6	608	8160	19926	39593	5219	66.4	40351
93-3	5690	5280.5	858	7167	21406	42227	5125	48.9	41988
00-1	7317	13273.3	432	8068	17534	35770	5041	84.9	36660
94-3	6607	8654.5	660	8158	22566	44210	4896	63.1	41628
99-3	8604	10446.5	461	8051	18150	36267	4751	79.9	36812
96-2	7709	9127.1	632	7938	20474	40161	4739	63.9	40399
98-3	8221	12420.9	493	7800	18658	36872	4830	77.1	37996
97-4	7388	17133.3	503	8136	19112	37996	4825	77.6	39047
95-1	7033	2415.9	692	8292	21352	42480	4809	65.3	45160
95-4	7925	10112.9	673	8076	20467	40351	4836	63.1	42480
93-2	5168	3094.3	973	7152	21632	42862	4852	45.3	44117
97-2	7469	9908.1	537	8075	19713	39039	4833	73.7	39593
93-4	6350	5712.0	777	6891	21327	41628	4787	54.8	42571
95-2	7000	6514.6	698	8024	21039	41440	4748	63.3	44210
99-2	8281	11218.3	474	7909	18465	36660	4741	77.8	36872
94-4	6955	7357.8	671	8331	22001	43485	4681	66.8	44842
00-2	7875	12814.2	464	8072	17626	36008	4585	78.2	36267
98-4	8465	14441.0	486	8033	18467	36812	4642	77.4	37598
94-2	5805	7305.2	666	7838	23153	45160	4681	63.4	42227
99-4*	8095	12237.5	437	8092	17920	36057	4647	83.6	36525
95-3*	7708	7620.9	673	7755	20725	40399	4617	64.6	43485
93-1*	4839	4380.2	1034	6843	21695	42571	4650	45.2	46731
98-2*	8162	14214.8	483	7666	19033	37461	4713	80.0	38640
99-1*	8024	13437.9	466	7987	18267	36525	4753	80.4	37461
00-3*	7569	10651.9	452	8388	17055	35636	4758	79.8	36057
00-4*	7395	13046.9	440	8219	17009	35409	4738	81.3	35770
*This quarter's data randomly selected and removed from model building process and used for sensitivity analysis									

Appendix Q: Explanatory Model

Response MC Rate

Actual by Predicted Plot



Summary of Fit

RSquare	0.990886
RSquare Adj	0.972658
Root Mean Square Error	0.00478
Mean of Response	0.7924
Observations (or Sum Wgts)	25

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	16	0.01987321	0.001242	54.3613
Error	8	0.00018279	0.000023	Prob > F
C. Total	24	0.02005600		<.0001

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-4.40093	2.641415	-1.67	0.1343
TNMCM Hrs Wtd Top 50	-2.791e-7	7.757e-8	-3.60	0.0070
Mx Rlblty Wtd Top 50	0.0000084	0.000006	1.29	0.2331
Cann Hrs Wtd Top 50	-0.000002	8.275e-7	-2.68	0.0279
Ttl Crewchief	0.0000184	0.000035	0.52	0.6152
8-hr Fix Rate (ACC)	0.0281608	0.087209	0.32	0.7550
Ttl Mntnrs (Lag 0)	-0.000149	0.000073	-2.05	0.0750
Avg Acft Inv	0.0031877	0.001525	2.09	0.0700
Maintainers per Acft (Lag 0)	0.1359465	0.063657	2.14	0.0652
3-lvls assgn (Lag 0)	-0.000046	0.000091	-0.51	0.6240
5-lvls assgn (Lag 0)	0.0001986	0.000097	2.06	0.0739
7-lvls (assgn) (Lag 0)	-0.00019	0.000123	-1.54	0.1612
Ratio of 3 to 7-lvls (Lag 0)	-3.520398	1.743336	-2.02	0.0781
Ratio of 3 to 5 and 7-lvls (Lag 0)	13.820362	7.398982	1.87	0.0987
Ttl O-3 (F/L) (Lag 3)	0.000097	0.000172	0.57	0.5870
Ttl Mntnrs (Lag 3)	0.0000029	0.000004	0.78	0.4559
Mntnrs per O3 (F/L) (Lag 3)	-0.000212	0.001589	-0.13	0.8970

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
TNMCM Hrs Wtd Top 50	1	1	0.00029571	12.9424	0.0070
Mx Rlblty Wtd Top 50	1	1	0.00003803	1.6644	0.2331
Cann Hrs Wtd Top 50	1	1	0.00016408	7.1814	0.0279
Ttl Crewchief	1	1	0.00000625	0.2734	0.6152
8-hr Fix Rate (ACC)	1	1	0.00000238	0.1043	0.7550
Ttl Mntnrs (Lag 0)	1	1	0.00009559	4.1838	0.0750
Avg Acft Inv	1	1	0.00009985	4.3701	0.0700
Maintainers per Acft (Lag 0)	1	1	0.00010421	4.5608	0.0652
3-lvls assgn (Lag 0)	1	1	0.00000594	0.2598	0.6240
5-lvls assgn (Lag 0)	1	1	0.00009652	4.2244	0.0739
7-lvls (assgn) (Lag 0)	1	1	0.00005447	2.3838	0.1612
Ratio of 3 to 7-lvls (Lag 0)	1	1	0.00009317	4.0778	0.0781
Ratio of 3 to 5 and 7-lvls (Lag 0)	1	1	0.00007972	3.4890	0.0987
Ttl O-3 (F/L) (Lag 3)	1	1	0.00000732	0.3202	0.5870
Ttl Mntnrs (Lag 3)	1	1	0.00001403	0.6139	0.4559
Mntnrs per O3 (F/L) (Lag 3)	1	1	0.00000041	0.0179	0.8970

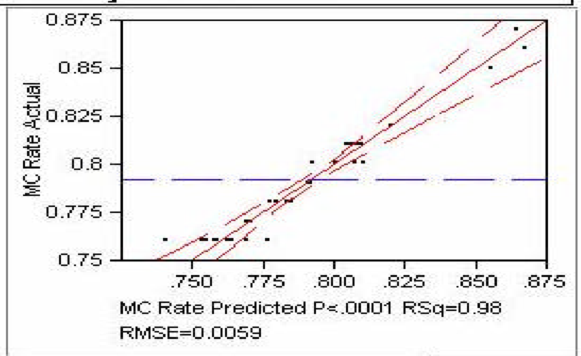
Durbin-Watson

Durbin-Watson	Number of Obs.	AutoCorrelation	Prob<DW
1.9177748	25	0.0140	0.5445

Figure 36. Full Explanatory Model

Response MC Rate

Actual by Predicted Plot



Summary of Fit

RSquare	0.977146
RSquare Adj	0.957808
Root Mean Square Error	0.005938
Mean of Response	0.7924
Observations (or Sum Wgts)	25

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	11	0.01959764	0.001782	50.5299
Error	13	0.00045836	0.000035	Prob > F
C. Total	24	0.02005600		<.0001

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-3.423393	1.695296	-2.02	0.0646
TNMCM Hrs Wtd Top 50	-2.592e-7	7.962e-8	-3.26	0.0063
Mx Rlblty Wtd Top 50	0.0000112	0.000005	2.19	0.0474
Cann Hrs Wtd Top 50	-0.000003	7.835e-7	-3.49	0.0040
Ttl Mntnrs (Lag 0)	-0.000083	0.000068	-1.22	0.2434
Avg Acft Inv	0.003201	0.001151	2.78	0.0156
Maintainers per Acft (Lag 0)	0.1461208	0.047303	3.09	0.0086
3-lvls assgn (Lag 0)	-0.000005	0.000086	-0.06	0.9545
5-lvls assgn (Lag 0)	0.0000909	0.000063	1.44	0.1749
7-lvls (assgn) (Lag 0)	-0.000291	0.000109	-2.66	0.0196
Ratio of 3 to 7-lvls (Lag 0)	-3.713251	1.382003	-2.69	0.0187
Ratio of 3 to 5 and 7-lvls (Lag 0)	11.038773	5.110427	2.16	0.0500

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
TNMCM Hrs Wtd Top 50	1	1	0.00037368	10.5983	0.0063
Mx Rlblty Wtd Top 50	1	1	0.00016902	4.7938	0.0474
Cann Hrs Wtd Top 50	1	1	0.00042943	12.1795	0.0040
Ttl Mntnrs (Lag 0)	1	1	0.00005265	1.4932	0.2434
Avg Acft Inv	1	1	0.00027287	7.7393	0.0156
Maintainers per Acft (Lag 0)	1	1	0.00033644	9.5421	0.0086
3-lvls assgn (Lag 0)	1	1	0.00000012	0.0034	0.9545
5-lvls assgn (Lag 0)	1	1	0.00007262	2.0596	0.1749
7-lvls (assgn) (Lag 0)	1	1	0.00024940	7.0734	0.0196
Ratio of 3 to 7-lvls (Lag 0)	1	1	0.00025454	7.2192	0.0187
Ratio of 3 to 5 and 7-lvls (Lag 0)	1	1	0.00016451	4.6658	0.0500

Durbin-Watson

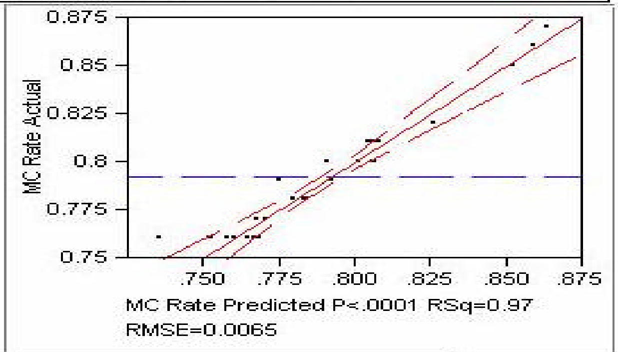
Durbin-Watson	Number of Obs.	AutoCorrelation	Prob<DW
2.1831968	25	-0.0968	0.7071

Figure 37. First Reduction - Full Explanatory Model

Response MC Rate

Whole Model

Actual by Predicted Plot



Summary of Fit

RSquare	0.968669
RSquare Adj	0.949871
Root Mean Square Error	0.006472
Mean of Response	0.7924
Observations (or Sum Wgts)	25

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	9	0.01942763	0.002159	51.5290
Error	15	0.00062837	0.000042	Prob > F
C. Total	24	0.02005600		<.0001

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.351036	1.016611	-0.35	0.7347
TNMCM Hrs Wtd Top 50	-3.668e-7	6.471e-8	-5.67	<.0001
Mx Rlblty Wtd Top 50	0.0000088	0.000005	1.86	0.0833
Cann Hrs Wtd Top 50	-0.000002	7.659e-7	-3.25	0.0054
Ttl Mntnrs (Lag 0)	-0.000039	0.000023	-1.72	0.1059
Avg Acft Inv	0.0013005	0.000746	1.74	0.1019
Maintainers per Acft (Lag 0)	0.0615104	0.026377	2.33	0.0340
3-lvls assgn (Lag 0)	0.0000786	0.000031	2.52	0.0235
7-lvls (assgn) (Lag 0)	-0.000087	0.000031	-2.81	0.0131
Ratio of 3 to 7-lvls (Lag 0)	-0.741602	0.286304	-2.59	0.0205

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
TNMCM Hrs Wtd Top 50	1	1	0.00134600	32.1306	<.0001
Mx Rlblty Wtd Top 50	1	1	0.00014421	3.4426	0.0833
Cann Hrs Wtd Top 50	1	1	0.00044292	10.5731	0.0054
Ttl Mntnrs (Lag 0)	1	1	0.00012404	2.9610	0.1059
Avg Acft Inv	1	1	0.00012717	3.0356	0.1019
Maintainers per Acft (Lag 0)	1	1	0.00022781	5.4381	0.0340
3-lvls assgn (Lag 0)	1	1	0.00026627	6.3562	0.0235
7-lvls (assgn) (Lag 0)	1	1	0.00033177	7.9197	0.0131
Ratio of 3 to 7-lvls (Lag 0)	1	1	0.00028107	6.7094	0.0205

Durbin-Watson

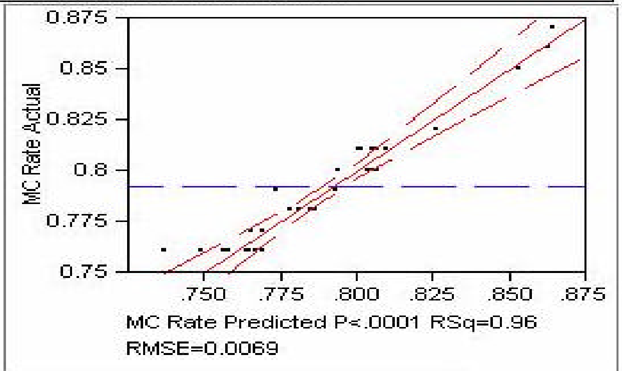
Durbin-Watson	Number of Obs.	AutoCorrelation	Prob<DW
2.0953001	25	-0.0496	0.6473

Figure 38. Second Reduction - Full Explanatory Model

Response MC Rate

Whole Model

Actual by Predicted Plot



Summary of Fit

RSquare	0.961479
RSquare Adj	0.942218
Root Mean Square Error	0.006949
Mean of Response	0.7924
Observations (or Sum Wgts)	25

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	8	0.01928341	0.002410	49.9191
Error	16	0.00077259	0.000048	Prob > F
C. Total	24	0.02005600		<.0001

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.4920867	0.976352	0.50	0.6211
TNMCM Hrs Wtd Top 50	-3.45e-7	6.832e-8	-5.05	0.0001
Cann Hrs Wtd Top 50	-0.000003	8.126e-7	-3.33	0.0042
Ttl Mntnrs (Lag 0)	-0.000019	0.000021	-0.88	0.3914
Avg Acft Inv	0.0007285	0.00073	1.00	0.3331
Maintainers per Acft (Lag 0)	0.0412736	0.025784	1.60	0.1290
3-lvls assgn (Lag 0)	0.0000753	0.000033	2.25	0.0388
7-lvls (assgn) (Lag 0)	-0.000106	0.000031	-3.36	0.0040
Ratio of 3 to 7-lvls (Lag 0)	-0.759761	0.307203	-2.47	0.0250

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
TNMCM Hrs Wtd Top 50	1	1	0.00123131	25.4999	0.0001
Cann Hrs Wtd Top 50	1	1	0.00053617	11.1038	0.0042
Ttl Mntnrs (Lag 0)	1	1	0.00003747	0.7760	0.3914
Avg Acft Inv	1	1	0.00004811	0.9963	0.3331
Maintainers per Acft (Lag 0)	1	1	0.00012373	2.5623	0.1290
3-lvls assgn (Lag 0)	1	1	0.00024478	5.0693	0.0388
7-lvls (assgn) (Lag 0)	1	1	0.00054585	11.3044	0.0040
Ratio of 3 to 7-lvls (Lag 0)	1	1	0.00029535	6.1165	0.0250

Durbin-Watson

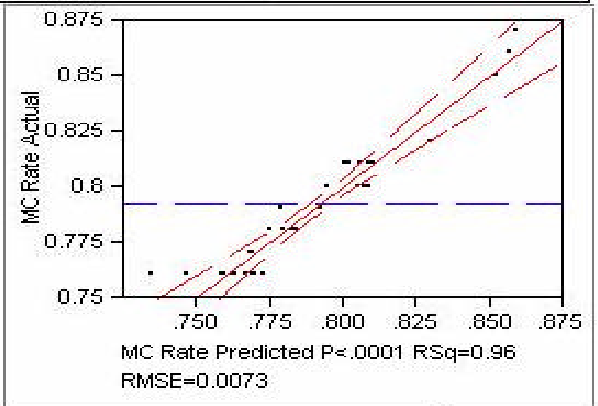
Durbin-Watson	Number of Obs.	AutoCorrelation	Prob<DW
2.1590692	25	-0.0926	0.6801

Figure 39. Third Reduction - Full Explanatory Model

Response MC Rate

Whole Model

Actual by Predicted Plot



Summary of Fit

RSquare	0.955309
RSquare Adj	0.936908
Root Mean Square Error	0.007261
Mean of Response	0.7924
Observations (or Sum Wgts)	25

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	7	0.01915969	0.002737	51.9134
Error	17	0.00089631	0.000053	Prob > F
C. Total	24	0.02005600		<.0001

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.938179	0.386955	5.01	0.0001
TNMCM Hrs Wtd Top 50	-3.886e-7	6.548e-8	-5.93	<.0001
Cann Hrs Wtd Top 50	-0.000003	8.475e-7	-3.10	0.0065
Ttl Mntnrs (Lag 0)	0.0000142	0.000006	2.44	0.0258
Avg Acft Inv	-0.00041	0.000172	-2.38	0.0295
3-lvls assgn (Lag 0)	0.0000682	0.000035	1.97	0.0653
7-lvls (assgn) (Lag 0)	-0.000104	0.000033	-3.18	0.0055
Ratio of 3 to 7-lvls (Lag 0)	-0.712375	0.319515	-2.23	0.0396

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
TNMCM Hrs Wtd Top 50	1	1	0.00185695	35.2201	<.0001
Cann Hrs Wtd Top 50	1	1	0.00050666	9.6096	0.0065
Ttl Mntnrs (Lag 0)	1	1	0.00031468	5.9683	0.0258
Avg Acft Inv	1	1	0.00029769	5.6462	0.0295
3-lvls assgn (Lag 0)	1	1	0.00020468	3.8821	0.0653
7-lvls (assgn) (Lag 0)	1	1	0.00053268	10.1031	0.0055
Ratio of 3 to 7-lvls (Lag 0)	1	1	0.00026209	4.9709	0.0396

Durbin-Watson

Durbin-Watson	Number of Obs.	AutoCorrelation	Prob<DW
2.1191103	25	-0.0758	0.6649

Figure 40. Final Reduction - Full Explanatory Model

Appendix R: Explanatory Model Assumption Analysis

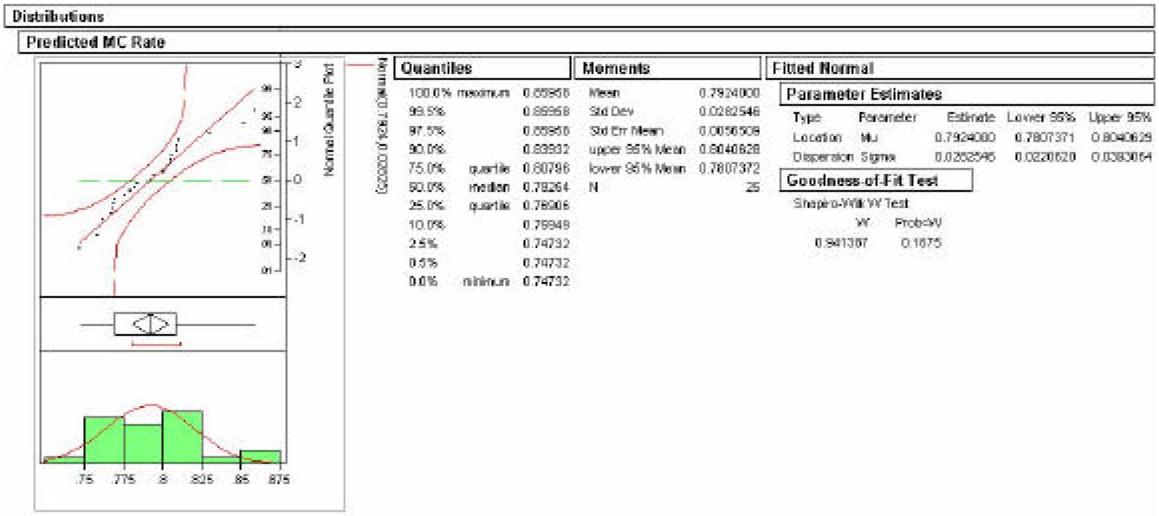


Figure 41. Normality Assumption Verification - Full Explanatory Model Output

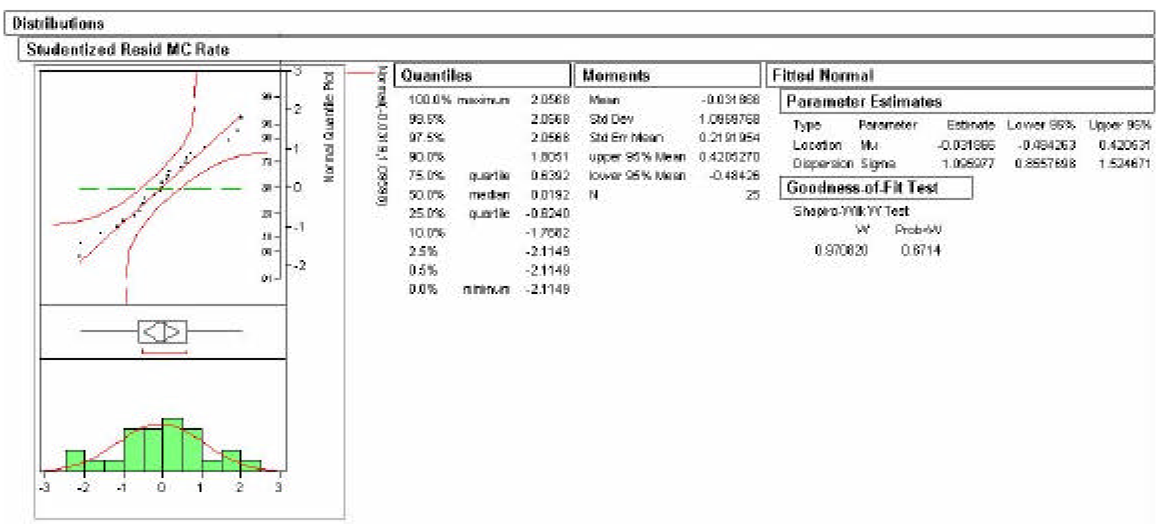
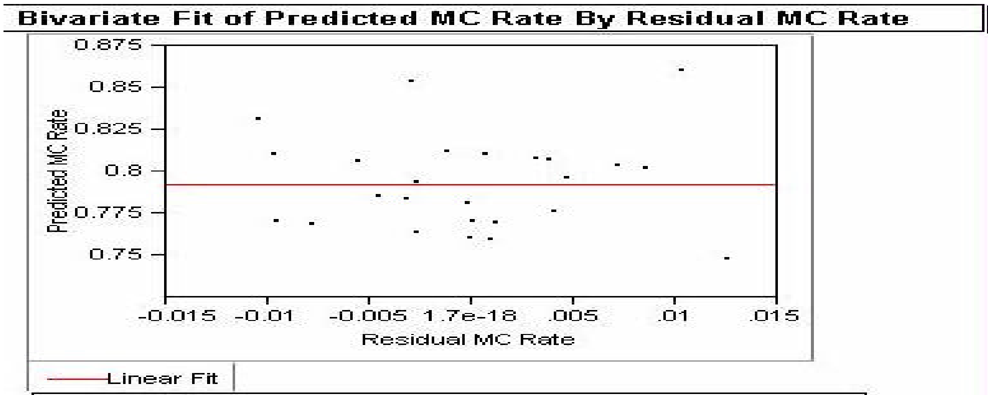


Figure 42. Normality Assumption Verification (Studentized) - Full Explanatory Model



Linear Fit

Predicted MC Rate = 0.7924 - 4.624e-12 Residual MC Rate

Summary of Fit

RSquare	0
RSquare Adj	-0.04348
Root Mean Square Error	0.028862
Mean of Response	0.7924
Observations (or Sum Wgts)	25

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00000000	0.000000	0.0000
Error	23	0.01915969	0.000833	Prob > F
C. Total	24	0.01915969		1.0000

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.7924	0.005772	137.27	<.0001
Residual MC Rate	-4.62e-12	0.964052	-0.00	1.0000

Figure 43. Constant Variance Assumption - Full Explanatory Model

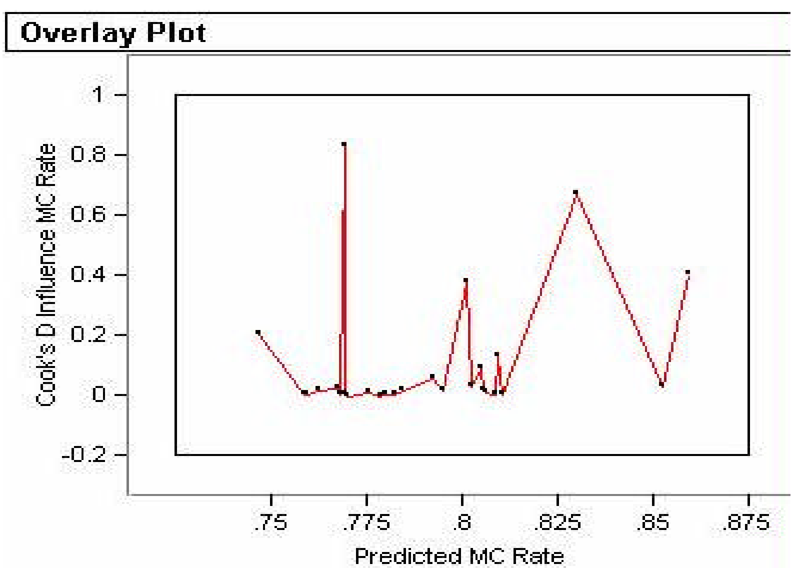


Figure 44. Cook's D Influence Statistic Verification - Full Explanatory Model

Appendix S: Forecasting Model Variable Data Points (Model 1)

Quarter	MC Rate	Avg Acft Inv	Flying Hours	Sorties	Total Maintainers (L1)	Maintainers per Acft (L1)
93-1	85.60%	1121	68301.9	49484	42571	38.0
93-2	86.59%	1130.6	72112.8	51002	42862	37.9
93-3	84.79%	1142.1	79311.9	56241	42227	37.0
93-4	82.08%	1162.7	75828.1	52009	41628	35.8
94-1	81.12%	1202.4	74158.6	51938	44842	37.3
94-2	80.41%	1226.5	75743.6	52218	45160	36.8
94-3	80.01%	1249	78734.4	54551	44210	35.4
94-4	81.01%	1264.7	76485.2	52436	43485	34.4
95-1	78.75%	1270.3	76687.6	51906	42480	33.4
95-2	79.62%	1278.5	80066.8	54097	41440	32.4
95-3	80.19%	1284.6	84309.7	57347	40399	31.4
95-4	81.03%	1287.9	84275.4	56179	40351	31.3
96-1	80.90%	1292	75740.6	52440	40092	31.0
96-2	81.31%	1293.4	81069.5	54847	40161	31.0
96-3	81.36%	1297.3	88516.5	60411	39593	30.5
96-4	78.18%	1300.8	82442.8	55548	39371	30.3
97-1	78.31%	1303.8	77650.8	52499	39047	29.9
97-2	78.18%	1303.7	81962.8	54512	39039	29.9
97-3	78.07%	1302.4	88855.5	60431	38640	29.7
97-4	76.20%	1301	80548.3	54399	37996	29.2
98-1	75.75%	1299.4	78913.2	53212	37598	28.9
98-2	75.58%	1297.2	82086.9	52752	37461	28.9
98-3	77.05%	1296.3	88552.4	59117	36872	28.4
98-4	75.75%	1291.3	79983.2	56617	36812	28.5
99-1	75.73%	1284.6	74520.5	51984	36525	28.4
99-2*	75.88%	1279.7	79513.7	53439	36660	28.6
99-3*	75.85%	1278.1	93523.3	55434	36267	28.4
99-4*	76.20%	1276.7	75867.0	53849	36057	28.2
00-1*	75.82%	1276.6	73538.6	51286	35770	28.0
00-2*	76.79%	1274.8	77129.1	53751	36008	28.2
00-3*	78.69%	1272.9	81735.4	56726	35636	28.0
00-4*	76.32%	1270.6	81036.3	55054	35409	27.9

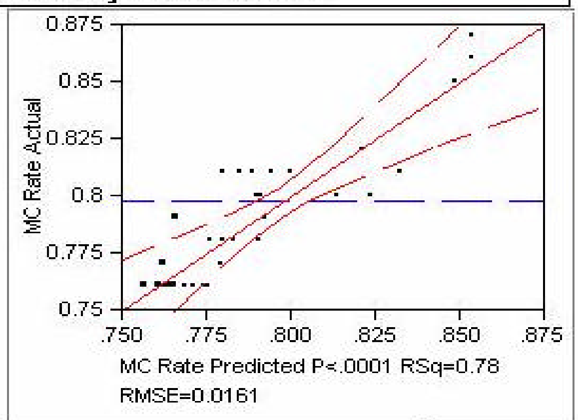
*This quarter's data removed from model building process and used for sensitivity analysis

Appendix T: Forecasting Model and MAPE Computations

Response MC Rate

Whole Model

Actual by Predicted Plot



Summary of Fit

RSquare	0.779547
RSquare Adj	0.721533
Root Mean Square Error	0.016142
Mean of Response	0.7976
Observations (or Sum Wgts)	25

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	5	0.01750550	0.003501	13.4372
Error	19	0.00495050	0.000261	Prob > F
C. Total	24	0.02245600		<.0001

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-1.836901	2.315754	-0.79	0.4374
Avg Acft Inv	0.0018045	0.001772	1.02	0.3212
Flying Hours	-1.939e-7	0.000002	-0.08	0.9340
Sorties	0.0000023	0.000004	0.66	0.5164
Ttl Mntnrs (Lag 0)	-0.000054	0.000047	-1.15	0.2655
Maintainers per Acft (Lag 0)	0.0749608	0.061041	1.23	0.2344

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Avg Acft Inv	1	1	0.00027031	1.0374	0.3212
Flying Hours	1	1	0.00000183	0.0070	0.9340
Sorties	1	1	0.00011390	0.4372	0.5164
Ttl Mntnrs (Lag 0)	1	1	0.00034297	1.3163	0.2655
Maintainers per Acft (Lag 0)	1	1	0.00039293	1.5081	0.2344

Durbin-Watson

Durbin-Watson	Number of Obs.	AutoCorrelation	Prob<DW
0.5773471	25	0.7073	<.0001

Figure 45. Forecasting Model

Quarter	Observed MC Rate	Forecasted MC Rate	Error	Absolute Error	Percent Error	Absolute Percent Error
99-2	75.884%	76.509%	-0.006	0.006	-0.824%	0.008%
99-3	75.847%	76.485%	-0.006	0.006	-0.841%	0.008%
99-4	76.200%	76.329%	-0.001	0.001	-0.170%	0.002%
00-1	75.815%	75.627%	0.002	0.002	0.248%	0.002%
00-2	76.785%	76.229%	0.006	0.006	0.724%	0.007%
00-3	78.687%	76.609%	0.021	0.021	2.640%	0.026%
00-4	76.323%	76.075%	0.002	0.002	0.325%	0.003%
		Sum	0.017	0.045	2.104	0.058%
Theil's U-Statistic = .771					**MAPE = 0.824%**	

Table 51. Forecasting Model Selection Criteria

Appendix U: Forecasting Model Assumption Analysis

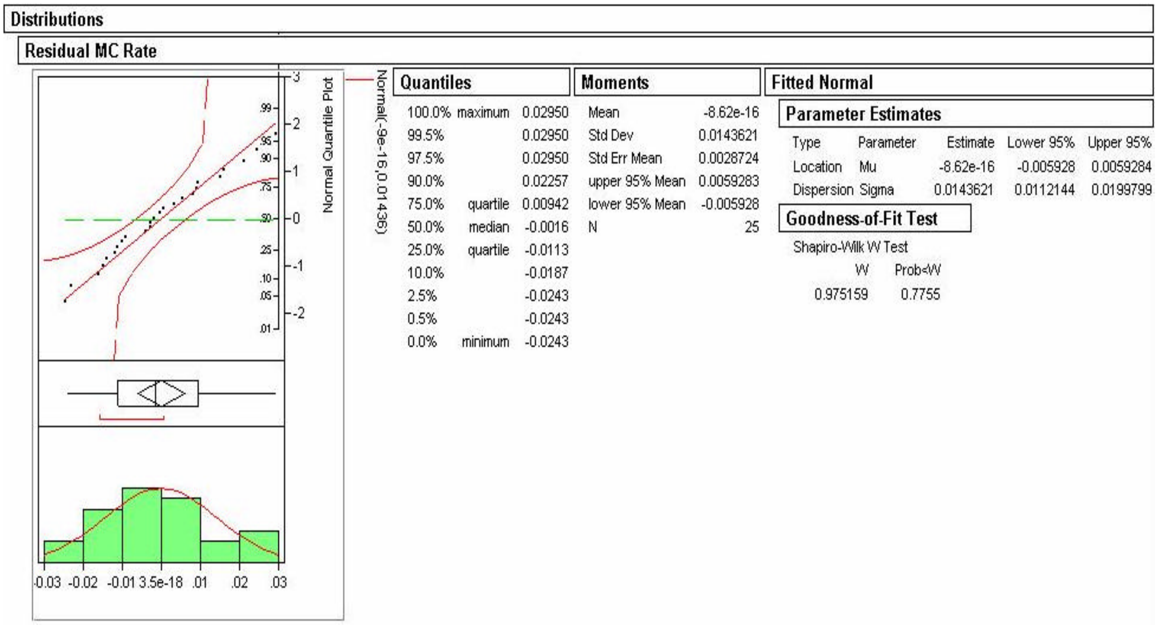


Figure 46. Normality Assumption Verification - Forecasting Model

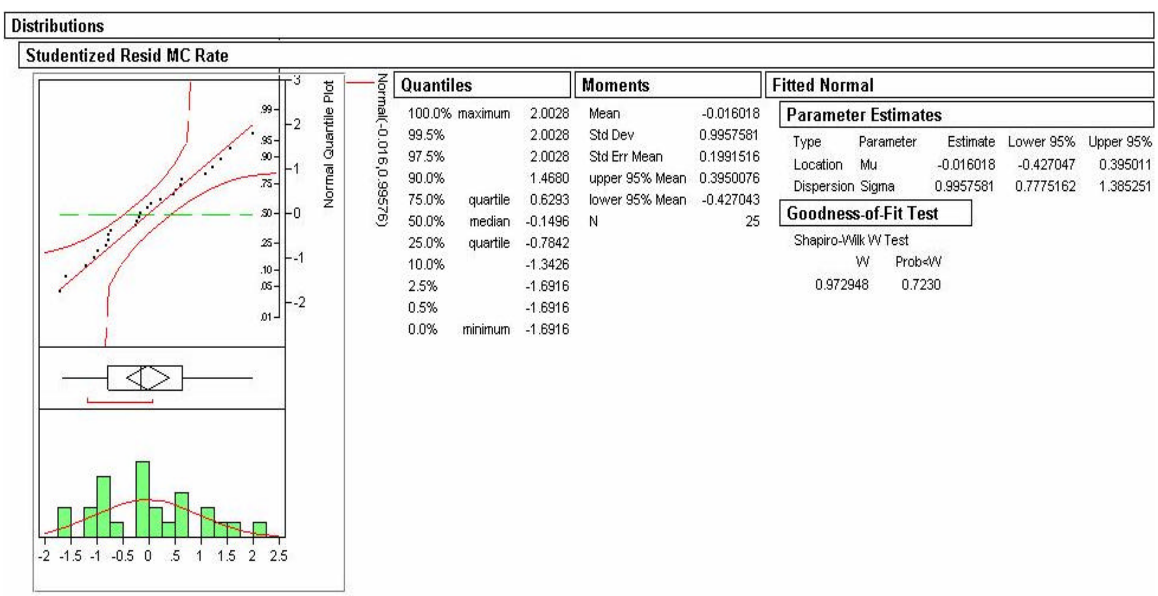
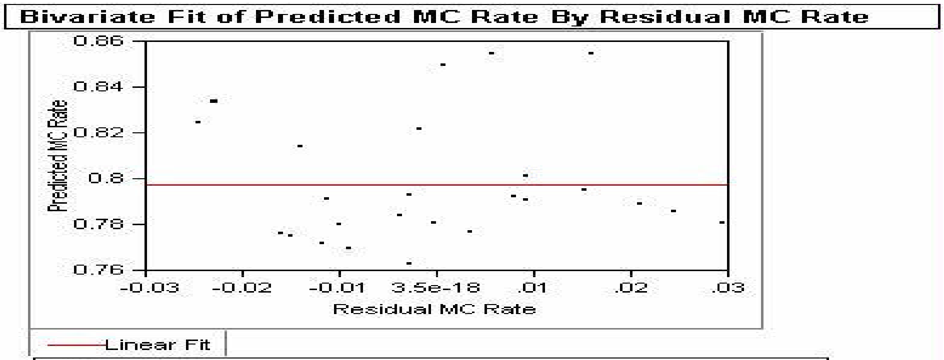


Figure 47. Normality Verification (Studentized) - Forecasting Model



Linear Fit

Predicted MC Rate = 0.7976 + 3.03e-12 Residual MC Rate

Summary of Fit

RSquare	0
RSquare Adj	-0.04348
Root Mean Square Error	0.027588
Mean of Response	0.7976
Observations (or Sum Wgts)	25

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00000000	0.000000	0.0000
Error	23	0.01750550	0.000761	Prob > F
C. Total	24	0.01750550		1.0000

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.7976	0.005518	144.55	<.0001
Residual MC Rate	3.03e-12	0.392102	0.00	1.0000

Figure 48. Constant Variance Assumption Verification – Forecasting Model

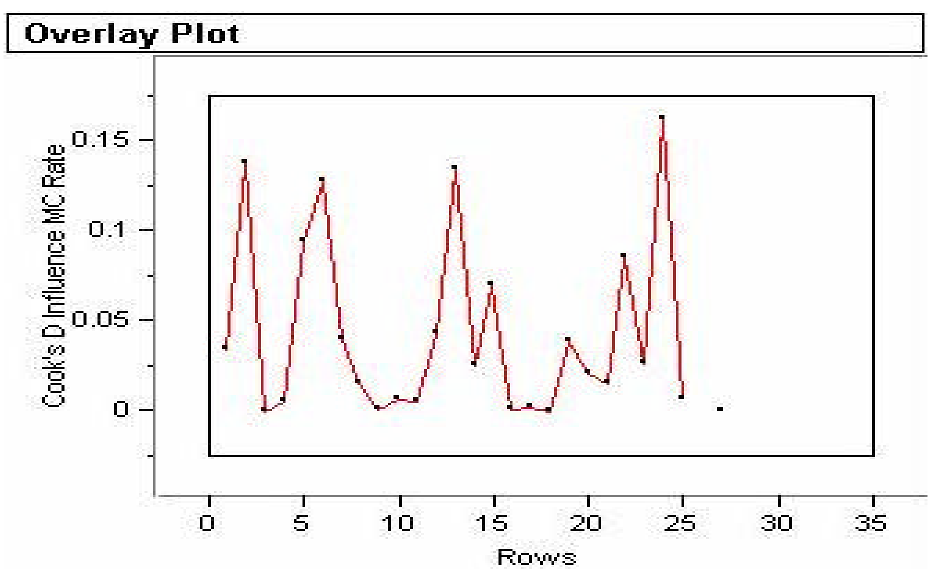


Figure 49. Cook's D Influence Statistic Verification – Forecasting Model

Appendix V: Forecasting Model Data Points (Model 2)

Quarter	MC Rate	Avg Acft Inv	Sorties	O-3 (F/L) (L3)	9-lvls (assgn)	2nd Term Rnlst (L0)	Ttl 5 and 7-lvls (assgn)
93-1	85.60%	1121.02	49484	1034	1364	82.28%	37976
93-2	86.59%	1130.59	51002	973	1390	83.83%	37023
93-3	84.79%	1142.10	56241	858	1346	86.45%	34771
93-4	82.08%	1162.72	52009	777	1308	84.04%	32939
94-1	81.12%	1202.45	51938	696	1263	86.23%	33209
94-2	80.41%	1226.46	52218	666	1342	87.36%	33192
94-3	80.01%	1248.95	54551	660	1279	85.23%	32667
94-4	81.01%	1264.75	52436	671	1261	84.59%	32425
95-1	78.75%	1270.26	51906	692	1153	77.68%	34902
95-2	79.62%	1278.48	54097	698	1140	82.42%	34887
95-3	80.19%	1284.64	57347	673	1127	81.80%	33776
95-4	81.03%	1287.95	56179	673	1166	79.78%	32899
96-1	80.90%	1291.96	52440	632	1102	80.48%	31985
96-2	81.31%	1293.45	54847	632	1114	84.26%	31286
96-3	81.36%	1297.30	60411	608	1110	85.85%	30587
96-4	78.18%	1300.77	55548	589	1137	84.83%	30221
97-1	78.31%	1303.76	52499	555	1035	82.29%	29984
97-2	78.18%	1303.73	54512	537	1057	81.22%	30135
97-3	78.07%	1302.35	60431	518	1061	77.49%	29440
97-4	76.20%	1301.00	54399	503	1081	81.28%	29100
98-1	75.75%	1299.41	53212	491	974	85.84%	28725
98-2	75.58%	1297.17	52752	483	948	82.64%	29015
98-3	77.05%	1296.29	59117	493	967	83.33%	28612
98-4	75.75%	1291.34	56617	486	972	85.11%	27967
99-1	75.73%	1284.57	51984	466	815	90.32%	27698
99-2*	75.88%	1279.68	53439	474	840	88.93%	27919
99-3*	75.85%	1278.13	55434	461	867	86.69%	27257
99-4*	76.20%	1276.69	53849	437	887	87.74%	27002
00-1*	75.82%	1276.63	51286	432	798	86.17%	26821
00-2*	76.79%	1274.80	53751	464	820	90.33%	27025
00-3*	78.69%	1272.86	56726	452	847	87.40%	26486
00-4*	76.32%	1270.59	55054	440	836	88.93%	26270

*This quarters data removed from model building process and used for sensitivity analysis

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14. ABSTRACT

According to many, the readiness of America's forces deteriorated in the 1990s. In the Air Force, the combat readiness of its fighter aircraft has declined. One of its indicators of combat readiness, the mission capable rate, is used to identify the percentage of aircraft unable to perform their missions. From FY94–FY98, the aggregate total not mission capable rate for maintenance steadily increased from 14% to 18.2% while total not mission capable rate for supply increased from 5.5% to 17.5% between FY86 and FY00. The USAF uses the Funding/Availability Multi-Method Allocator for Spares model to forecast these rates for its aircraft. While FAMMAS does an excellent job of predicting mission capable rates using funding data and other factors, it is does not explain the key drivers influencing mission capable rates, limiting its effectiveness. Studies have identified other variables, manning/experience levels, retention, fix rates, OPSTEMPO, spare parts issues, and aircraft systems reliability and maintainability as influencing mission capable rates. The research used these and other variables, using the F-16 as an example, to develop regression models that provide more insightful forecasts. Results are obtained from analyzing 600+ variables and 10 years of data, from the REMIS, D041, PDS, and HAF MDS systems.

15. SUBJECT TERMS

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