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Improving Maintenance Data Collection via Point-of-Maintenance (POMX) Implementation

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IMPROVING MAINTENANCE DATA COLLECTION VIA

POINT-OF-MAINTENANCE (POMX) IMPLEMENTATION

THESIS

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AFIT/GLM/ENS/06-03

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Abstract

Maintenance data collection is an integral part of flightline aircraft maintenance. Historically, this data was input via traditional keyboard data entry methods at a computer terminal. These terminals are typically located in the aircraft maintenance unit (AMU) facility, away from where the actual maintenance is being performed. In contrast to the traditional approach, the Point-of-Maintenance system (POMX) seeks to reduce the data entry burden while increasing data accuracy through the use of E-Tools such as ruggedized laptop computers and handheld portable maintenance aids (PMAs). POMX enables data entry at the aircraft or other maintenance location via wireless local area network or batch storage, and seeks to capture data as the maintenance is performed.

This research analyzes the impact of a POMX system on maintenance data error rates. This research takes a careful look at the implementation of POMX at Randolph AFB to enable current designers and system engineers to gain insight into what to expect as the next generation of POMX comes on-line. Initial results indicate no significant improvement in data quality and no reduction in the number of data errors recorded with POMX systems. Follow-up interviews with POMX users and experts revealed that the Air Force still has a number of managerial, technical and organizational constraints which must be overcome before a POMX system can add to the effectiveness of Air Force maintenance operations.

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For my wife and son who repeatedly sacrificed family time and had to listen to my frustration and fears on multiple occasions, you are the most important people in my life and I love you tremendously. Finally, to my Lord and Savior Jesus Christ who gives me life; thank you for never letting go.

William D. Cone

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IMPROVING MAINTENANCE DATA COLLECTION VIA

POINT-OF-MAINTENANCE (POMX) IMPLEMENTATION

I. Introduction

Background

Maintenance data collection (MDC) is an integral part of flightline aircraft maintenance. Until recent years, the Core Automated Maintenance System (CAMS) was the Air Force's primary MDC database with the exception of Air Mobility Command (AMC), which used a slightly different system called G081 - CAMS for Mobility. CAMS and G081 are presently being phased out in favor of an enterprise-wide solution known as the Integrated Maintenance Data System (IMDS). IMDS is part of the larger logistics enterprise architecture (LogEA) which serves as "the operational and systems architecture that will support the execution of the eLog21 campaign" (LogEA CONOPS, 2004). eLog21 is a senior-leader initiative to reshape logistics for the 21st century to better support the network-centric warfare efforts of the Department of Defense (DOD).

MDC has historically been a tedious and time-consuming task resulting in marginal data accuracy. Inputs under the CAMS and G081 systems occur via traditional keyboard data entry methods at a computer terminal. These terminals are typically located in the aircraft maintenance unit (AMU) facility, away from where the actual maintenance is being performed. Inputs are manually reviewed and errors are identified and corrected by a member of the organizational level data integrity team (DIT). In contrast to the manual approach, the Point-of-

Maintenance system (POMX) seeks to reduce the data entry burden while increasing data accuracy through the use of E-Tools such as handheld portable maintenance aids (PMAs).

Efforts to streamline the data collection process are not a new endeavor. An obvious example is the pervasive use of point-of-sale technology in the retail industry. Besides enhancing the consumer checkout process by shortening customer wait time, the bar-code scanners and UPC codes in use today have resulted in automated and comprehensive data collection for inventory management purposes while effectively eliminating keypunch entry errors.

POMX is an alternative front-end method of interfacing with IMDS which is represented in Figure 1 by the CAMS database. It is part of the eLog21 initiative sponsored by Headquarters Air Force/Logistics, Installations & Mission Support/Maintenance Management branch (AF/A4MM) and managed by the Automatic Identification Technology (AIT) Program Management Office (PMO) at Wright-Patterson AFB. The POMX architecture includes a wireless local area network (LAN) that serves as the backbone of the system, ruggedized handheld terminals (HHTs) for use by maintenance technicians, a dedicated POMX server which receives the data and synchronizes it with IMDS, laptop computers for in-vehicle use by flightline expediters, desktop computer interfaces for system administration and analysis, and handheld radios that interface with a speech conversion box connected to a voice recognition application resident on the POMX server. Figure 1 provides a graphical representation of the architecture and hardware components.

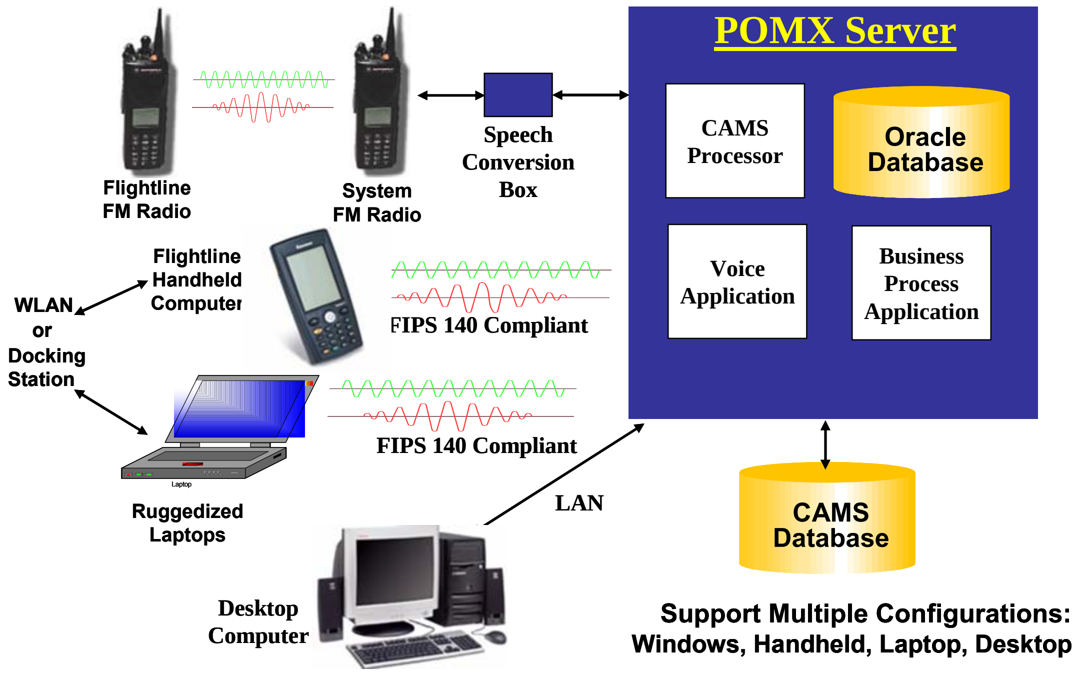


Figure 1. POMX Architecture (Klarer, 2005)

POMX enables data entry at the aircraft or other maintenance locations, and seeks to capture data as the maintenance is performed. This is in contrast to the legacy approach of computer terminal keyboard entry in a location removed from the flightline environment. The legacy method typically resulted in MDC being delayed until the technician was able to return to the aircraft maintenance unit (AMU) often resulting in incomplete and inaccurate data.

POMX also provides an intelligent interface via the POMX server to guard against incorrect input by performing error checking routines as information is entered. Certain logical combinations of input data are required based on a series of decision rules and categorical assignments. This seeks to create a fail-safe environment and eliminates both inadvertent and intentional erroneous inputs and their underlying causes as identified in two different studies by Folmar (1986) and Determan (1991).

Problem Statement

The current state of the POMX initiative is focused on designing and implementing the necessary architecture to enable the Automatic Identification Technology (AIT) requirements of eLog21 and fulfill the point-of-maintenance requirements of the IMDS system. Existing POMX contracts involve detailed functional requirements rather than broad performance objectives. It is not clear to what extent POMX will impact data accuracy once these functional requirements are met. The purpose of this research is to determine whether the POMX implementation at Randolph AFB, Texas led to an increase in the accuracy of maintenance data when compared to the legacy method of MDC.

Research Question

Does implementation of Point-of-Maintenance (POMX) at Randolph AFB, Texas provide significant improvement to flightline maintenance data accuracy over the legacy method of inputting data via IMDS computer terminals located at the aircraft maintenance unit (AMU)? Two investigative questions are considered during the course of this research to aid in answering this question.

Investigative Questions

IQ1. Does the POMX system at Randolph AFB provide a significant reduction in MDC error rates when compared to legacy systems?

IQ2. Do aircraft maintenance units at Randolph AFB experience a reduction in specific types of errors as a result of using POMX when compared to legacy systems?

Research Objective

The overarching objective of this research is to analyze the impact of a POMX system on data accuracy. Accurate data is an essential goal of the Air Force's eLog21 initiative. In an effort to ensure current efforts are headed in the right direction, this study seeks to validate the idea of POMX as a valuable tool to ensure the Air Force technician is capturing good maintenance data. Additionally, skilled Air Force aircraft maintenance technicians are an underutilized resource when they are performing tedious proofreading tasks instead of performing aircraft maintenance tasks for which they were trained. The potential exists for POMX to eventually eradicate the need for error checking and reporting. This research takes a careful look at the implementation of POMX at Randolph AFB to enable current designers and system engineers to gain insight into what to expect as the next generation of POMX comes on-line.

Scope and Limitations

This research is designed to support the POMX effort currently sponsored by Headquarters Air Force/Logistics, Installations & Mission Support/Maintenance Management branch (AF/A4MM) and managed by the Air Force Automated Information Technology Program Management Office. Due to delays in user evaluations, data were not available to perform analysis on the most current POMX system being tested by the Air Force at Hurlburt Field, FL.

It was initially thought that several other bases were actively using various forms of POMX systems to perform flightline maintenance. As this research effort continued to mature, it became evident that the bases originally thought to be actively using POMX were suffering from implementation issues and were not using MDC systems in a manner consistent with the POMX data collection methodology use. These bases included Nellis AFB, Nevada, Langley AFB, Virginia, and Moody AFB, Georgia. The only base that was confirmed as currently using POMX technology was Randolph AFB which implemented the system during June-July 2003.

Though Randolph is a training base, it is believed that the results of this study provide valuable information regarding the future potential of the both the current POMX venture sponsored by AF/A4MM and of the various other wireless efforts taking place in the Air Force. Compared to the architecture depicted in Figure 1, the Randolph AFB system in Figure 2 is both less complex and less capable at this point in time. It consists of the IMDS/CAMS database which is accessed by desktop computers via a hardwired local area network (LAN) or by ruggedized laptops via a wireless LAN. Maintainers access the system on the flightline by using the laptops. There are no handheld terminals and no dedicated POMX server. Additionally, it does not use voice recognition technology. Although this hardware configuration contains less functionality than the system this research originally hoped to evaluate, it provides the point-of-maintenance capability called for in the IMDS requirements. For this reason, it is a valid representation of the POMX concept.

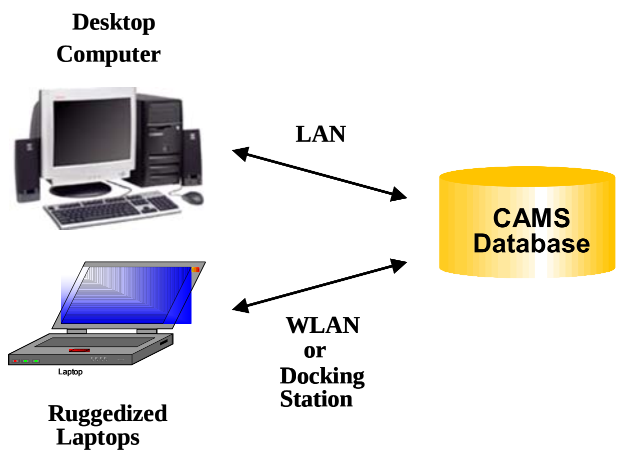


Figure 2. Randolph AFB POMX Architecture (Adapted from Klarer, 2005)

Methodology

This research implements an ex post facto experimental design using quantitative analysis of MDC error data reported by the maintenance analysis organization at Randolph AFB, TX. This data consists of two data sets comprised of monthly error rates. There are 24 data points collected prior to the implementation of POMX and 24 collected after POMX

Analysis consists of a series of individual tests of hypothesis to determine if significant differences exist between the mean error rates of the populations. Due to the small sample sizes ($n \leq 30$), the t-statistic is used to compute the appropriate rejection regions. Individual results are reported as each hypothesis is evaluated. The findings are also considered in light of the current POMX program's objectives, goals, and expectations in an effort to identify potential shortcomings or pitfalls.

Summary

The current POMX initiative is only a small piece of the Air Force's future logistics environment. As the requirements for accurate information have developed to support an integrated logistics system, the accuracy of the maintenance data affects not only the demand placed on the supply chain, but also weapon system sustainment efforts. The ability to capture information as tasks are being performed is believed to be a factor in ensuring accurate data. This research seeks to add credibility to this claim and provide further basis for upcoming decisions on POMX implementation and expected outcomes.

The next chapter reviews literature relevant to the POMX concept. This review provides the frame of reference which serves as the basis for this research. The framework establishes the importance of this study and assists the reader in understanding how the study was conceived.

II. Literature Review

Chapter Overview

Increased data accuracy attributable to the Point-of-Maintenance (POMX) system is the focus of this research, and such a discussion has a natural progression. Beginning with the importance of data accuracy, this literature review explores both present and future Air Force requirements. Current guidance regarding aircraft maintenance management describes legacy systems and practices, while documentation regarding the Air Force's logistics transformation campaign (eLog21) provides the foundation that drives the POMX initiative and demands its successful implementation. Nearly error free data are absolutely essential to the current logistics transformation efforts that enable network-centric warfare. Next, this review explores some of the reasons for maintenance data collection errors as reported in the findings of two Air Force Institute of Technology (AFIT) studies. Following that discussion is the description of the POMX concept as reported in contractual documents, news releases, and test reports. This includes isolated system implementation efforts as well as the current program sponsored by Headquarters Air Force. Finally, the literature review concludes by capturing how the POMX initiative integrates into the future Air Force logistics system to meet the data accuracy requirements mentioned in the first part of this discussion.

The Importance of Data Accuracy

Aircraft maintenance is an extremely regimented and detailed endeavor. This is a necessity not only to ensure successful mission accomplishment, but more so because the lives of aircrew and passengers rest in the hands of the technicians, managers, and senior leaders who make it their job to ensure all aircraft and equipment under their charge are mission capable.

Fundamental to the maintenance mission are the Air Force core values of "integrity first, service before self, and excellence in all we do."

Integrity in the aircraft maintenance world addresses not only the individuals performing their duties, but also inanimate aspects such as equipment and information. Good information enables good decision making while incorrect information can lead decision makers to fall well short of their goals. Air Force Instruction (AFI) 21-101 describes integrity as follows:

> Maintenance discipline involves integrity in all aspects of the maintenance process. It is the responsibility of all maintenance personnel to comply with all written guidance to ensure all required repairs, inspections, and documentation are completed in a safe, timely, and effective manner (AFI 21-101, 2004).

The instruction also stresses the importance of data accuracy in the following discussion regarding maintenance management metrics:

> Leaders, supervisors and technicians must have accurate and reliable information to make decisions. Maintenance management metrics are a crucial form of information used by maintenance leaders to improve the performance of maintenance organizations, equipment, and people when compared to established goals and standards. Metrics must be accurate and useful for decision-making (AFI 21-101, 2004).

Useful and accurate metrics serve as a baseline necessary to support an environment of continuous organizational improvement. Today's global environment and rapidly changing battle-space demand a sustained focus on continuous improvement to ensure the Air Force is able to outthink and outperform its enemies. The Air Force has determined that error free data is of enough importance to make Maintenance Group Commanders (MXG/CC) responsible to:

> Ensure aircraft maintenance data is accurate by establishing and supporting a data integrity team (DIT). Ensure members assigned to the DIT are suitably qualified and provided sufficient time to accurately assess the data. Ensure each aircraft maintenance work center performs a review of all documentation entered into CAMS/G081 daily IAW TO 00-20-2, *Maintenance Data Documentation* (AFI 21-101, 2004).

The data integrity team (DIT) consists of representatives from each maintenance squadron in addition to representatives from the Maintenance Data Systems Analysis (MDSA) section who work directly for the MXG/CC and lead the DIT effort. More commonly there are DIT members from each flight within a squadron, and those individual are charged with ensuring the accuracy of the data within their flight. To do this, they enlist the help of workcenter representatives within their flight. A typical flightline unit's representatives might include a crew chief, electrician, hydraulic technician, jet engine mechanic, avionics technician, and possibly an egress technician. These technically qualified individuals are charged with the daily review of all job data documentation (JDD) input into CAMS or G081 in order to find, correct, and document errors. This is a tedious and time consuming task that is hardly foolproof. Few maintainers relish the idea of paperwork when they could be turning wrenches, so careful selection is important when choosing DIT members. While every Air Force member should strive to maintain the core value of "integrity first", the most conscientious individuals should be chosen to perform these daily workcenter reviews to find and correct documentation errors. For the purposes of this research, the Air Force Instruction is used as the baseline criteria upon which the premise of the DIT is established. The instruction reads as follows:

> The purposes of the Data Integrity Team include: (1) ensuring the unit has complete and accurate data in the MIS and aircraft forms (to include all inputs made by staff agencies), (2) identifying and quantifying problems within the unit preventing complete and accurate documentation, (3) identifying and correcting the root causes for poor data integrity, and (4) educating the unit on the critical need for data integrity. The DIT/DIG teams are established to evaluate/isolate/eliminate documentation problems in CAMS/G081 (AFI 21-101, 2004).

The future of maintenance data collection (MDC) in the Air Force is designed to depart from outdated practices of manual keyboard entry at a computer terminal located in the aircraft maintenance unit. Legacy processes consist of multiple logistics systems that are slow and fragmented. These systems often have difficulty talking to one another, and in many instances there is no interface at all. In a presentation by Mr. Grover Dunn on the subject of Air Force Logistics Transformation, he points out the following:

> Implementation of the new logistics architecture (LogEA) focuses on three key elements.
> 1. Establishing a customer-focused enterprise-wide perspective
> 2. Developing a lean, fully integrated logistics enterprise
> 3. Data exploitation and predictive logistics awareness (Dunn, 2005).

This enterprise-wide integrated logistics system will provide the Air Force a comprehensive capability that links all of the major logistics functions and their information systems. Two of the six architecture design principles outlined in the LogEA Concept of Operations (CONOPS) focus on maintaining the data. First, the design calls for a single data model which will serve as the enterprise data warehouse for all logistics data. This serves to eliminate redundant and conflicting data while greatly increasing the speed at which decision makers can understand relevant information. It also emphasizes data integrity and quality by dictating that "every data element has only single point of entry", and that "all edits for a data element, and for all data in the transaction, are performed at time of entry" (LogEA CONOPS, 2004).

POMX is the data entryway into the Integrated Maintenance Data System (IMDS) which is one of the components of the Expeditionary Combat Support System (ECSS), the enterprise resource planning (ERP) system the Air Force has selected to meet the operating and systems architectures defined in the LogEA (LogEA Fact Sheet, 2004). The LogEA also includes a detailed transformation plan that serves as a roadmap to fulfill the eLog21 campaign goals of providing a fully integrated logistics enterprise by incorporating all logistics processes into a common framework (LogEA CONOPS, 2005). ECSS is the actual software that accomplishes this by integrating "…over 500 legacy information technology systems with a Commercial-of-the-Shelf (COTS) IT suite" (ECSS Fact Sheet, 2004). ECSS will be readily accessible via the

Air Force Portal's Global Combat Support System (GCSS-AF), and will provide comprehensive actionable information coupled with decision support tools to aid users at all levels of the decision making chain.

Today, systems engineers, program managers, and industry consultants are taking great care to ensure data is entered accurately the first time. This involves developing highly intelligent systems that make use of error checking routines to quickly alert an individual if they enter erroneous data. Much of the effort focuses on how the system will capture data and is being designed to automate the process to the maximum extent possible. Mr. Grover Dunn addresses this as part of the logistics transformation vector of "Accurate timely and secure integrated enterprise data" (Dunn, 2005). While the POMX functionality has great potential to ease the maintainer's burden, it is important to remember that it is not intended to simply be an update to the CAMS interface.

In summary, it is clear that the Air Force is dedicated to obtaining accurate data through manual error checking by dedicated personnel or through the intelligent design of systems. In order to make the transition from legacy to future state data collection, designers must have an understanding of the types and causes of data errors. This is discussed in the upcoming section.

Data Entry Errors

There are multiple reasons why data entry errors may occur. In attempting to understand the cause of inaccurate information, it is necessary to begin with a framework that concedes that human factors play a major role and will never be a variable which can be fully controlled. Two studies on data entry are looked at in this review. The first piece of research discusses the fact that some personnel appear to input errors intentionally, while the second study attempts to capture the inherent causes of data input errors. Both works are deemed to be appropriate representations of legacy maintenance data collection systems to include CAMS and G081 as well as Air Force Technical Order (AFTO) 349 paper forms which are still used when the electronic systems go offline.

In the first study, Folmar looked at intentional input errors in 1986 by conducting a survey of 430 maintenance personnel from Strategic Air Command (SAC) and 434 from Tactical Air Command (TAC). The survey return rate was a rather high 58 percent, resulting in 249 responses from TAC and 256 from SAC. Folmar's research was conducted prior to fleet-wide implementation of the CAMS system. MDC at that time consisted of AFTO Form 349s to document maintenance job data. Folmar found that inaccurate data was intentionally input into the MDC system approximately 10 percent of the time, and the reason most commonly listed for this was "pressure from supervisors and managers to account for 100 percent of their man-hour availability" (Folmar, 1986). While this was the most common reason cited for intentional errors, this result ranked fourth when it came to the causes of errors in general. The most common reason noted for data errors was that "personnel failed to take the necessary time to fill out the paperwork right" (Folmar, 1986). This was followed by lack of proper training and understanding of the complex maintenance data collection system.

In addition, Folmar's research captured individual perceptions of the value of the MDC information that they were expected to enter. Maintenance personnel were not convinced of the necessity of the maintenance data they were entering. Although they survey found there was a slight consensus that the information provided useful information for base-level decision makers, personnel were ambivalent regarding the timeliness of the information for management purposes. Folmar sums up the question of individual's perceptions as follows:

> Maintenance personnel feel that the data collected is important for base-level managers but the current MDC system is much less than ideal. They see the data base as being full

> of inaccuracies and invalid inputs. They feel the current system is flawed, slow and tedious. They would like to see changes made to make the system quicker and more user oriented. Many hoped that the CAMS data collection system would be implemented as soon as possible (Folmar, 1986).

In the second study, Determan conducted similar research 5 years later once CAMS had become the Air Force's primary means of MDC. 436 personnel were surveyed from both TAC and SAC, with respondents numbering 180 and 191 respectively for a 42.5 percent return rate. Determan's results were similar to Folmar's in that approximately 10 percent of the time personnel felt the errors were intentional. Intentional causes included pressure to falsify information, lack of perceived benefit from accurate information, and difficulty in entering the information into CAMS (Determan, 1991). In open-ended responses, additional reasons reported included the following:

> CAMS won't accept the correct information so erroneous information is entered to clear the job (15 responses), personnel are lazy and not motivated to enter the correct information (7 responses), and personnel are not adequately trained on CAMS (8 responses) (Determan, 1991).

Accidental errors were reported to be caused by keystroke errors, lack of training in using the technical order (T.O.) system, and lack of training in using the CAMS system. This was further explained by comments on how difficult it was to find the correct codes in the T.O., and that navigating the multiple screens required to document job data in CAMS was confusing (Determan, 1991). When asked "what is the single most beneficial action we could take to reduce or eliminate data entry errors in CAMS?", responses were to provide CAMS training, make the system more user friendly, and provide on-line help functionality within the system. Finally, there was a perceived improvement in data accuracy at the supervisor and manager level, but not at the worker level (Determan, 1991).

While CAMS seems to be an improvement over paper documentation, maintenance data collection remains a tedious and time-consuming task. Documentation frequently still takes place away from the aircraft and well after the maintenance is performed. It is often the current practice to complete several jobs before returning to the maintenance unit to document the job information, as leaving the flightline after every job to "go do CAMS" wastes precious time that can be utilized for aircraft maintenance. It is thought that more accurate data could be captured at the aircraft as soon as the maintenance action took place, only in recent years has it become technologically feasible. The next section describes the evolution of the Point-of-Maintenance (POMX) concept as a way to capture CAMS and G081 data with minimal inconvenience to maintenance personnel.

POMX Development

The POMX concept originated as a requirement for the Air Force's new Integrated Maintenance Data System (IMDS) to have the "ability to capture maintenance data at point of origin" (Gober, 2003). When dealing with the acquisition of a new information system, it often takes time for the requirements to fully mature. This has never been more evident than in today's world of rapidly advancing technology and spiral development programs based on incremental requirements and the fielding of systems in multiple blocks of progressive capability. IMDS is no different, and it has taken time for developers to fully understand what the POMX capabilities should be. This section reviews several wireless local area network (LAN) implementations that have fallen under the broad umbrella of POMX as well as the official Air Force sponsored program that is sponsored by AF/A4MM and run by the AIT Program Management Office at Wright-Patterson AFB, Ohio.

A 2001 study by the Logistics Management Institute (LMI) explored the following objectives while capturing the current state of Portable Maintenance Aid (PMA) use:

- Assess current and emerging PMA concepts, equipment and programs for DoD weapon systems.
- Characterize potential PMA benefits.
- Identify implementation desirability, issues, and challenges (Bapst et al., 2001).

The team accomplished this goal by examining 33 applications of PMA use in both military and civilian settings. It was noted that the Department of Defense (DOD) could obtain the following benefits by pursuing PMA use.

- Give maintainers on-the-job access to electronic technical information, maintenance documentation, and parts availability data.
- Provide a capability for maintainers to enter repair data from job sites in real time in order to provide instantaneous visibility to multiple users regarding maintenance actions and equipment status.
- Enable on-the-job access to detailed technical data and remote engineering support via automated information technology (AIT) and telemaintenance.
- Allow direct communications with weapon systems in order to facilitate troubleshooting, particularly for complex systems that do not have embedded diagnostic and prognostic functionality (Adapted from Bapst et al., 2001).

Examples of the various types of PMAs evaluated are depicted in Figure 3.

Figure 3. Sample PMA Hardware (Bapst et al., 2001).

Some of the devices in Figure 2.1 are older devices that were only used as the Air Force began exploring the advantages of collecting data at the point-of-maintenance, however the evolution of this technology has closely followed the advances of personal and laptop computers and portable data assistants (PDAs). As these devices matured, they became smaller, lighter, and more capable. One of the earlier test locations for these devices was Randolph AFB, TX, where these ruggedized laptops were used to test a wireless LAN in October 2002 in an effort to bring POMX to the Air Education and Training Command (AETC) architecture. Ruggedized laptop computers provided by Itronix were used to connect to the wireless LAN and gain access to CAMS and SBSS. While slow log-on times and the short battery life of the laptops were problematic, AETC News Service quoted one avionics technician who noted “The wireless local area network laptop is convenient and saves time” (AETC News Service, 2003). Overall, the test results were promising, and the base officially adopted the new system in July 2003. A similar effort took place shortly thereafter at Nellis AFB, NV where the 57th Aircraft Maintenance Squadron implemented the Itronix system as the first Air Combat Command (ACC) base to go wireless (Network World, 2004). Since these early tests, many other bases in various commands have adopted various versions of POMX and wireless LANs with both laptop and handheld terminal data entry based on the most current technology and funding available at the time of fielding.

As POMX began to emerge as an idea garnering Headquarters Air Force level attention, independent testing of version 1.0 was conducted in a collaborative effort between the Air Force Research Laboratory (AFRL), the University of Dayton Research Institute Human Factors Group, and NCI Information Systems, Inc. The testing that took place from 4 - 7 November, 2002 at Hurlburt Field, FL and was designed to answer the following questions:

1. For opening jobs, ordering parts, and closing jobs on the flightline, how does mode of operation (real-time with POMX, batch with POMX, or baseline without POMX) affect performance?
2. Which mode of operation do users prefer?
3. Is information presented on POMX device readable and usable (Gorman, et al., 2003)?

The hardware used during the test included the Intermec 710 handheld device with POMX software, extra batteries and charger for the device, and a CAMS terminal based on the legacy "green screen" type display (Gorman, et al., 2003).

Test results were mixed as the software did not function entirely as expected. The researchers found that the only function in question 1 they were able to test was the ability to open jobs, and the real-time functionality was hampered by RF connectivity difficulties. Nevertheless, the team was able to test the POMX system using the batch mode and compare those input times to the CAMS input times. Results were promising as the benefits from being able to capture the data at the point-of-maintenance resulted in significant improvement over the CAMS data entry method. Even when not considering travel time to the AMU building where the CAMS terminal was located, the POMX method of opening a job showed that subjects took an average of 5 minutes 41 seconds to complete the task compared to 8 minutes 13 seconds using CAMS. When travel time to the CAMS terminal was considered, the CAMS task took an average of 10 minutes 46 seconds (Gorman, 2003). The report also noted relative acceptance of the POMX handheld system based on subjective user feedback. Most users felt the handheld device was more user friendly than the CAMS environment when considered separately from the frustrations experienced with the software and wireless LAN.

This early testing eventually led to continued systems engineering and the POMX acquisition program that is currently in development. Since version 1.0, the system has followed the following progression as reported in a 13 April 2005 Status Update by the AIT PMO:

Table 1. POMX Progression

Version	Status/Issues	Testing
2.0/2.1	Expanded Year 1 capability	Nov-03
2.2	Updated Synchronization Process	Mar-05
3.0	Addressing software speed and synchronization issues. Software problems have been an ongoing concern. AIT PMO will not accept the system version until the initial handheld terminal synchronization is 2 minutes or less, and subsequent updates 20 seconds or less.	Mid-2005
3.0	Qualification Testing & Evaluation	Scheduled for late March-06
3.0	User evaluations at Hurlburt Field, Florida	Scheduled for Aug-06
3.1	In development	Unknown

(Adapted from Klarer, 2005).

Currently, POMX version 3.0 enables the following processes as listed in the version 3.0 Interface Design Description (IDD):

Voice Process: Provides an alternative functionality of updating the POMX Database Server with maintenance transactions voiced in over the FM radio to be verified via the handheld terminal (HHT). Table 2 details a list of the voice commands currently being developed to use this technology (CDO Technologies, Inc., 2004).

Table 2. Voice Commands

Create Job	Add Profile
Create Unscheduled Job	Reopen Event
Schedule Job	Order Part
Create WCE (Work Center Event)	Micap
Schedule WCE	Back Order
Schedule Cann (Cannibalization Action)	Status Update
Schedule TCTO (Time Compliance Technical Order)	

(CDO Technologies, Inc., 2004)

Database Synchronization Process: Provides functionality of synchronization (Bi-Directional Replication) of the POMX Database Server (Oracle 9i Database) with the Handheld Databases (Sybase UltraLite). The maintenance events that were recorded at the Point of Maintenance needs to be sent to CAMS for processing and the maintenance transaction results processed at CAMS needs to be sent back to the handheld device. POMX Database Synchronization Process provides the functionality of sending and receiving the transactions between the POMX Server Database and the handheld databases.

Web Application: Provides functionality to review and update the data required for support of the POMX processing.

POMX CAMS Processor (PCP): Retrieves from the queue on the POMX Database Service the transactions to be processed through to CAMS.

Query Language Program (QLP) Importer Process: Provides functionality of updating the POMX Database Server with the up to date job information and look up table information from the Core Automated Maintenance System (CAMS).

RF Messaging Process: RF Messaging Process provides functionality of immediately sending a Voiced in Record to the appropriate Handheld Terminal (HHT). When a POMX user voices in a transaction to be run through CAMS, they will immediately receive a message on the HHT stating that a new voice record has been received. They will then be able to verify and send the transaction to the POMX database to be processed into CAMS (CDO Technologies, Inc., 2004).

Also detailed in the version 3.0 IDD are sixteen transaction sets that POMX will allow a maintainer to perform. These transactions encompass the same functionality previously available only through CAMS, and will afford maintainers a distinct advantage in minimizing the potential to input bad data.

Table 3. Transaction Sets

Create Maintenance Event	Query Supply
Schedule Event (various types)	TCTO Kit Order Event
Reschedule Maintenance Event/Workcenter Event	Corrective Action Event
Reschedule Unscheduled Discrepancy	Change Event/Workcenter Event Narrative
Reopen Maintenance Event	Status Update
Create Workcenter Event	Defer Job
Order Part Event	Configuration Management
Bench Stock Order	Error Results Sets

(CDO Technologies, Inc., 2004)

Summary

This chapter began by making the case for the importance of aircraft maintenance data accuracy as a tool for decision making. It also made the connection between POMX and the larger logistics transformation efforts taking place under the eLog21 campaign as structured by the Logistics Enterprise Architecture and enabled by the Expeditionary Combat Support System. This was followed by an exploration of some earlier studies that quantified causes of data entry errors under older maintenance data collection (MDC) systems. The chapter concluded with a description of POMX attributes, capabilities, and expected benefits, as well challenges faced by users during testing of the system tools. This study proceeds in the next chapter with a discussion of the research methodology. This encompasses the details of how the study will address the investigative questions which in-turn are used to answer the research question.

III. Methodology

Chapter Overview

Having established the background for the POMX effort in the previous chapter, this section provides the methods and rationale used to answer the research question. This research uses quantitative data analysis to accomplish this goal. Following a review of the research question, this chapter discusses the specific techniques used to answer the investigative questions. The questions are discussed in terms of underlying assumptions, data organization, and tests of hypotheses. In order to build the framework of understanding that will answer the investigative questions, it is helpful to review these questions in the context established by the literature review and overall research problem.

Research Question Review and Structure

As previously noted, the purpose of this research is to determine whether POMX leads to increased data accuracy over the legacy method of inputting data into the IMDS system via a stationary computer terminal located in the AMU at Randolph AFB. To answer this, the two investigative questions (IQs) are used to conduct a quantitative comparison of maintenance data error rates between POMX and legacy systems. In conducting this type of analysis, these questions capture the state of the current system in use and shed light on any changes in data accuracy attributable to the POMX concept. This information should be considered by the current POMX acquisition program to demonstrate advances in data quality achieved to date through POMX use. The investigative questions are considered in more detail in the section that follows.

IQ1. Does the POMX system at Randolph AFB, TX provide a significant reduction in MDC errors when compared to legacy systems?

IQ2. Are specific types of MDC errors at Randolph AFB, TX reduced by using POMX when compared to legacy systems?

To answer these questions, a post hoc experimental design is used in which a series of hypotheses are proposed and tested. These are further explained in a later discussion under the heading of hypothesis testing.

Assumptions

It is noteworthy that Randolph AFB is unique in several ways compared to the other mentioned bases. First, Randolph AFB utilizes contract aircraft maintenance, therefore the maintenance being performed and documented is not accomplished by active duty Air Force personnel. Many contract maintainers are former active duty members who are familiar with the airframes and information systems they're using, and those who are not prior service members have undergone similar extensive aircraft maintenance training and certification via other programs. Second, Randolph AFB is an Air Education and Training Command (AETC) training base and typically operates somewhat differently from bases in commands such as Air Combat Command (ACC) and Air Mobility Command (AMC). For the purposes of this research, the personnel are believed to have common skills and training for entering data into POMX, CAMS, or G081, and there is no substantial difference among maintainers at various bases, whether active duty or civilian contract personnel. It is therefore assumed that POMX data entry has a similar potential to improve data accuracy regardless of base or organization. It is also believed that lessons learned from this study should be applicable to other POMX efforts in the Air Force.

During the course of this research, it was confirmed that Randolph AFB attempts to use POMX as much as possible, but there are still problems related to the wireless connectivity that sometimes prevent its use. These connectivity problems were also cited by Nellis, Langley, and

Moody when questioned about why they were not actively attempting to use their systems. It appears that Randolph has enjoyed a relative sustained level of success for their POMX system while the other bases investigated have not reached an acceptable level of use for any measurable length of time. Because Randolph had the most experience in actually using the system, the base was assumed to have the most reliable data attributable to POMX data entry. The categorization of the data is further explored in the next section.

Data Organization

To make comparisons among the data provided by POMX or traditional CAMS data entry, it is necessary to code the data in a meaningful format. To effectively accomplish this task, it is important to determine which data elements comprise the dependent and independent variables of interest in this study. The variables used to answer IQ1 are categorized in Table 4.

Table 4. IQ1 Variables

Independent Variable	Dependent Variable
POMX Status	Error Rate

Error rate is computed as shown in equation (1).

$$ER = \frac{\#\ Jobs\ in\ Error}{\#\ Jobs\ Reviewed} \qquad (1)$$

where

ER = Error Rate

Answering IQ2 involves analyzing different types of discrepancies that lead to an individual job being counted as an error. This study evaluates the following five discrepancies:

Table 5. IQ2 Discrepancy Types

Abbreviation	Discrepancy
WUC	Work Unit Code
AT	Action Taken Code
HMAL	How Malfunctioned Code
WD	When Discovered Code
WCE NARR	Work Center Event Narrative

Whereas in IQ1 a single error rate is evaluated, in IQ2 discrepancy rate by POMX status is evaluated for each of the five discrepancy types. The variables of interest are shown in Table 6.

Table 6. IQ2 Variables

Independent Variables	**Dependent Variable**
POMX Status	# of Discrepancies

This categorization allows for comparison of the dependent variable "number of discrepancies" based on the matrix shown in Table 7 to determine if there are significant differences between the types of discrepancies identified in Table 5.

Table 7. IQ2 Comparison Matrix

Construct	**Sample 1**	**Sample 2**
1	NON POMX, AT	POMX, AT
2	NON POMX, WUC	POMX, WUC
3	NON POMX, HMAL	POMX, HMAL
4	NON POMX, WD	POMX, WD
5	NON POMX, WCE NARR	POMX, WCE NARR

The data of interest include the monthly error rates and number of errors before and after POMX implementation. A period of 24 months before POMX implementation comprises Sample 1, and 24 months after implementation comprises Sample 2. The use of equal sample sizes ensures a balanced experimental design and allows more flexibility in the data analysis. Data from June and July of 2003 are excluded as this was the transition period during which Randolph was installing the POMX infrastructure and implementing the system. Due to the small sample sizes, the t-statistic is appropriate to test for significant difference between the mean error rates of the two samples. This is necessary because we are unable to rely on the Central Limit Theorem which would allow us to assume the data were normally distributed if both sample sizes contained at least 30 measurements. The comparisons in IQ2 are made only between sample groups that include the same type of discrepancy. The logic for this decision lies in the fact that this research is not concerned with the frequency of types of discrepancies in comparison with the frequency of other types of discrepancies; rather this study remains focused solely on determining whether the POMX variable has any effect on these five different types of discrepancies.

Hypotheses and Analysis

This section details the specific hypotheses used to test the investigative questions. Equations (2) and (3) are provided to demonstrate the theory behind the analytical test; however the actual tests are conducted using the SAS JMP 6.0 statistical software package. Following traditional convention, H_o refers to the null hypotheses and H_a refers to the alternative hypothesis. The following hypothesis is proposed to test IQ1:

Hypothesis 1: H_o: $\mu_2 \geq \mu_1$
H_a: $\mu_2 < \mu_1$

where μ_1 = mean population error rate without POMX
and μ_2 = mean population error rate with POMX

This hypothesis is tested using the t-statistic at the .05 level of significance. A one-way test is used because this research is interested in whether the POMX mean value is lower than the NON POMX mean value. The formula for computing the critical value of t is shown in equation (2).

$$t = \frac{(\bar{X}_1 - \bar{X}_2)}{\sqrt{s_p^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} \tag{2}$$

where

$\bar{X}_1$ = sample 1 mean
and $\bar{X}_2$ = sample 2 mean
and s_p^2 = pooled sample estimator of σ^2
and n_1 = number of measurements in sample 1
and n_2 = number of measurements in sample 2
(adapted from McClave et al., 2005)

The value s_p^2 is a pooled sample estimator of σ^2 (the population variance). Since the use of the t-statistic assumes equal variance between the two populations, the sample variances can be pooled to provide a better estimate of σ^2 as shown in equation (3) (McClave et al., 2005).

$$s_p^2 = \frac{\sum (X_1 - \bar{X}_1)^2 + \sum (X_2 - \bar{X}_2)^2}{n_1 + n_2 - 2} \tag{3}$$

where

X_1 = a measurement from sample 1
and X_2 = a measurement from sample 2
and $\bar{X}_1$ = mean from sample 1
and $\bar{X}_2$ = mean from sample 2
and n_1 = number of measurements in sample 1
and n_2 = number of measurements in sample 2
(adapted from McClave et al., 2005)

There are some assumptions that are generally accepted as necessary for the t-statistic to yield valid results. Both populations must be approximately normally distributed, and the population variances should be equal (McClave et al., 2005). Normality is tested using the "fit distribution" and "goodness of fit test" functions in JMP 6.0 at a .05 level of significance. Equality of variances is tested using the "Levene test" function in JMP 6.0 at the .05 level of significance.

In some instances the populations do not meet the required assumptions and adjustments must be made to the test procedures. While in some cases the problem can be simply noted and the standard t-test used anyway, other situations require further explanation and adjustments to the formula used to compute the critical value of the test statistic. In some instances increased reliance in placed on other research in statistical methods to help deal with the violation of assumptions. Any such departures from the norm are noted in the appropriate section of the results and analysis of the next chapter.

The same procedures used for testing IQ1 are used to test hypotheses 2 – 6 for IQ2.

Hypothesis 2: H_o: $\mu_2 \geq \mu_1$
H_a: $\mu_2 < \mu_1$

where μ_1 = mean # of Action Taken (AT) code discrepancies without POMX
and μ_2 = mean # of Action Taken (AT) code discrepancies with POMX

Hypothesis 3: H_o: $\mu_2 \geq \mu_1$
H_a: $\mu_2 < \mu_1$

where μ_1 = mean # of Work Unit Code (WUC) discrepancies without POMX
and μ_2 = mean # of Work Unit Code (WUC) discrepancies with POMX

Hypothesis 4: H_o: $\mu_2 \geq \mu_1$
H_a: $\mu_2 < \mu_1$

where μ_1 = mean # of How Malfunction (HMAL) code discrepancies without POMX
and μ_2 = mean # of How Malfunction (HMAL) code discrepancies with POMX

Hypothesis 5: H_o: $\mu_2 \geq \mu_1$
H_a: $\mu_2 < \mu_1$

where μ_1 = mean # of When Discovered (WD) discrepancies without POMX
and μ_2 = mean # of When Discovered (WD) discrepancies with POMX

Hypothesis 6: H_o: $\mu_2 \geq \mu_1$
H_a: $\mu_2 < \mu_1$

where μ_1 = mean # of Work Center Event Narrative (WCE NARR) discrepancies without POMX
and μ_2 = mean # of Work Center Event Narrative (WCE NARR) discrepancies with POMX

Summary

This chapter detailed the analysis used in the analysis of POMX error rates at Randolph AFB, TX. After reviewing the research problem and investigative question, the major assumptions were stated regarding the use of the POMX system at Randolph and the exclusion of other bases which did not have sufficient data for this study. Next was a discussion of the organization and coding of the data, which included the identification of the independent and dependent variables. The chapter concluded by addressing the specific hypotheses and test statistic used to make the comparisons between the samples. The next chapter applies these methods and captures the results from the hypothesis testing.

IV. Results and Analysis

Chapter Overview

This chapter reports the results of the data analysis conducted as part of the research design described in the previous chapter. Each test of hypothesis is treated individually, followed by a synthesis of the results as they pertain to the investigative questions. The populations from which the POMX and NON POMX samples are taken are assumed to be approximately normally distributed unless otherwise indicated by the results of the Shapiro-Wilk test. A test of equal variances for the samples being compared in each hypothesis is also conducted to ensure the proper use of the test statistic and the validity of the results. The data in this study were analyzed using the SAS JMP 6.0 statistical software package. The results for the tests of the normality and variance assumptions are available in Appendix C.

Test of Hypothesis 1: H_o: $\mu_2 \geq \mu_1$
H_a: $\mu_2 < \mu_1$

where μ_1 = mean population error rate without POMX
and μ_2 = mean population error rate with POMX

The assumption of a normally distributed population in the NON POMX data set was not entirely satisfied by the Shaprio-Wilk goodness-of-fit test in the sample data. The months of December 2000 and March 2002 appear to be outliers in relation to the remainder of the distribution. When these outliers were removed, the sample distribution was still not quite normal. For the purposes of the test the outliers remained in the distribution to ensure the maximum amount of available data was considered in the means comparison, and the true population was assumed to be normally distributed. The Levene test for equal variances between the POMX and NON POMX samples indicated that they are equal.

Based on the results in Table 8, there was no evidence that the POMX error rate was less than the NON POMX error rate.

Table 8. Hypothesis 1 Results

Levene test for Equal Variances			
p-value =	0.9115		
Variances are equal			
POMX Status	**N**	**Mean (μ)**	**Std. Dev. (σ)**
NON POMX	24	0.2163	0.1577
POMX	24	0.2518	0.1348
t-test			
p-value =	0.2031		
Fail to reject Ho			
POMX is greater than or equal to NON POMX			

Test of Hypothesis 2: H_o: $\mu_2 \geq \mu_1$
H_a: $\mu_2 < \mu_1$

where μ_1 = mean # of Action Taken (AT) code discrepancies without POMX
and μ_2 = mean # of Action Taken (AT) code discrepancies with POMX

In this case, the normality assumptions were not met for either sample; however the distributions did possess equal variances and were symmetric. According to his review of Clinch & Kesselman (1982) and Tan (1982), George Keppel noted that the results of the F-test (or t-test in this case) are not especially affected by departures from normality as long as the distributions are symmetric and of equal sample size greater than n = 12 (Keppel, 1991). Because the number of measurements in each sample was equal, the distributions possessed equal variances, and the distributions were symmetric, the departure from normality was not considered to be a significant barrier to the validity of the test. This foundation was used in subsequent hypothesis testing when similar conditions existed. Based on the results in Table 9, there was no evidence that the mean number of POMX AT discrepancies was less than the mean number of NON POMX AT discrepancies.

Table 9. Hypothesis 2 Results

Levene test for Equal Variances			
p-value =	0.7909		
Variances are equal			

POMX Status	**N**	**Mean (μ)**	**Std. Dev. (s)**
NON POMX	24	0.875	1.227
POMX	24	1.292	1.1971

t-test			
p-value =	0.1199		
Fail to reject Ho			
POMX is greater than or equal to NON POMX			

Test of Hypothesis 3: H_o: $\mu_2 \geq \mu_1$
H_a: $\mu_2 < \mu_1$

where μ_1 = mean # of Work Unit Code (WUC) discrepancies without POMX
and μ_2 = mean # of Work Unit Code (WUC) discrepancies with POMX

Again, the Shipro-Wilk test showed that the NON POMX sample data were not normally distributed; however the graph in Appendix C shows that the data resembled a normal distribution more than other types of distributions. It is believed that a larger sample size would be normally distributed, therefore the population data were assumed to be normally distributed and no further modification was made for the purposes of comparing the mean WUC discrepancy rates. The Levene test indicated that the variances were also unequal in these samples; therefore the t-statistic was adjusted by modifying the degrees of freedom used to compute the critical t-value (McClave et al., 2005).

The resulting formulas are shown in equations (4) and (5).

$$t = \frac{(\bar{X}_1 - \bar{X}_2)}{\sqrt{(\frac{s_1^2}{n_1}) + (\frac{s_2^2}{n_2})}} \tag{4}$$

where

$\bar{X}_1$ = sample 1 mean
and $\bar{X}_2$ = sample 2 mean
and s_1^2 = sample estimator of σ_1^2
and s_2^2 = sample estimator of σ_2^2
and n_1 = number of measurements in sample 1
and n_2 = number of measurements in sample 2
(adapted from McClave et al., 2005)

The difference between equations (2) (used to test hypotheses 1 & 2) and (4) is that equation (2) pools the variances from both samples to compute the critical value of the t-statistic while equation (4) keeps the sample variances separate. Additionally, equation (5) must be used to adjust the degrees of freedom to account for the difference in sample sizes. The computed value is rounded down to the nearest integer for use in selecting the proper critical value from the t-table (McClave et al., 2005).

$$v = \frac{(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2})^2}{\frac{(\frac{s_1^2}{n_1})^2}{n_1 - 1} + \frac{(\frac{s_2^2}{n_2})^2}{n_2 - 1}} \tag{5}$$

where

v = the degrees of freedom used to compute the critical value of t
and s_1^2 = sample estimator of σ_1^2
and s_2^2 = sample estimator of σ_2^2
and n_1 = number of measurements in sample 1
and n_2 = number of measurements in sample 2
(adapted from McClave et al., 2005)

Based on the results in Table 10, there was no evidence that the mean number of POMX WUC discrepancies was less than the mean number of NON POMX WUC discrepancies.

Table 10. Hypothesis 3 Results

Levene test for Equal Variances			
p-value =	0.3884		
Variances are not equal			

POMX Status	**N**	**Mean (μ)**	**Std. Dev. (σ)**
NON POMX	24	2.125	1.8253
POMX	24	1.9583	1.4289

t-test			
p-value =	0.3631		
Fail to reject Ho			
POMX is greater than or equal to NON POMX			

Test of Hypothesis 4: H_o: $\mu_2 \geq \mu_1$
H_a: $\mu_2 < \mu_1$

where μ_1 = mean # of How Malfunction (HMAL) code discrepancies without POMX
and μ_2 = mean # of How Malfunction (HMAL) code discrepancies with POMX

The Shapiro-Wilk test indicated that neither the NON POMX nor the POMX sample data were normally distributed. This test of hypothesis assumed that the population is normally distributed based on the shape of the distribution even though the results of the goodness-of-fit test indicated otherwise. It is believed that a larger sample size would support this conclusion. The Levene test indicated that the variances between the two sample distributions were not equal; therefore the t-statistic was adjusted by using equations (4) and (5) to modify the degrees of freedom as demonstrated in the previous discussion of the hypothesis 3 test results. Based on the results in Table 11, there was no evidence that the mean number of POMX HMAL discrepancies was less than the mean number of NON POMX HMAL discrepancies

Table 11. Hypothesis 4 Results

Levene test for Equal Variances			
p-value =		0.0006	
Variances are not equal			

POMX Status	N	Mean (μ)	Std. Dev. (σ)
NON POMX	24	0.9583	0.9079
POMX	24	3.6667	2.8387

t-test	
p-value =	0.9999
Fail to reject Ho	
POMX is greater than or equal to NON POMX	

Test of Hypothesis 5: H_o: $\mu_2 \geq \mu_1$
H_a: $\mu_2 < \mu_1$

where μ_1 = mean # of When Discovered (WD) discrepancies without POMX
and μ_2 = mean # of When Discovered (WD) discrepancies with POMX

The Shapiro-Wilk test indicated that the data in both samples were not normally distributed. The distributions were symmetric, and the Levene test indicated equal variances. Using the logic from hypothesis 2, the departure from normality was not thought to impact the test results. Based on the results in Table 12, there was no evidence that the mean number of POMX WD discrepancies was less than the mean number of NON POMX WD discrepancies.

Table 12. Hypothesis 5 Results

Levene test for Equal Variances	
p-value =	0.9119
Variances are equal	

POMX Status	N	Mean (μ)	Std. Dev. (σ)
NON POMX	24	0.125	0.3378
POMX	24	0.125	0.4484

t-test	
p-value =	0.5
Fail to reject Ho	
POMX is greater than or equal to NON POMX	

Test of Hypothesis 6: H_o: $\mu_2 \geq \mu_1$
H_a: $\mu_2 < \mu_1$

where μ_1 = mean # of Work Center Event Narrative (WCE NARR) discrepancies without POMX
and μ_2 = mean # of Work Center Event Narrative (WCE NARR) discrepancies with POMX

The data in both samples were not normally distributed, and the variances were not equal. In previous tests of hypothesis this research made assumptions regarding the normal distribution of the populations from which the data was gathered, however it did not seem appropriate in this case. The degree to which the data were not normally distributed seemed to be significant based on the graphs of the data and the results of the Shapiro-Wilk tests. The Wilcoxon Rank Sum test is a nonparametric way of determining whether the populations possess equivalent distributions when the assumptions of normality and equal variances are not met. Based on the results in Table 13, there was no evidence that the number of POMX WCE NARR discrepancies was less than the number of NON POMX WCE NARR discrepancies.

Table 13. Hypothesis 6 Results

Levene test for Equal Variances			
p-value =	0.0157		
Variances are not equal			
POMX Status	**N**	**Mean (μ)**	**Std. Dev. (σ)**
NON POMX	24	1.2083	3.323
POMX	24	0.2917	0.55
Wilcoxon Ranked Sums Test			
p-value =	0.3929		
Fail to reject Ho			
POMX is greater than or equal to NON POMX			

Summary of Quantitative Results

Table 14 shows that no test of hypothesis indicated improvement in data accuracy using POMX compared to using data entry methods away from the point-of-maintenance at Randolph AFB during the 48 months that comprised the data samples.

Table 14. Summary of Hypothesis Test Results

Hypothesis	Discrepancy Type	Comparison Results		
1	Overall Error Rate	POMX	≥	NON POMX
2	AT	POMX	≥	NON POMX
3	WUC	POMX	≥	NON POMX
4	HMAL	POMX	≥	NON POMX
5	WD	POMX	≥	NON POMX
6	WCE NARR	POMX	≥	NON POMX

These results did not batch expectations. It was suspected that POMX would lead to decreased error rates over conventional methods of inputting data because the data would be captured immediately following the completion of the maintenance action. Because no difference was found between the two groups, the following *post hoc* user interviews attempted to capture the reasons why POMX did not lead to increased data accuracy at Randolph AFB.

Post hoc Interviews

Further exploration into possible causes for the lack of increased data accuracy revealed that POMX was not being used at Randolph AFB to the extent originally thought at the onset of this research. A similar finding occurred earlier during this study regarding POMX use at Langley and Nellis. Though higher organizational echelons (above Wing level) believed there was a moderate amount of system use, phone calls to the using units revealed otherwise. This disparity drove the need to conduct a series of interviews at the unit level in an effort to capture a broad understanding of what was actually occurring at these bases, and what factors were behind the minimal system use.

Randolph, Nellis, and Langley were selected as the three focal bases for these interviews, and an additional interview was conducted with an individual at Hurlburt Field, Florida regarding the POMX version 3.0 effort sponsored by AF/A4MM. These bases were selected because they were the bases originally thought to have robust POMX systems that had been successfully implemented and were receiving high levels of usage. It was from these bases that data was originally sought for the quantitative analysis portion of this research before it was discovered that the data was not representative of actual POMX use.

Fifteen individuals were contacted and asked to answer three open-ended questions regarding their experience with POMX implementation at their respective bases. Twelve respondents provided their observations via email or telephone, and this equated to an 80% response rate. The respondents are coded to ensure anonymity, and each base is treated as a separate case. The respondents are coded as shown in Table 15.

Table 15. List of Respondents

Code	Respondent
L1	Respondent 1 at Langley AFB
L2	Respondent 2 at Langley AFB
N1	Respondent 1 at Nellis AFB
N2	Respondent 2 at Nellis AFB
N3	Respondent 3 at Nellis AFB
N4	Respondent 4 at Nellis AFB
N5	Respondent 5 at Nellis AFB
R1	Respondent 1 at Randolph AFB
R2	Respondent 2 at Randolph AFB
R3	Respondent 3 at Randolph AFB
R4	Respondent 4 at Randolph AFB
H1	Respondent 1 at Hurlburt AFB

Two respondents were from Langley and Nellis F-22 units that use the Integrated Maintenance Information System (IMIS), a proprietary system designed by Lockheed Martin to perform maintenance data collection functions for the F-22 Raptor. While this system does not utilize POMX or IMDS directly, the concept of capturing data at the point of maintenance is the same as the other bases, and many of the findings are just as relevant. The F-22 responses are incorporated among the POMX responses, and the IMIS specific information is included due to the fact that some readers may find the insights meaningful. Finally, some responses were edited for clarity while remaining diligent to capture the original thought.

Langley AFB Responses

The respondents from Langley AFB included representatives from the maintenance analysis and F-22 units.

Question 1: What efficiencies have been experienced by using the POMX or IMIS systems when they operate as they should? (How do they make life better than the old way of taking time in CAMS/IMDS? For IMIS, discuss batch mode if unable to use the RF LAN).

L1: Good when it works; saves time to and from the building.

L2: The ability to update and retrieve maintenance data, and to research aircraft history from the flightline, is beneficial. The Windows XP environment is user friendly and familiar to most users. Personnel can access the Air Force portal during breaks or lulls to review personnel data or review Air Force Instructions (AFIs).

Question 2: What were the implementation barriers? (What slowed you down or kept you from using the system? What problems existed/still exist?)

L1: Technical Barriers: The data transfer process from IMIS to IMDS is slow and sometimes locks the system up for 30 – 40 minutes. When this happens, personnel are unable to take any further action until the system completes the transfer.

Workforce Barriers: Workers become frustrated with the slow system and when the system times out and logs them off involuntarily. Rather than waste their time only to get logged off before they complete their documentation, many personnel prefer to go into the building and use the wired terminal.

L2: Management/Leadership Barriers: POMX came suddenly and there did not seem to be an appropriate amount of preparation. It was uncertain who in the Maintenance Group would be in charge of the effort. Effective coordination of schedules and timelines was an issue, and there was little direction in how to prepare for the implementation. The Communications Squadron (Comm.) is charged with the administration of the wireless network that enables POMX; however clear communication is lacking between Comm. and the users. Comm. personnel do not seem to fully understand the needs of the maintenance personnel and how the system is used.

Technical Barriers: Network connectivity continues to be a problem. If too many users are on the wireless network at one time, then some users are dropped without warning.

Workforce Barriers: The contractor provided limited training in the use and maintenance of the system. Information Management (IM) personnel at the flight level are overtasked. POMX did not replace any of the IMs former duties; rather it added tasks to an already busy career field without additional manpower provisions. A single contractor representative is on base, and he resides within the Comm. squadron, not within the aircraft maintenance squadron. When the IMs have a problem with the system, their lack of training requires them to track down the contractor representative.

Question 3: What needs to be different in future POMX implementations?

L1: Technical: The network coverage needs to be comprehensive from the beginning. The IMIS software user interface could also be improved.

L2: Management/Leadership: Lines of communication between the maintenance organization and the Comm. squadron should be open and established early on, and Comm. needs to fully understand the needs of the maintenance users.

Workforce: Additional IM personnel are needed, and they need more rigorous training in the administration of the POMX system.

Nellis AFB Responses

The respondents from Nellis AFB included representatives from F-22, F-15, F-16, and A-10 aircraft maintenance units (AMUs).

Question 1: What efficiencies have been experienced by using the POMX or IMIS systems when they operate as they should? (How do they make life better than the old way of taking time in CAMS/IMDS? For IMIS, discuss batch mode if unable to use the RF LAN).

N1: The ability to immediately capture data as it happens and complete the process at the job site improves the accuracy of the data (as opposed to the old way of having one individual accomplish all the documentation for the entire team regardless of whether they performed the actual maintenance themselves) and allows for less end of shift turnover and wrap-up time. Additionally, the ability to access maintenance data at the aircraft saves travel time of going back to the shop.

N2: POMX provides near real time CAMS/IMDS update capability. This allows the maintainer to open and close jobs at the work site rather than having to find a hardwired desktop CAMS terminal to perform this task. Technicians can order parts through SBSS without leaving job site. Expeditors and production superintendents can verify CAMS/IMDS (380 Screen) against the aircraft 781 series forms to ensure the aircraft is safe to fly. Maintainers no longer have to go into the office to do CAMS/IMDS updates before they can go home…this allows less rushing to complete the documentation so they can leave around the 12 hour mark. The bottom line is that with proper usage the maintainer should spend more time on his/her jet because the need to leave the flightline to access CAMS/IMDS has been eliminated.

N3: The use of the wireless gives us the ability to complete maintenance actions on the spot concurrent with the maintenance; this alleviates having to send someone inside once the work is done to complete the computer work. In addition, some of the actions we complete require that we input the part number and serial number of the component at the time of removal/installation. Frequently we make several trips back out to the aircraft to confirm these numbers, but with POMX we have the part right in front of us as we enter the information. From a supervisory standpoint, it gives us direct oversight of everything in CAMS/IMDS, as well as in other base tracking systems, without having to leave the area. This is very important during the flying day when we must oversee CAMS/IMDS actions, but cannot leave the flightline. The potential is tremendous and we are only beginning to see the benefits of using the POMX.

N4: The system works well when you receive a discrepancy from pilot data transfer cartridge that has a failure code attached to it. Jobs are automatically scheduled with job numbers, and the maintainer is able to simply open the electronic forms, perform task, and is taken to the appropriate electronic technical data session. Once the job is complete, forms are automatically annotated. When everything works right, the system is very efficient. IMIS makes the job easier with respect to time expended because you are only documenting one electronic maintenance document as opposed to paper forms and CAMS/IMDS. Also, there is increased traceability and sense of responsibility with IMIS because each maintainer inputs their own data. Under the old system, a single maintainer sometimes input the data for all jobs on a shift while other maintainers performed the work. While this is often someone who is injured, pregnant, or otherwise unable to work directly on aircraft, job data is often diluted, misunderstood, or otherwise lost during translation.

N5: Time management efficiencies are realized as maintainers no longer need to leave the flightline and travel to and from a building to perform the necessary job data documentation.

Question 2: What were the implementation barriers? (What slowed you down or kept you from using the system? What problems existed/still exist?)

N1: Technical Barriers: Network coverage is a problem. There are places on the flightline where the maintainer is working and cannot connect to the network; however a recent upgrade is expected to have improved this.

Workforce Barriers: Since POMX usage is not absolutely required, there are still maintainers who do not use it and are not even trained on how to use it. Maintainers are very hesitant to use the WLAN when faced with the loss of data and the need to reaccomplish their documentation work.

N2: Management/Leadership Barriers: Buy-in from the rank and file wasn't solicited. It came down with a "this is how you use it and you WILL use it" methodology. Management help with overcoming funding procurement issues with storage racks for the hardware was problematic. The fielding plan was not well developed as care and feeding of the system was an afterthought. Requirements were not effectively pushed down to personnel. Laptop usage was not strongly advocated.

Technical Barriers: Output power/connectivity was an issue until approximately 1 February 2006. Laptops would lose connection if barriers were in the way or if signal strength became weak because of distance to antennas. Low throughput was causing sluggish response when data updated or transferred. The requirement to ensure laptop was logged into the network at least once a week for required security updates became another task for an already burdened support section.

Workforce Barriers: Culture barriers are difficult to overcome. Some maintainers are resistant to change.

N3: Management/Leadership Barriers: Initially it was challenging getting everyone under the mindset that these are really computers that will work on the flightline just as they do in the building. Since that time folks have started to gain some understanding and trust, but there is still a lot of ground to cover. The biggest challenge to management is trying to keep the workers interested in the light of the extensive downtime issues. We are just coming back up from having non-availability for over 3 months and effectively have to start over when it comes to inspiring personnel to use these computers enough to regain competency.

Technical Barriers: System downtime and connectivity issues continue to be a problem. The wireless signal on our flightline area is very unreliable and has led to a great amount of distrust regarding use of the laptops.

Workforce Barriers: We have no formal training for using the POMX laptops or for any other PC, so the training comes via trial and error or asking somebody. Occasionally this leads to problems where folks inadvertently cause problems, or undo something that requires a great amount of work to correct. Maintaining the computers has been the biggest problem and will probably remain for some time. Our single IM person is burdened with too much to begin with, and adding the laptops did not seem to help matters. They also seem to be lacking the necessary training, and many of our problems go for weeks or months before they get resolved. We have no real conduit to funnel our wireless problems to, and our IM person is not adequately trained or equipped to solve them. We don't have the IM manning to maintain and solve the problems to make this system reliable. Until our people have a reliable system, it will never see high usage rates.

N4: Technical Barriers: IMIS is unable to log or document the cannibalization (CANN) of parts. The parts ordering process is only about 15% usable, therefore it makes it extremely unusable for production to process CANN parts. Because there is no paper parts breakdown, our only source of ordering parts is via hardware and software trees. If we run into problems, it forces us to use our Lockheed reps to source the parts, and this causes additional delays.

N5: Technical Barriers: Connectivity was an issue until only recently. New power boosters for the access point transmitters have improved coverage.

Question 3: What needs to be different in future POMX implementations?

N1: Management/Leadership: Mandating use will ensure that problems are readily identified and addressed while helping eliminate workarounds and band-aid processes that do not offer permanent solutions.

N2: Management/Leadership: Management needs to be brought in early in order to "sell it" to the prospective users. The users need to be briefed in advance and have the opportunity to see a contractor demonstration so they can have the experts answer their questions. In addition, an extensive fielding plan needs to be developed to address all areas of logistics bed down at each location.

Technical: All issues such as power, connection, and throughput need to be resolved up front to allow users to update the databases.

Workforce: Need to keep the workforce informed. These kids aren't dumb and if they perceive the wireless CAMS/IMDS interface to be non-user friendly then they will become disenchanted and frustrated causing the implementation to slow down or stop.

N3: Management/Leadership: To make POMX work effectively will require patience, people, and training. This is not a system that can become fully functional overnight. Once we built up trust and confidence in the system, we experienced great usage rates among our personnel. This trust was lost when the wireless signal became problematic. An effective system of reporting difficulties with a quick reaction will go a long way to demonstrate that there is a commitment to making the system work. For now it does not appear that keeping this system fully operational is a priority.

Technical: This is the hardest part, but reliable computers and a reliable network are essential. The quickest way to cause users to lose interest and trust in the system is for it to be unreliable.

Workforce: Early training and information will generate interest among users and make them more likely to use the system.

N4: No response to this question.

N5: Technical: Ensure the capability actually exists at the unit. A thorough network site survey will avoid a partial implementation that's full of dead spots and degraded signal areas. Laptops should be as modern as possible to ensure the fastest transactions, thus minimizing both timeouts and network congestion.

Workforce: "Old-heads" require extra attention to bring them on board.

Randolph AFB Responses

The respondents from Randolph AFB included representatives from T-1 and T-38 AMUs, as well as quality assurance (QA) personnel.

Question 1: What efficiencies have been experienced by using the POMX or IMIS systems when they operate as they should? (How do they make life better than the old way of taking time in CAMS/IMDS? For IMIS, discuss batch mode if unable to use the RF LAN).

R1: No response.

R2: It is an advantage to be able to enter job data on the flightline as opposed to returning to the building and having to find a computer that is not being used. When it works, we can access Air Force Instructions along with other useful websites.

R3: Using the wireless system, we are able to capture data sooner, and it tends to be more detailed as opposed to waiting until we return to the building.

R4: It is a useful system when it works.

Question 2: What were the implementation barriers? (What slowed you down or kept you from using the system? What problems existed/still exist?)

R1: Technical Barriers: Connectivity problems have been the biggest challenge. Though network coverage is good now, weather plays a factor in the quality of the signal. Excessively hot temperatures and high winds can cause a user to lose the network signal.

Workforce Barriers: Users have become frustrated with the network problems. In addition, many maintainers perceive the laptop as an additional burden when they're already carrying large Technical Order (T.O.) binders and tools to the flightline. It is believed that once Interactive Electronic Technical Manuals (IETMs) replace the large paper T.O. libraries, maintainers will be more receptive to carrying the laptop as it will reduce their burden. Also, many users take the laptop indoors to use it so they can take a break and escape the elements.

R2: Management/Leadership Barriers: Laptops were brought in before the system was usable. We were just showed how to log in, but no other user training took place.

Technical Barriers: The system took too long to connect and would often timeout, which required you to start over. There were times when you would get dropped offline in the middle of documenting your data, also requiring you to start over. Batteries would not stay charged early on, but this was quickly resolved.

Workforce Barriers: Although the laptop is “ruggedized", it is one more thing we have to worry about dropping and damaging. Also, operational tempo and mission requirements drive us to use what works. When the wireless system keeps dropping us off or locking up, it becomes a waste of time. As maintainers we do not have the time or personnel to fiddle with a system that only works sometimes when we can go inside, get it done, and move on to the next job.

R3: Technical Barriers: Multiple logons are time consuming and require that you sit and wait for the system to finish logging you in. Many times we get dropped and then cannot log back in, forcing us to go inside anyway.

Workforce Barriers: Heat is an issue, and going inside to accomplish the documentation also gives us an opportunity for a break. Asking us to accomplish this with the wireless laptops on the flightline creates the appearance that we will not be allowed to take breaks from the heat throughout the day. Carrying T.O.s, tools, and now laptops is too much stuff. Many people are not even familiar with CAMS and do not know how to use it. They rely on the Red “X” authority to clear their CAMS data and don't see why they should have to do it when it has to be signed off anyway by a higher authority. They just let the higher authority do all of the documentation.

R4: Management/Leadership Barriers: No initial training was provided

Technical Barriers: Multiple logons are time consuming and frustrating. It has taken over a year to resolve our wireless LAN connectivity issues.

Workforce Barriers: There is not a good point of contact at the unit level for when we have problems. Many people in the unit weren't computer literate to begin with and were just expected to use the technology.

Question 3: What needs to be different in future POMX implementations?

R1: Management/Leadership: Explain to the workforce the importance of using the system before and throughout the implementation process.

Technical: More thorough site surveys are needed to ensure the proper amount of access points are designed into the network architecture before turning it over to the user.

Workforce: The most important thing that can be done to prepare the workforce is to provide training prior to expecting them to use the system in their daily routines.

R2: Management/Leadership: There needs to be more testing before you put this type of system in the user's hands.

Technical: The system needs good network coverage from the beginning and fewer passwords/logons. The ability to switch screens back and forth like in CAMS page files would be useful.

Workforce: The contractor needs to work more closely with the users, and perhaps staff a dedicated on-site user representative in the maintenance organization for a period of time until usage stabilizes.

R3: Management/Leadership: Leadership needs to emphasize CAMS usage and documentation for all individuals. Individuals who do not even know how to operate CAMS need to be identified and trained.

Technical: It might be easier to use the CAC card to login if this would reduce the number of passwords we had to remember.

R4: Management/Leadership: Handouts or quick reference cards for using the system would be useful. Points of contact for problems need to be identified and available to work problems at the unit level.

Technical: Digital T.O.s would be nice, but there is still a need for paper schematics and wiring diagrams, as the laptop screen is not large enough for detailed wire-tracing.

Hurlburt Field Responses

The representative from Hurlburt Field was a program integrator familiar with the ongoing POMX effort and the previous user evaluations that identified the software problems currently being addressed.

Question 1: What efficiencies have been experienced by using the POMX or IMIS systems when they operate as they should? (How do they make life better than the old way of taking time in CAMS/IMDS? For IMIS, discuss batch mode if unable to use the RF LAN).

H1: Air Force Special Operations Command (AFSOC) has not seen the full efficiencies of the POMX program due to software problems during our testing.

Both of the previous versions of software had significant issues that prevented full scale use of the software. The POMX concept is a sound one however. While there are no definitive numbers, it is anticipated that POMX should increase data integrity by as much as 75% or more.

Question 2: What were the implementation barriers? (What slowed you down or kept you from using the system? What problems existed/still exist?)

H1: Management/Leadership Barriers: Leadership and users are both frustrated with POMX because of software issues. Leadership continuously asks "Why are we putting the extra burden on the maintainer if the software doesn't work correctly?"

Technical Barriers: Two main issues arose with the use of POMX.

1. Wireless LAN (WLAN). Initially POMX had connectivity issues. This turned out to be more configuration issues as opposed to the POMX software. This issue did create a major negative view that POMX would not work unless there was connectivity. This is not the case as the POMX software does have a store forward capability which allows users to input data and then dock the device once they return to the AMU.
2. Initialization of the hand held device (HHD). In order to use POMX the HHD must re-sync (initialize) with the POMX server. The initialization process was designed to only take approximately 30 seconds, but the process was not working. Some HHD basically "locked up" during the process. This issue is scheduled to be fixed with the release of version 3.0, but this release continues to suffer delays.

Workforce Barriers: Changing the mind set within the workforce is always a barrier. Maintainers do not see the benefit of documenting the data during or immediately after the maintenance action is performed. Currently, maintainers must return to the hanger/office to document maintenance thus allowing the technician to take a break. During the initial tests some users made the comment that they saw POMX as way for supervision to keep the maintainer on the flightline.

Question 3: What needs to be different in future POMX implementations?

H1: Leadership/Management: It is believed that Leadership will accept POMX version 3.0 once the software begins to work on regular basis. Need to thoroughly demonstrate a fully functional capability.

Technical: Software must work with limited-to-no interruptions. If WLAN connectivity is unavailable, then the store forward capability must kick in automatically. Synchronization with the POMX server and the feed to IMDS must work with limited data rejects.

Workforce: Maintainers must change their mind set. As Interactive Electronic Technical Manuals (IETMs) come on-line the maintainer will be forced to use the technology. POMX will become an integrated part of the maintainer's capability suite.

Based on the responses of the first three questions, a fourth question seemed appropriate.

Question 4: Are these issues being addressed in the current POMX version 3.0 implementation at Hurlburt Field?

Network connectivity issues have been adequately addressed according to the AFSOC/A4 Logistics Integration Superintendent. Hurlburt is constrained by the software however. AF/ILM, along with the AIT PMO is taking a hard stance regarding the software. The contractor is well overdue for the latest version, and the Air Force is refusing to accept the deliverable until the problems are fixed. The frustrations of the users have been taken into account, and the Air Force appears set on regaining the trust and confidence of its Airmen while equipping them with a system that performs as intended.

Cross-case Analysis

The interview responses provided insightful perspectives regarding the use of POMX at different bases. No two bases experienced exactly the same implementation issues, yet there were some obvious commonalities and trends that are worth further exploration.

Question 1: What efficiencies have been experienced by using the POMX or IMIS systems when they operate as they should?

Two themes emerged as efficiencies gained using POMX. The first was that POMX saves travel time to and from the AMU. Two respondents from Langley, four from Nellis, and one from Randolph provided this answer, for a total of 58% of all respondents. The second theme was that POMX seemed to improve data accuracy by avoiding the dilution of data that occurs with the passage of time. Two respondents from Nellis and one from Randolph felt that capturing the data sooner increases the accuracy and detail level of the data. This accounted for 25% of the respondents.

Question 2: What were the implementation barriers? (What slowed you down or kept you from using the system? What problems existed/still exist?)

Table 16. Implementation Barriers

Mgmt/Ldrshp	Technical	Workforce
Lack of good implementation plan (25%)	Network Connectivity/Coverage (75%)	Frustration with system due to poor network reliability (33%)
		Contractor rep not in maintenance unit (25%)
		Lack of training (33%)

A number of common barriers were cited by respondents across the different bases. The more frequent responses to this question are shown in Table 16. The lack of a good implementation plan was cited by one respondent from Langley, one from Nellis, and one from Randolph. The network connectivity barrier was cited by 9 respondents in all, two from Langley, 4 from Nellis, 2 from Randolph, and one from Hurlburt. Frustration faced by maintainers due to these network problems was cited by one respondent from Langley, two from Nellis, and one from Randolph. The lack of a contractor representative in the maintenance unit to assist maintainers with system problems came from one individual at Langley, one at Nellis, and one at Randolph. Finally, lack of adequate training was cited by one from Langley, two from Nellis, and one from Randolph.

Question 3: What needs to be different in future POMX implementations?

Table 17. Keys to Implementation

Mgmt/Ldrshp	Technical	Workforce
Emphasize the importance of using the system (33%)	Comprehensive and reliable network coverage from the start. (67%)	Provide proper training prior to expecting workers to use the system (25%)

Three common areas were seen as important to POMX implementation as shown in Table 17. Two respondents from Nellis and two from Randolph felt that management and leadership needed to do a better job of stressing the importance of maintainers using the system. Ensuring comprehensive and reliable network coverage from the beginning of the implementation effort was cited by one respondent from Langley, four from Nellis, two from Randolph, and one from Hurlburt. Finally, the necessity of providing proper training to workers before expecting them to use the system was cited by one from Langley and two from Randolph.

Summary

This chapter reported the results of the tests of hypotheses as well as responses from interviews conducted at several bases with POMX systems. Each test of hypothesis provided a small but necessary piece of information used to build the analytical foundation of this research. The interview responses were used to construct a cross-case analysis identifying some common trends regarding efficiencies, implementation barriers, and keys to successfully implementing POMX. The most common efficiency was that POMX saves travel time, the most common implementation barrier was that POMX suffered from network connectivity and coverage problems, and the number one key to successful implementation was to ensure that the network has good coverage from the beginning of the implementation. The next chapter makes conclusions regarding this research, offers suggestions and opinions on the current state of POMX development, and highlights areas for future research that will contribute to the body of knowledge regarding POMX and MDC error rates.

V. Conclusions and Recommendations

Chapter Overview

This chapter summarizes the research effort and answers the research question. Observations made based on the results of the analysis are presented, along with recommendations for future research related to this study. The research question is restated, followed by a discussion of the investigative questions, research conclusions, and recommendations for future research.

Research Question

The overarching question for this research is: Does implementation of Point-of-Maintenance (POMX) at Randolph AFB, Texas provide significant improvement to flightline maintenance data accuracy over the legacy method of inputting data via IMDS computer terminals located at the aircraft maintenance unit (AMU)? Based on the data provided by Randolph AFB, there was no significant evidence to suggest that current POMX implementations provide any improved accuracy benefits to flightline maintenance data over legacy MDC methods. This conclusion is further substantiated by the answers to the investigative questions.

Investigative Question 1

Does the POMX system at Randolph AFB, Texas provide a significant reduction in MDC errors when compared to legacy systems?

The test results from hypothesis 1 indicate that there is not enough statistical evidence at the .05 level of significance to reject the null hypothesis that the POMX mean error rate at Randolph AFB is equal to or greater than the NON POMX mean error rate. In other words, there is no support for the research hypothesis that POMX mean error rates are less than NON POMX error rates. The position of this research is that the POMX system at Randolph AFB does not currently provide a significant reduction in MDC error rates when compared to legacy systems.

Investigative Question 2

Are specific types of MDC errors at Randolph AFB, TX reduced by using POMX when compared to legacy systems?

This analysis did not provide any statistically significant results at the .05 significance level to reject the null hypothesis that the mean number of different types of POMX discrepancies is equal to or greater than the mean number of NON POMX discrepancies at Randolph AFB. In other words, there is no support for the research hypothesis that the POMX mean number of errors is less than the NON POMX mean number of errors. There remains the possibility that a Type II error has occurred and the null hypothesis was not rejected when should have been, therefore this study does not claim that the POMX mean is in fact equal to or greater than the NON POMX mean. Instead, this study takes the position that there is insufficient evidence to say that the mean number of discrepancies is less with POMX, and therefore the status quo (null) position is the default position.

***Post Hoc* Analysis**

The *post hoc* interview results indicated that maintainers are frustrated with the POMX system due to the network issues that they have faced. Some users stated that they felt as if they were being used to test a system that was not actually ready to be implemented. This study was unable to determine precisely how often the system is down due to connectivity problems, but it is believed that this downtime is a major factor in the lack of more significant results because during these periods users revert to the legacy methods of data entry. The interviews also confirmed that users and system administrators are both aware of and concerned with the volatility of the wireless networks. This concern was voiced by individuals contacted at multiple locations, including Nellis AFB, Nevada, Randolph AFB, Texas, and Langley AFB, Virginia. . The demands of flying and maintenance schedules often led these users to abandon POMX after repeated attempts to use the system resulted in lost connections and having to re-input data once they were disconnected. Rather than waste the time by rolling the dice on the wireless connection, maintainers stated a preference to use what they knew would work so that they could complete the documentation and move on to their next job.

An additional observation of note involves the two respondents from Nellis that felt data "seemed to be" more accurate or less diluted when using POMX. While this is a favorable observation and a good indicator that these maintainers understand the potential benefits to POMX, this was not taken to mean that they had actually realized these benefits. The quantitative analysis at Randolph AFB shows that the perceived benefit has not been realized at that location.

Research Conclusions

The quantitative analysis did not indicate that POMX had any effect on reducing the number of data entry errors, and this is likely the result of several factors. Foremost is the fact that the bases explored are greatly underutilizing their POMX systems. The data at Randolph AFB after POMX implementation was essentially the same as before POMX implementation. Reasons for this underutilization included network connectivity issues, loss of faith in the POMX system by maintenance personnel, the addition of bulky equipment to an already burdened maintainer, lack of adequate training, and lack of communication among organizational entities.

The interviews highlighted two main themes important to successfully implementing POMX: Network connectivity and user training. While not to be taken in isolation from the remainder of the responses, these two issues permeated the responses as both implementation barriers to past efforts and keys to successful implementation for future POMX endeavors.

Network connectivity was cited by 75% of respondents across all four bases queried as a technical barrier, and it was cited by 67% of respondents as being a key to successful future implementations. Many users at these bases felt the frustration of having to reaccomplish their MDC due to losing a network connection. It is not practical to expect users to adopt a system that regularly increases their workload and causes rework due to connection problems. It seems that both contractors and leadership need to do a better job with future implementations to ensure this type of problem does not occur. In the future, rigorous site surveys should continue to be emphasized to ensure the contractor offers the proper network coverage before the system is deemed ready for use. While all of the bases studied here have experienced network connectivity problems since they installed POMX, the reports from the field are that these issues are slowly resolving themselves, and Hurlburt Field reports good coverage throughout in anticipation of the next round of user evaluations.

Training was not perceived to be as problematic as network connectivity; still it was cited by 33% of respondents as a barrier to successful implementation, and by 25% of respondents as a key to successful implementation in the future. There is a positive outlook for the future regarding training, as the current POMX effort incorporates both detailed training modules and quick reference sheets. A comprehensive user's guide will also function as both a training tool and a permanent reference. These documents are in various iterations of development, yet each has significant fidelity at this point in time. This appears to be a very positive step toward alleviating the types of training concerns stated in the interview responses.

Based on the many news releases over the past three years, it is surprising that these existing POMX systems at Langley, Nellis, and Randolph are being so underutilized. Estimates at the bases range from 1-2% to 50% of jobs being input at the point-of-maintenance. The use of IETMs is hoped to help spur the use of the wireless technology, and conversion efforts among the various weapon systems should continue to be a priority.

While implementation of POMX systems has been at the MAJCOM level, there is a need for a feedback link to ensure lessons learned are captured for the benefit of the current POMX acquisition program at AFMC. Some interviewees were concerned with the amount of communication occurring between the Communications squadron and the Aircraft Maintenance squadron. A good communication link should also exist between these two entities to ensure POMX user issues are fully understood and adequately addressed. The Communications squadron maintains the network and functions as a key enabler for the maintainers using POMX; therefore they should understand the maintenance perspective. POMX will succeed over time, but each new base that implements POMX would do well to study past implementation efforts. There are also opportunities to make successful implementation more probable through additional research.

Recommendations for Future Research

The POMX version 3.0 software user evaluations at Hurlburt Field are scheduled for August, 2006. This software, coupled with the error checking capability of the POMX server, is expected to provide a significant reduction in data collection errors. A case study of the POMX effort at Hurlburt Field could capture not only past successes and failures, but also the latest user feedback and data error rates. The error rates could then be analyzed and compared with the results of this study to see if the Air Force is getting better at implementing POMX, or if they are making the same mistakes.

Another area of interest falls into the predictability of data errors. While Folmar and Determan used a survey to determine the potential causes of MDC errors, an opportunity seems to exist for developing a regression model to assist in predicting when MDC errors are more likely to occur. Variables such as rank, Air Force Specialty Code (AFSC), years of experience, career development course score, and EPR ratings may prove useful in helping identify those individuals who are most likely to have difficulty entering correct data. Early identification of these individuals can help prevent inaccurate data entry through a tailored training program and emphasis on proper supervision.

A global study based on the concepts from the *post hoc* analysis of Chapter 4 would help identify the problems and issues being faced by all bases implementing POMX. Advantages and disadvantages of different types of hardware might result in a best-of-breed configuration that bases can use as a template for updating their infrastructure.

Finally, a deployable POMX capability needs to be studied to help identify requirements such as equipment, additional personnel (Comm.), security concerns, and a host of other factors that affect our potential ability to use POMX in a deployed location.

Summary

This chapter reviewed the research effort and answered the research question through the use of the two investigative questions and the *post hoc* interviews. The conclusion is that POMX at Randolph AFB does not currently provide a significant increase to data accuracy over legacy MDC entry methods. Underutilization of POMX is an issue across multiple bases, and there are various factors contributing to this scenario. Several areas for future research were presented, including a global survey of issues and problems at all POMX bases, a regression model to predict which individuals are more prone to making data entry errors, a case study based on the next round of POMX version 3.0 user evaluations at Hurlburt Field in August 2006, and an evaluation of deployable POMX requirements.

Appendix A. Error Rate Table

Month - Yr.	POMX Status	Jobs in Error	Jobs Reviewed	Error Rate
Nov-05	POMX	4	20	0.200
Oct-05	POMX	5	21	0.238
Sep-05	POMX	7	20	0.350
Aug-05	POMX	8	20	0.400
Jul-05	POMX	6	20	0.300
Jun-05	POMX	7	20	0.350
May-05	POMX	4	21	0.190
Apr-05	POMX	3	20	0.150
Mar-05	POMX	3	20	0.150
Dec-04	POMX	10	20	0.500
Nov-04	POMX	3	20	0.150
Oct-04	POMX	6	20	0.300
Sep-04	POMX	8	20	0.400
Aug-04	POMX	8	21	0.381
Jul-04	POMX	4	20	0.200
Jun-04	POMX	2	20	0.100
May-04	POMX	3	20	0.150
Apr-04	POMX	9	18	0.500
Mar-04	POMX	12	32	0.375
Feb-04	POMX	2	27	0.074
Nov-03	POMX	6	20	0.300
Oct-03	POMX	3	22	0.136
Aug-03	POMX	3	20	0.150
May-03	NON POMX	3	24	0.125
Apr-03	NON POMX	1	21	0.048
Mar-03	NON POMX	2	20	0.100
Jan-03	NON POMX	5	20	0.250
Dec-02	NON POMX	4	23	0.174
Nov-02	NON POMX	5	20	0.250
Oct-02	NON POMX	4	20	0.200
Sep-02	NON POMX	4	20	0.200
Aug-02	NON POMX	3	20	0.150
Jul-02	NON POMX	1	20	0.050
Jun-02	NON POMX	3	20	0.150
May-02	NON POMX	6	22	0.273
Apr-02	NON POMX	3	21	0.143
Mar-02	NON POMX	8	13	0.615
Feb-02	NON POMX	6	12	0.500
Jan-02	NON POMX	3	11	0.273
Nov-01	NON POMX	2	28	0.071
Jun-01	NON POMX	2	20	0.100
Mar-01	NON POMX	3	20	0.150
Jan-01	NON POMX	4	20	0.200
Dec-00	NON POMX	18	29	0.621

Oct-00	NON POMX	3	10	0.300
Sep-00	NON POMX	6	38	0.158
Jul-00	NON POMX	2	22	0.091
Jun-00	NON POMX	8	21	0.381
May-00	NON POMX	12	28	0.429
Apr-00	NON POMX	6	25	0.240
Mar-00	NON POMX	12	44	0.273
Feb-00	NON POMX	10	41	0.244
Jan-00	NON POMX	11	37	0.297
Dec-99	NON POMX	9	29	0.310
Nov-99	NON POMX	17	51	0.333
Oct-99	NON POMX	16	35	0.457
Sep-99	NON POMX	8	29	0.276
Aug-99	NON POMX	23	68	0.338
Jul-99	NON POMX	17	43	0.395
Jun-99	NON POMX	21	25	0.840
May-99	NON POMX	21	42	0.500
Mar-99	NON POMX	35	58	0.603
Feb-99	NON POMX	40	74	0.541

Appendix B: Number of Discrepancies Table

Month - Yr_	POMX Status	WCE NARR	AT	WUC	HMAL	WD
Nov-05	POMX	1	0	2	3	0
Oct-05	POMX	0	1	3	3	2
Sep-05	POMX	0	3	1	4	0
Aug-05	POMX	1	2	3	5	0
Jul-05	POMX	0	2	0	6	0
Jun-05	POMX	0	1	3	5	0
May-05	POMX	0	0	2	2	0
Apr-05	POMX	0	1	2	0	1
Mar-05	POMX	0	1	3	3	0
Dec-04	POMX	0	5	5	9	0
Nov-04	POMX	1	1	1	2	0
Oct-04	POMX	0	1	3	5	0
Sep-04	POMX	0	2	2	7	0
Aug-04	POMX	1	3	3	3	0
Jul-04	POMX	0	0	1	4	0
Jun-04	POMX	0	2	0	0	0
May-04	POMX	0	0	0	3	0
Apr-04	POMX	2	2	3	5	0
Mar-04	POMX	0	1	1	12	0
Feb-04	POMX	0	0	1	2	0
Nov-03	POMX	1	1	5	2	0
Oct-03	POMX	0	1	1	2	0
Sep-03	POMX	0	0	0	0	0
Aug-03	POMX	0	1	2	1	0
May-03	NON POMX	0	1	1	1	0
Apr-03	NON POMX	0	1	0	1	0
Mar-03	NON POMX	0	0	2	0	0
Jan-03	NON POMX	0	2	4	1	0
Dec-02	NON POMX	0	0	1	3	0
Nov-02	NON POMX	0	0	4	1	0
Oct-02	NON POMX	0	0	3	1	0
Sep-02	NON POMX	0	0	3	1	0
Aug-02	NON POMX	0	0	3	0	0
Jul-02	NON POMX	0	1	0	0	0
Jun-02	NON POMX	0	0	0	3	0
May-02	NON POMX	0	4	3	2	0
Apr-02	NON POMX	1	0	1	2	0
Mar-02	NON POMX	0	0	8	0	0
Feb-02	NON POMX	0	3	2	1	0
Jan-02	NON POMX	0	0	3	1	0
Nov-01	NON POMX	0	1	0	1	1
Jun-01	NON POMX	0	1	0	1	1
Mar-01	NON POMX	0	0	2	0	0
Jan-01	NON POMX	3	0	1	0	0
Dec-00	NON POMX	15	0	3	0	0
Oct-00	NON POMX	7	3	1	2	0
Sep-00	NON POMX	1	3	3	0	0
Jul-00	NON POMX	2	1	3	1	1

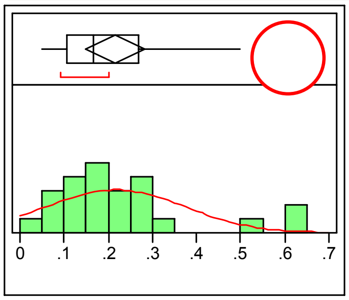
Appendix C: Tests of t-statistic Assumptions

Hypothesis 1

Shaprio-Wilk goodness-of-fit test for a normal distribution at the .05 level of significance.

Distributions POMX Status=NON POMX

Error Rate



Normal(0.21633,0.15765)

Moments

Mean	0.2163333
Std Dev	0.1576542
Std Err Mean	0.032181
upper 95% Mean	0.2829049
lower 95% Mean	0.1497618
N	24

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	0.2163333	0.1497618	0.2829049
Dispersion	σ	0.1576542	0.122531	0.2211511

Goodness-of-Fit Test

Shapiro-Wilk W Test

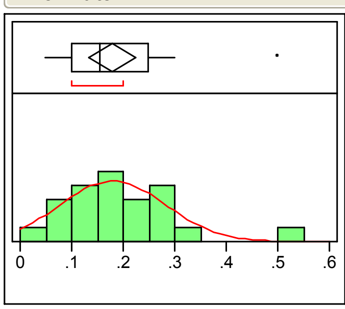
W	Prob<W
0.807421	

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

Note the outliers shown in the box-plot above for the NON POMX data set of overall Error Rate. This results in the p-value of .0004 < .05. The data are not approximately normal

Distributions POMX Status=NON POMX

Error Rate



Normal(0.17982,0.10227)

Moments

Mean	0.1798182
Std Dev	0.1022689
Std Err Mean	0.0218038
upper 95% Mean	0.2251616
lower 95% Mean	0.1344747
N	22

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	0.1798182	0.1344747	0.2251616
Dispersion	σ	0.1022689	0.0786807	0.1461488

Goodness-of-Fit Test

Shapiro-Wilk W Test

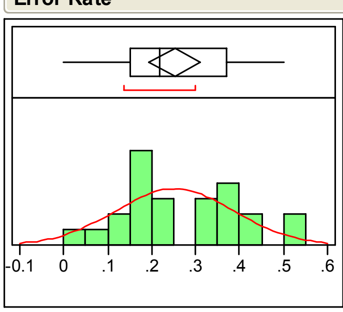
W	Prob<W
0.893231	

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

The test is repeated with the outliers removed, which results in a p-value of .0218 < .05. Though still not quite normal, the population is assumed to be normal for testing purposes.

Distributions POMX Status=POMX

Error Rate



Normal(0.25183,0.1348)

Moments

Mean	0.2518333
Std Dev	0.134798
Std Err Mean	0.0275155
upper 95% Mean	0.3087535
lower 95% Mean	0.1949131
N	24

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	0.2518333	0.1949131	0.3087535
Dispersion	σ	0.134798	0.1047668	0.1890893

Goodness-of-Fit Test

Shapiro-Wilk W Test

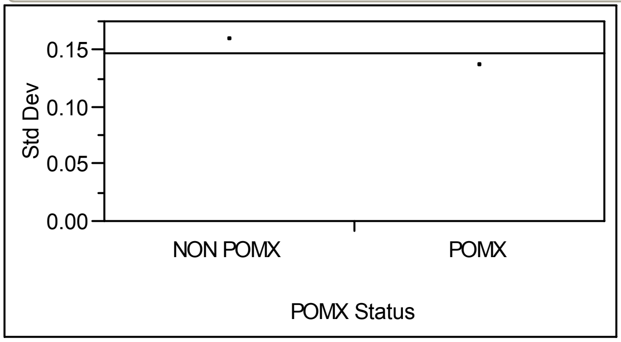
W	Prob<W
0.955006	

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

The POMX data set are normally distributed.

Levene test of equal variances at the .05 level of significance. The variances are equal.

Tests that the Variances are Equal



Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
NON POMX	24	0.1576542	0.1126111	0.1050000
POMX	24	0.1347980	0.1154861	0.1143333

Test	F Ratio	DFNum	DFDen	p-Value
O'Brien[.5]	0.3861	1	46	0.5374
Brow n-Forsythe	0.0966	1	46	0.7574
Levene	0.0125	1	46	
Bartlett	0.5500	1	.	0.4583
F Test 2-sided	1.3679	23	23	0.4584

Welch Anova testing Means Equal, allow ing Std Devs Not Equal

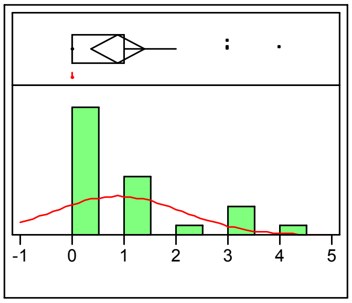
F Ratio	DFNum	DFDen	Prob > F
0.7030	1	44.916	0.4062

t Test
0.8384

Hypothesis 2

Shaprio-Wilk goodness-of-fit test for a normal distribution at the .05 level of significance.

AT



Normal(0.875,1.22696)

Moments

Mean	0.875
Std Dev	1.2269616
Std Err Mean	0.2504525
upper 95% Mean	1.3931004
lower 95% Mean	0.3568996
N	24

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	0.875	0.3568996	1.3931004
Dispersion	σ	1.2269616	0.9536112	1.7211334

Goodness-of-Fit Test

Shapiro-Wilk W Test

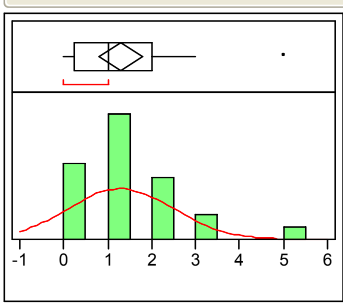
W	Prob<W
0.732481	

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

The NON POMX data are not normally distributed.

Distributions POMX Status=POMX

AT



Normal(1.29167,1.19707)

Moments

Mean	1.2916667
Std Dev	1.1970677
Std Err Mean	0.2443504
upper 95% Mean	1.797144
lower 95% Mean	0.7861893
N	24

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	1.2916667	0.7861893	1.797144
Dispersion	σ	1.1970677	0.9303773	1.6791994

Goodness-of-Fit Test

Shapiro-Wilk W Test

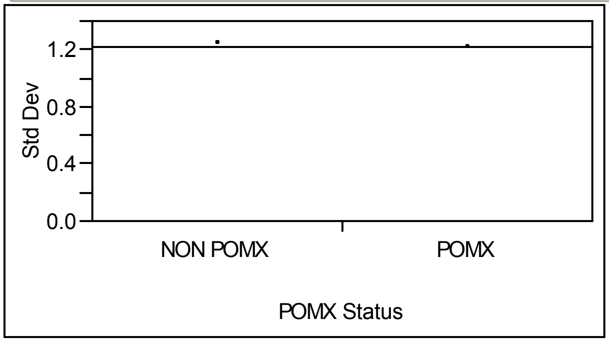
W	Prob<W
0.838833	

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

The POMX data are not normally distributed.

Levene test of equal variances at the .05 level of significance. The variances are equal.

Tests that the Variances are Equal



Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
NON POMX	24	1.226962	0.9479167	0.8750000
POMX	24	1.197068	0.8888889	0.7916667

Test	F Ratio	DFNum	DFDen	p-Value
O'Brien[.5]	0.0086	1	46	0.9264
Brown-Forsythe	0.0702	1	46	0.7922
Levene	0.0711	1	46	
Bartlett	0.0137	1	.	0.9068
F Test 2-sided	1.0506	23	23	0.9069

Welch Anova testing Means Equal, allowing Std Devs Not Equal

F Ratio	DFNum	DFDen	Prob > F
1.4180	1	45.972	0.2398

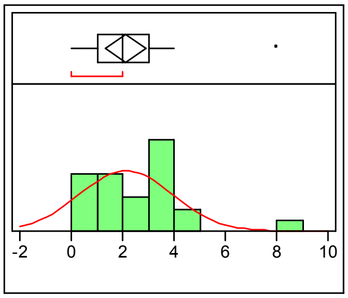
t Test
1.1908

Hypothesis 3

Shaprio-Wilk goodness-of-fit test for a normal distribution at the .05 level of significance.

Distributions POMX Status=NON POMX

WUC



Normal(2.125,1.82525)

Moments

Mean	2.125
Std Dev	1.8252457
Std Err Mean	0.3725767
upper 95% Mean	2.8957336
lower 95% Mean	1.3542664
N	24

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	2.125	1.3542664	2.8957336
Dispersion	σ	1.8252457	1.4186057	2.5603827

Goodness-of-Fit Test

Shapiro-Wilk W Test

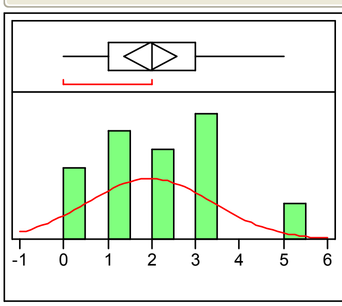
W	Prob<W
0.852109	

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

The NON POMX data are not normally distributed.

Distributions POMX Status=POMX

WUC



Normal(1.95833,1.42887)

Moments

Mean	1.9583333
Std Dev	1.428869
Std Err Mean	0.2916667
upper 95% Mean	2.5616918
lower 95% Mean	1.3549749
N	24

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	1.9583333	1.3549749	2.5616918
Dispersion	σ	1.428869	1.1105364	2.0043612

Goodness-of-Fit Test

Shapiro-Wilk W Test

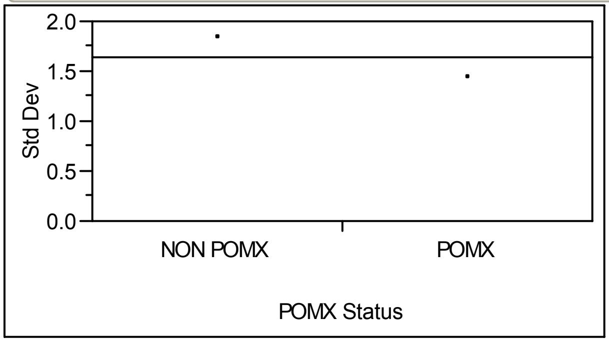
W	Prob<W
0.907838	

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

The POMX data are not normally distributed

Levene test of equal variances at the .05 level of significance. The variances are equal.

Tests that the Variances are Equal



Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
NON POMX	24	1.825246	1.385417	1.375000
POMX	24	1.428869	1.131944	1.125000

Test	F Ratio	DFNum	DFDen	p-Value
O'Brien[.5]	0.6516	1	46	0.4237
Brown-Forsythe	0.7150	1	46	0.4022
Levene	0.7583	1	46	
Bartlett	1.3361	1	.	0.2477
F Test 2-sided	1.6318	23	23	0.2478

Welch Anova testing Means Equal, allowing Std Devs Not Equal

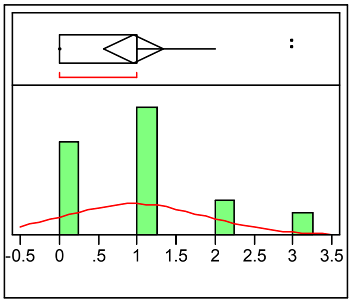
F Ratio	DFNum	DFDen	Prob > F
0.1241	1	43.494	0.7264

t Test
0.3522

Hypothesis 4

Shaprio-Wilk goodness-of-fit test for a normal distribution at the .05 level of significance.

HMAL



Normal(0.95833,0.9079)

Moments

Mean	0.9583333
Std Dev	0.9078961
Std Err Mean	0.1853235
upper 95% Mean	1.3417042
lower 95% Mean	0.5749624
N	24

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	0.9583333	0.5749624	1.3417042
Dispersion	σ	0.9078961	0.7056292	1.2735609

Goodness-of-Fit Test

Shapiro-Wilk W Test

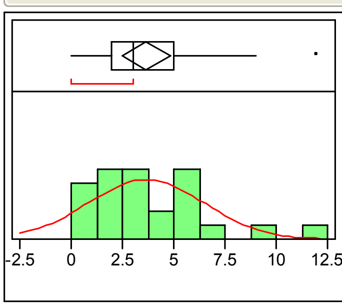
W	Prob<W
0.825833	

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

The NON POMX data are not normally distributed.

Distributions POMX Status=POMX

HMAL



Normal(3.66667,2.83866)

Moments

Mean	3.6666667
Std Dev	2.8386566
Std Err Mean	0.5794383
upper 95% Mean	4.8653262
lower 95% Mean	2.4680071
N	24

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	3.6666667	2.4680071	4.8653262
Dispersion	σ	2.8386566	2.2062424	3.9819556

Goodness-of-Fit Test

Shapiro-Wilk W Test

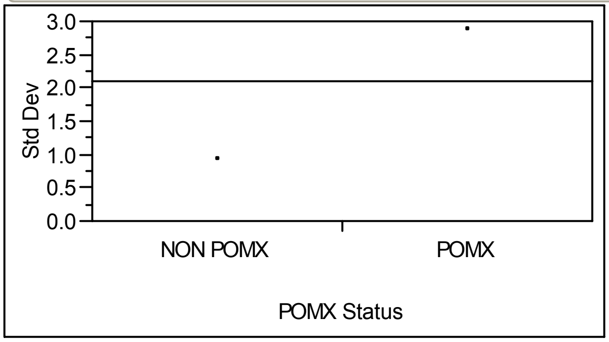
W	Prob<W
0.900479	

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

The POMX data are not normally distributed.

Levene test of equal variances at the .05 level of significance. The variances are not equal.

Tests that the Variances are Equal



Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
NON POMX	24	0.907896	0.638889	0.625000
POMX	24	2.838657	2.111111	2.000000

Test	F Ratio	DFNum	DFDen	p-Value
O'Brien[.5]	5.0434	1	46	0.0296*
Brow n-Forsythe	9.5200	1	46	0.0034*
Levene	13.6684	1	46	
Bartlett	24.5007	1	.	<.0001*
F Test 2-sided	9.7758	23	23	<.0001*

Welch Anova testing Means Equal, allow ing Std Devs Not Equal

F Ratio	DFNum	DFDen	Prob > F
19.8195	1	27.657	0.0001*

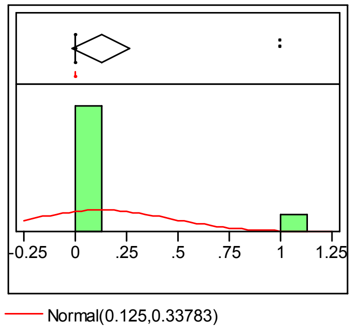
t Test
4.4519

Hypothesis 5

Shaprio-Wilk goodness-of-fit test for a normal distribution at the .05 level of significance.

Distributions POMX Status=NON POMX

WD



Moments

Mean	0.125
Std Dev	0.337832
Std Err Mean	0.0689597
upper 95% Mean	0.2676539
low er 95% Mean	-0.017654
N	24

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Low er 95%	Upper 95%
Location	μ	0.125	-0.017654	0.2676539
Dispersion	σ	0.337832	0.2625676	0.4738974

Goodness-of-Fit Test

Shapiro-Wilk W Test

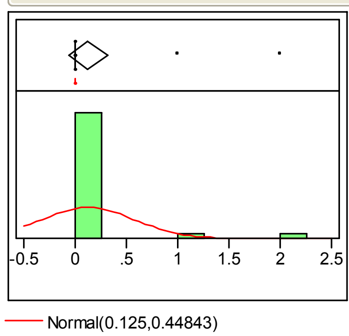
W	Prob<W
0.392899	

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

The NON POMX data are not normally distributed.

Distributions POMX Status=POMX

WD



Moments

Mean	0.125
Std Dev	0.4484272
Std Err Mean	0.0915348
upper 95% Mean	0.3143542
low er 95% Mean	-0.064354
N	24

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Low er 95%	Upper 95%
Location	μ	0.125	-0.064354	0.3143542
Dispersion	σ	0.4484272	0.3485237	0.629036

Goodness-of-Fit Test

Shapiro-Wilk W Test

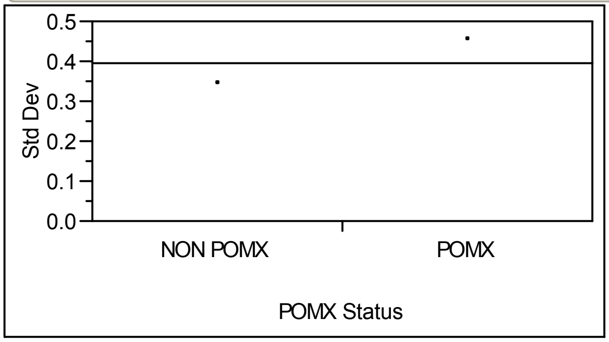
W	Prob<W
0.315543	

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

The POMX data are not normally distributed.

Levene test of equal variances at the .05 level of significance. The variances are equal.

Tests that the Variances are Equal



Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
NON POMX	24	0.3378320	0.2187500	0.1250000
POMX	24	0.4484272	0.2291667	0.1250000

Test	F Ratio	DFNum	DFDen	p-Value
O'Brien[.5]	0.2707	1	46	0.6053
Brown-Forsythe	0.0000	1	46	1.0000
Levene	0.0124	1	46	
Bartlett	1.7817	1	.	0.1819
F Test 2-sided	1.7619	23	23	0.1820

Welch Anova testing Means Equal, allowing Std Devs Not Equal

F Ratio	DFNum	DFDen	Prob > F
0.0000	1	42.747	1.0000

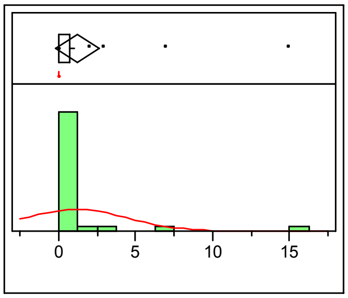
t Test
0.0000

Hypothesis 6

Shaprio-Wilk goodness-of-fit test for a normal distribution at the .05 level of significance.

Distributions POMX Status=NON POMX

WCE NARR



Normal(1.20833,3.3229)

Moments

Mean	1.2083333
Std Dev	3.3229003
Std Err Mean	0.6782842
upper 95% Mean	2.6114711
lower 95% Mean	-0.194804
N	24

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	1.2083333	-0.194804	2.6114711
Dispersion	σ	3.3229003	2.5826033	4.6612337

Goodness-of-Fit Test

Shapiro-Wilk W Test

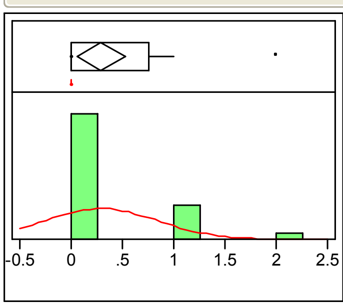
W	Prob<W
0.428300	

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

The NON POMX data are not normally distributed.

Distributions POMX Status=POMX

WCE NARR



Normal(0.29167,0.55003)

Moments

Mean	0.2916667
Std Dev	0.5500329
Std Err Mean	0.112275
upper 95% Mean	0.5239252
lower 95% Mean	0.0594081
N	24

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	0.2916667	0.0594081	0.5239252
Dispersion	σ	0.5500329	0.4274931	0.7715645

Goodness-of-Fit Test

Shapiro-Wilk W Test

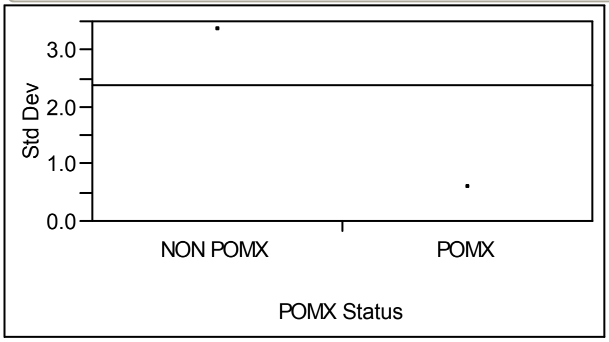
W	Prob<W
0.580106	

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

The POMX data are not normally distributed.

Levene test of equal variances at the .05 level of significance. The variances are not equal.

Tests that the Variances are Equal



Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
NON POMX	24	3.322900	1.847222	1.208333
POMX	24	0.550033	0.437500	0.291667

Test	F Ratio	DFNum	DFDen	p-Value
O'Brien[.5]	1.6120	1	46	0.2106
Brown-Forsythe	1.7777	1	46	0.1890
Levene	6.2891	1	46	
Bartlett	50.9865	1	.	<.0001*
F Test 2-sided	36.4970	23	23	<.0001*

Welch Anova testing Means Equal, allowing Std Devs Not Equal

F Ratio	DFNum	DFDen	Prob > F
1.7777	1	24.259	0.1948

t Test
1.3333

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Vita

Captain William D. Cone graduated from Huffman High School in Birmingham, Alabama in 1989. He enlisted in the Air Force in 1992 as an F-15 Avionics Technician and was assigned to Kadena AFB, Japan and Seymour Johnson AFB, North Carolina. As a Senior Airman, he was selected under the Scholarships for Outstanding Airmen to ROTC program and entered undergraduate studies at Birmingham-Southern College in 1997 where he graduated with a Bachelor of Science degree in Economics in May 1999. He was commissioned through the Detachment 012 AFROTC at Samford University.

His first assignment as an officer was to Fairchild AFB, Washington where he gained experience on the KC-135 Stratotanker. While at Fairchild, he attended the Aircraft Maintenance Officer Course at Sheppard AFB, and deployed multiple times to Incirlik AB, Turkey in support of Operation NORTHERN WATCH. He was assigned to the Joint Strike Fighter Program Office at Wright-Patterson AFB, Ohio in August 2002, where he served as Pilot Systems Logistics Lead for the F-35 acquisition program. In September 2004, he entered the Graduate School of Engineering and Management, Air Force Institute of Technology. Upon graduation, he will be assigned to Headquarters Air Mobility Command, Scott AFB, Illinois.

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14. ABSTRACT

Maintenance data collection is an integral part of flightline aircraft maintenance. Historically, this data was input via traditional keyboard data entry methods at a computer terminal. These terminals are typically located in the aircraft maintenance unit (AMU) facility, away from where the actual maintenance is being performed. In contrast to the traditional approach, the Point-of-Maintenance system (POMX) seeks to reduce the data entry burden while increasing data accuracy through the use of E-Tools such as ruggedized laptop computers and handheld portable maintenance aids (PMAs). POMX enables data entry at the aircraft or other maintenance location via wireless local area network or batch storage, and seeks to capture data as the maintenance is performed.

This research analyzes the impact of a POMX system on maintenance data error rates. This research takes a careful look at the implementation of POMX at Randolph AFB to enable current designers and system engineers to gain insight into what to expect as the next generation of POMX comes on-line. Initial results indicate no significant improvement in data quality and no reduction in the number of data errors recorded with POMX systems. Follow-up interviews with POMX users and experts revealed that the Air Force still has a number of managerial, technical and organizational constraints which must be overcome before a POMX system can add to the effectiveness of Air Force maintenance operations.

15. SUBJECT TERMS

Point of Maintenance, Automatic Identification Technology, Portable Maintenance Aid, Integrated Maintenance Data System,
Core Automated Maintenance System, Maintenance Data Collection, Aircraft Maintenance, Data Integrity, Data Accuracy
POMX, AIT, PMA, IMDS, CAMS, MDC

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