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Evaluating Management Strategies for Automated Test Systems/ Equipment (ATS/E): An F-15 Case Study

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EVALUATING MANAGEMENT STRATEGIES FOR AUTOMATED TEST SYSTEMS/EQUIPMENT (ATS/E): AN F-15 CASE STUDY

THESIS

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Abstract

The management of United States Air Force Automatic Test Systems presents a variety of issues that affect the long-term capability and mission readiness of weapon systems. Historical procurement processes suggest that individual System Program Offices developed and replaced Automatic Test Equipment “as-required”; their specific managerial actions being driven in parallel support of the managed weapon system. With the passage of time, growing numbers of platform-specific pieces of Automatic Test Equipment, coupled with aging aircraft, led to significant increases in parts obsolescence and greater sustainment challenges. This obsolescence and a desire for longer-term viability provided the inertia for a movement towards consolidated, common test equipment that would support multiple weapon systems.

In 1998, the Air Force Chief of Staff directed Headquarters Air Force Materiel Command to establish a support equipment office to facilitate the combination of similar legacy Automatic Test Equipment into common equipment. Still, two different sustainment strategies continue to exist today. Some Automatic Test Equipment continues to be primarily supported by individual System Program Offices, while other Automatic Test Equipment is primarily managed by the Automated Test Systems Division at Warner-Robins Air Logistics Center (WR-ALC/LEA). This research is designed to examine the similarities and differences of these two approaches. Specifically, this research focuses on the management of two pieces of Automatic Test Equipment for a mature aircraft system – the F-15.

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Jeremy A. Howe

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I. Introduction

Overview

The management of United States Air Force Automatic Test Systems and Equipment presents a variety of supportability and sustainability issues that directly affect the long-term capability and mission readiness of weapon systems. Given that many already mature platforms are programmed into the active inventory for several more years, it is important to provide reliable support for the various test equipment responsible for weapon system condition verification and diagnosis. An historical view would indicate that this effort is certainly dramatic in scope, not only for the Air Force, but for the entire Department of Defense, as the Department spent approximately $50 billion on the operation and support of Automatic Test Equipment from 1980-1992 (Ross, 2003).

Past procurement processes suggest that individual aircraft platform System Program Offices developed, improved and replaced Automatic Test Equipment on an "as-required" basis; their specific managerial actions being driven in parallel support of the managed weapon system. Previous researchers contend that the Air Force did not historically have directive policy on tester standardization (Ross, 2003). With the passage of time, however, growing numbers of platform-specific pieces of Automatic

Test Equipment, coupled with ever-aging aircraft, have led to significant increases in replacement part obsolescence and greater challenges in long-term weapon system sustainment. As an example, the F-15 and B-52 are projected to reach a 51- and 94-year life-cycle, respectively, before retirement in 2040. (Griffith, 2004). This obsolescence and a concern for maintaining longer-term viability of Automatic Test Systems and Equipment in support of aging aircraft provided the necessary inertia for a movement towards the procurement and development of consolidated, common test equipment that would support multiple weapon systems.

The first appearance of senior-leader direction espousing the benefits of core, consolidated Automatic Test Systems and Equipment appeared in the 1994 Air Force Policy Directive 63-2. Specifically, the directive stated, “Standardized automatic test systems (ATS) and equipment can provide efficiency and reduced cost by minimizing the proliferation of system-unique test equipment while ensuring that the maintenance and deployment requirements of existing and developing weapon systems and equipment are met.” (USAF-1, 1994). Furthermore, the directive emphasizes “Air Force policy is to minimize new ATS development and to acquire automatic test systems that have applications across multiple weapon systems.” (USAF-1, 1994).

In 1998, the Air Force Chief of Staff directed Headquarters Air Force Materiel Command to establish a Common Support Equipment office to facilitate the combination of similar legacy Automatic Test Equipment into common core test equipment. Still, despite this initiative and the presence of Air Force policy regarding the acquisition and development of common test equipment, two different Automatic Test Equipment management strategies continue to exist in practice today. Some Automatic Test

Equipment continues to be primarily supported by individual System Program Offices, while other Automatic Test Equipment is consigned to the Automated Test Systems Division at Warner-Robins Air Logistics Center (WR-ALC/LEA) for sustainment through the remainder of the life-cycle. On the surface, the first approach sets the stage for wasted resources, since there is a strong likelihood that multiple weapon systems, when encountering similar needs from field users, could individually fund and acquire identical or similar testers. (MacAulay Brown, 2002). The second approach, however, introduces a greater level of complexity to Automatic Test Equipment management, since individual System Program Office managers would need to involve and accommodate the needs of other System Program Offices, as well as the future sustainment concerns of the Automated Test Systems Division at Warner-Robins Air Logistics Center, throughout the acquisition management process. (MacAulay Brown, 2002). Previous research suggests that since support funding flows through individual System Program Offices, managers from competing organizations would be concerned about paying more than their "fair share" for the sake of commonality during the acquisition and development of new testers. (MacAulay Brown, 2002).

Consensus opinion suggests that common Automatic Test Equipment may leverage economies of scale and afford savings in terms of life-cycle costs, but the elimination of "single-point ownership" may complicate both supportability and the managerial abilities of individual program offices. In contrast, while individually procured and uniquely managed Automatic Test Equipment may be more easily managed by System Program Offices, it seems exceptionally wasteful not to capitalize on the similarities of function between related testers across weapon systems. In short, common

Automatic Test Equipment may add complexity to equipment procurement and sustainment, but offers potential savings in cross-system usage. Equipment managed by individual System Program Offices may benefit from focused, tailored procurement and sustainment, but perhaps at the cost of redundancy or wasted resources.

The existence of two distinct strategies suggests the question of comparison. The choice is between one solution that is easy to implement but somewhat inefficient (individual weapon system management), and another (consolidated management), which is more complex to implement and maintain, but potentially offers efficiencies in acquisition, logistics, and sustainment. (MacAulay Brown, 2002). Accordingly, this research is designed to examine, compare and investigate the existing similarities and differences of these two approaches. Specifically, this research focuses on the management of two pieces of Automatic Test Equipment for a mature aircraft system – the F-15.

Problem Statement

United States Air Force decision-makers need to understand specific costs, benefits and concerns regarding the implications of two alternative strategies for Automatic Test Equipment sustainment: 1) single-point Automatic Test Equipment management under the weapon system ownership of a System Program Office or 2) the consolidation of Automatic Test Equipment to be managed at an existing stand-alone automated test systems support office. This research will compare the existing management strategies for two pieces of Automatic Test Equipment under a single mature weapon system (F-15) – the primary difference being the focal point of management support. Both pieces of

Automatic Test Equipment under study are in the sustainment phase. One is primarily supported by the Air Force's Automatic Test Systems product group manager (Avionics Intermediate Shop (AIS), WR-ALC/LEA), while the other's focal management remains at the F-15 System Program Office (Tactical Electronic Warfare System Intermediate Service Station (TISS), WPAFB).

Research Question

This research seeks to answer the question: Is F-15 automatic test equipment more supportable and efficient when managed by a separate support office or when managed by the supported weapon system?

Investigative Questions

Multiple questions will be addressed in order to answer the research question:

1. What are the differences in how Automatic Test Equipment is being managed by the respective programs?
    a. Prior to making assessments of supportability and efficiency, the structural and practical differences in management technique must be identified and studied. There may or may not be dissimilarity between the System Program Office and the depot regarding communication, formal requests, deadlines, timelines, bureaucracy, etc.
2. How much sustainment funding is budgeted and funded in the Program Objective Memorandum (POM) and Future Year Defense Plan (FYDP) by each program?

a. As an example, has one equipment system historically received a greater proportion of its requested budget? Has the flow of funding been more responsive, timely and consistent? Where do equipment Program Objective Memorandum inputs rank among Air Staff and Major Command funding priorities?

3. What are System Program Office, depot and Major Command assessments of Automatic Test Equipment sustainability for the two programs?

    a. This question seeks to compare both the volume and severity of sustainability issues (e.g. hardware and component reparability and availability) between the two systems.

4. What are Major Command assessments of field units' abilities to support assigned equipment with resources provided by the System Program Office and depot?

    a. For example, do technicians and frontline users receive the parts they need, and are they received in a timely fashion?

    b. Alternatively, how often are field unit personnel confronted with inadequate data from technical orders or insufficient troubleshooting support, necessitating workarounds and "creative solutions" to return equipment to operational status?

Scope and Limitations of Research

This research effort focuses solely on comparing the management of two pieces of Automatic Test Equipment within the F-15 weapon system. The selection of the Tactical Electronic Warfare System Intermediate Service Station and the Avionics Intermediate

Shop as the two representative systems for this study was made on the recommendation and concurrence of experts within the F-15 weapon system and test equipment community. While the Avionics Intermediate Shop is not "common" to other weapon systems, its primary managerial support is focused at the Air Force's Automated Test Systems Division (WR-ALC/LEA), and was deemed by field experts and the researcher as a representative system for the purposes of this study. Additionally, both of these systems pre-existed the implementation of the Secretary of the Air Force's guidance on new Automatic Test Systems acquisition in 1994. As a result, both systems are observed in the sustainment phase. The aim of this research is to investigate and potentially discover any significant differences in managerial practice between depot and weapon system (F-15) System Program Office managers. The resultant data analysis, therefore, is limited to the management of equipment under study, and its applicability should be carefully extrapolated to other managed systems.

Methodology

The researcher chose a qualitative research methodology and specifically a case study strategy for the research design. Based on the recommendation of subject matter experts, a suitable equipment candidate for study was chosen from each of the two management communities for Automatic Test Equipment. This researcher relied primarily on structured interviews and document analysis to collect data on the management approaches for the two pieces of equipment under study. In accordance with case study data analysis, this researcher sought to identify convergence and triangulate data. (Leedy and Ormrod, 2001) Additionally, pattern identification, single instance interpretation and overall data synthesis were employed as a means to draw conclusions about and comparisons between the two management strategies. (Creswell, 1998).

Summary

This chapter introduced the research objectives and approach contained within this study. We began by providing a brief overview of United States Air Force Automatic Test Equipment, the importance and cost of supporting Automatic Test Equipment, and the two managerial concepts currently being used to manage Automatic Test Equipment. Next, a problem statement was formulated and a research question was identified to guide the direction of the study. Additionally, four investigative questions were introduced to further narrow the scope of the research and provide a framework to guide data collection and analysis efforts.

Additionally, limitations affecting the scope of this research were identified and a research methodology strategy was outlined. In the following chapter, a variety of specific literature is examined addressing the management of Automatic Test Equipment.

II. Literature Review

Background

In examining the related literature, the second chapter familiarizes the reader with Automatic Test Systems and Equipment by defining the system terms themselves, as well as discussing in greater depth the characterization of "common" test equipment. Next, a review of associated official policy and guidance documentation examines both historical and current approaches to the acquisition and management of Automatic Test Equipment. Additionally, the current state of United States Air Force Automatic Test Equipment is discussed using references of existing third-party reports and government audits into existing practices. In preparation for the in-depth examination specific to this study, the researcher will then provide specific background on Automatic Test Equipment for the F-15 weapon system, including organizational management structure. The chapter then concludes with specific familiarization material pertaining to the two test equipment systems chosen for this study.

Introduction to Automatic Test Systems and Equipment

Automatic Test Systems and Equipment are carefully defined within the relevant USAF guidance on their acquisition. Specifically, "ATS consist of ATE and the Test Program Sets (TPS) required for testing the unit-under-test (UUT). Test program sets include software, interface devices and necessary data. ATS are equipment designed to conduct analysis of functional or static parameters automatically and to evaluate the degree of unit-under-test performance degradation. They may be used to perform fault isolation of unit-under-test malfunctions. The decision making, control, or evaluative functions are conducted with minimum reliance on human intervention and usually done under computer control" (USAF-1, 1994). In simpler terms, an Automatic Test System is the broadest category; Automatic Test Equipment and Test Program Set are nested categories within, as illustrated in Figure 1.

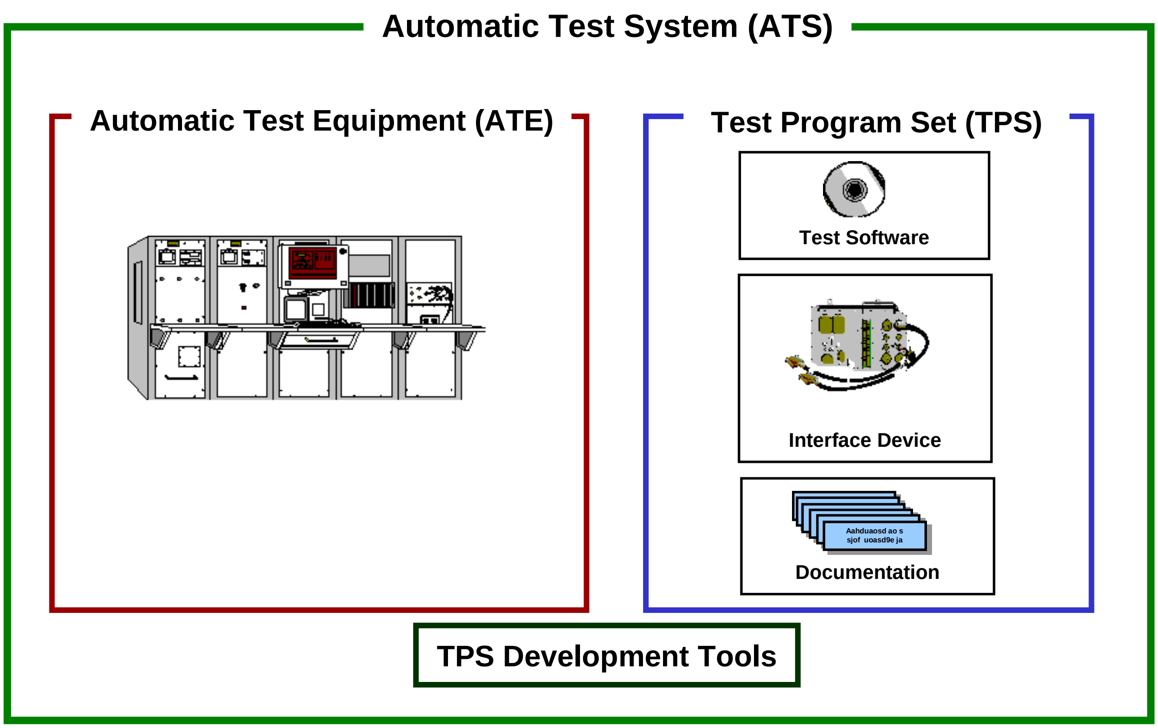

Figure 1. ATS, ATE, & TPS Categorization (Fletcher, 1998).

Automatic Test Equipment includes both the hardware and software required for system operation, but not the software required to execute specific tests (this is part of a given Test Program Set). Hardware size and, consequently, Automatic Test Equipment portability vary greatly. Some systems are easily transportable in hardened suitcases; others are bookshelf-sized equipment racks that are more or less fixed in place. Still, observers will find Automatic Test Equipment employed in environments hostile and non-hostile, local and remote. Specialized Automatic Test Equipment may be ruggedly designed to withstand harsh climates or use aboard ships; other locations may employ more generalized commercial off-the-shelf (COTS) systems. Regardless of the specificity of particular Automatic Test Equipment, the primary functions are basically the same. First, a computer is used to control one or more test instruments, such as signal generators, voltmeters or waveform analyzers. These instruments are guided by test software programs to stimulate a designated circuit or electrical component in the unit under test. The instruments will then measure electrical response at the relevant pins, ports or connections to determine the status of the unit-under-test (e.g. meets or does not meet specifications, presence of one or more faults). The specific electronics tested by Automatic Test Equipment include "black boxes" (line-replaceable units), circuit cards (shop-replaceable units), and in some cases, all-up rounds themselves. Finally, most Automatic Test Equipment will also perform internal maintenance and diagnosis operations, such as self-calibration (Fletcher, 1998).

Test Program Sets most often are comprised of specific program software, interface hardware (e.g. connection devices, fixtures or cables) and documentation. Test Program Set software will analyze the response measurements taken by Automatic Test Equipment test instruments and relay pertinent information to the operating technician (e.g. fault detection, cause of failure, satisfactory function) (Fletcher, 1998).

Automatic Test Systems may be found at all levels of maintenance: production factory, depots, contractor facilities, intermediate repair facilities and organizational shops. The current Department of Defense inventory numbers over 400 different

Automatic Test Systems (GAO, 2003). As one might expect, there are tens of thousands of individual Test Program Sets (Vandenberg, 2004) to accompany these systems. Within the United States Air Force, the Warner-Robins Air Logistics Center Automatic Test Systems Division (WR-ALC/LEA) manages seventy-percent and Warner Robins Air Logistics Center as a whole manages eighty three-percent of the 31,783 Air Force managed Automatic Test Systems and Equipment items (Johnson, 2004). To generalize, in its present state, there is negligible interoperability across different United States Air Force Automatic Test Systems, let alone across the military services. Test Program Sets developed for a given Automatic Test System generally cannot be easily migrated to another system. Some suggest that this lack of flexibility is severely limiting, and a key contributor to the accumulation of more and more test sets to attain the desired (or, as it were, needed) capacity for each supported unit-under-test (Vandenberg, 2004).

"Common" Automatic Test Systems Defined

For the purposes of this study, the term commonality is used to describe Automatic Test Systems that can be used to test more than one type of weapon system. More importantly, the term "common" will be used a convenient means to categorize all Automatic Test Systems that are managed by the Automated Test Systems Division at Warner-Robins Air Logistics Center (WR-ALC/LEA), to include managed Automatic Test Equipment that is *not* used by more than one weapon system. Although all Automatic Test Systems under the focused management of WR-ALC/LEA may not possess a degree of commonality, this researcher wished to draw a distinction between 1) single-point Automatic Test System ownership by individual System Program Offices and 2) separate Automatic Test System ownership by Warner-Robins Air Logistics Center's Automated Test Systems Division. Furthermore, in terms of future implications, any newly acquired Automatic Test Systems will ultimately fall under the sustainment ownership of WR-ALC/LEA following traditional commodity consignment processes, which will be discussed in greater detail later in this chapter. As such, this researcher theorized that an examination of existing management practices for equipment at both System Program Office and depot (WR-ALC/LEA) levels would yield beneficial information for Air Force decision-makers, regardless of the chosen equipment's level of commonality.

Interestingly, the existing literature is not as explicit in its definition of "common" as one might expect. Within published Air Force guidance, the term "standard" is favored over "common". Air Force Policy Directive 63-2 defines standardized Automatic Test Systems as "automatic test systems that have applications across multiple weapon systems" (USAF-1, 1994). Alternatively, Air Force Instruction 63-201 states "Standardized ATS are ATS that can satisfy the requirements of multiple systems and weapon systems and meet designated architecture and interface standards" (USAF-3, 1994). Existing studies make no mention of architecture or interface standards, instead offering a more general definition similar to that of Air Force Policy Directive 63-2. The 2002 MacAulay Brown Report describes common Automatic Test Systems only in terms of "servicing multiple platforms" (MacAulay Brown, 2002). Additionally, a 2003 General Accounting Office report explains test equipment commonality as "used on multiple airframes and weapon systems" (GAO, 2003).

Automatic Test Systems and Equipment Policy and Guidance

This section will discuss the existing published guidance on Automatic Test Systems acquisition and management. There is a variety of published policy across the defense hierarchical structure, beginning with the highest level in the form of Department of Defense regulations. Next, the broad guidance of United States Air Force publications Air Force Instruction 63-201 and Air Force Policy Directive 63-2 is reviewed. Finally, publications from Automatic Test Systems management organizations at the Department of Defense Automatic Test Systems Executive Agent and at the Warner-Robins Air Logistics Center Automated Test Systems Division are examined.

DoD Publications

A series of Department of Defense directives and instructions serves as the foundation for the acquisition of new systems. These policies directly affect the actions of the program manager (PM) overseeing a system's acquisition. Specifically, DoDI 5000.1, *The Defense Acquisition System,* mandates that program managers consider supportability, life-cycle costs, performance, and schedule as comparable factors when making program decisions. Furthermore, supportability is to be considered as a key component of performance and examined throughout the item life-cycle (DOD-1, 2003). At this point, there is no clear direction driving an Automatic Test Systems program manager towards multiple weapon-system commonalities. At best, one could only speculate that life-cycle costs would be reduced through this pursuit. However, a stronger link with reduced cost resonates within Department of Defense Instruction 5000.2, which provides specific guidance for considering commercial-off-the-shelf sources of supply. It states that Department of Defense components shall affirmatively answer, among others, the question: Does the acquisition support work processes that have been simplified or otherwise redesigned to reduce costs, improve effectiveness, and make maximum use of commercial off-the-shelf technology?” (DOD-2, 2003). Effectively, this requires the program manager to use those sources judged to be the most cost-effective throughout a system’s life-cycle. In regards to commonality, Department of Defense Instruction 5000.2 states that, prior to any acquisition entering the “Production and Deployment Phase”, it must demonstrate “acceptable interoperability” (DOD-2, 2003).   The term “interoperability” is not defined in the context of this instruction.

For clarifying guidance on the Automatic Test Systems acquisition process, this researcher turned to the DoD Executive Directorate for Automatic Test Systems.

Department of Defense Automatic Test Systems Executive Directorate

In February 2004, The Office of the Secretary of Defense (Acquisition, Technology and Logistics), Logistics Plans and Programs office tasked the United States Navy to serve as the DoD's Executive Director for Automatic Test Systems. Shortly thereafter, in June 2004, the Deputy Assistant Secretary of the Navy (Logistics) tasked the Naval Air Systems Command PMA260, the Aviation Support Equipment Program Manager, to serve as the Automatic Test Systems Executive Directorate. The organizational structure of the Executive Directorate (formerly known as Executive Agent) is depicted in Figure 2.

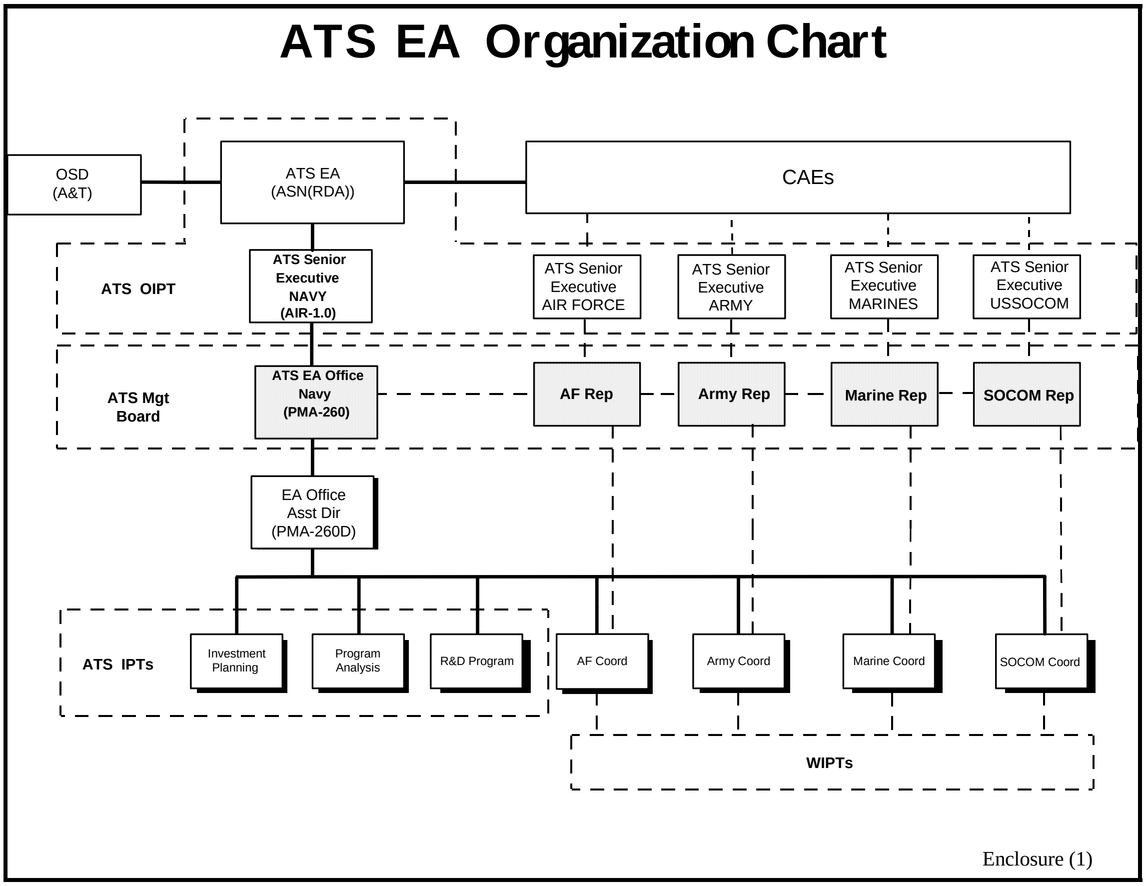

Figure 2. ATS Executive Directorate Organizational Chart (ATS ED, 2004).

Essentially, the Automatic Test Systems Executive Directorate's mission is to coordinate acquisition, research and development for Automatic Test Systems throughout the Department of Defense. Under their published mission statement, the Directorate cites four major goals:

1) *Minimize the cost of automatic testing to DoD*
2) *Foster interoperability of automatic test systems across the Services*
3) *Reduce logistics footprint*
4) *Improve the quality of test by leveraging embedded and other diagnostic data* (ATS ED, 2004).

The achieve these goals, the Directorate further specifies four tasks: 1) minimize unique types of Automatic Test Systems within the Department of Defense, 2) define and manage the Automatic Test Systems Open Systems Approach, 3) coordinate the convergence and modernization of the Automatic Test Systems inventory, and 4) provide Automatic Test Systems management tools and lessons learned (ATS ED, 2004).

In an effort to minimize the number of unique Automatic Test Systems entering the inventory, the Office of the Secretary of Defense (OSD) put forth guidance regarding Automatic Test Systems acquisition procedures in the form of a Joint Memorandum of Agreement. The Memorandum of Agreement states:

> DoD Components shall minimize, *to the maximum extent feasible*, the introduction of unique types of ATS into the DoD inventory by using designated ATS Families or commercial testers that meet defined critical interfaces to fulfill acquisition needs for ATS hardware and software.
>
> (ATS EA MOA, 1997).

Most notably, as indicated by the italicized text above, the Memorandum of Agreement does not forbid the introduction of unique Automatic Test Systems, but establishes a “last resort” strategy regarding its selection. While the policy verbiage is likely intended to allow for new technologies and not “tie hands”, so to speak, it is this researcher’s contention that this wording (i.e. minimize to the maximum extent feasible) is subjective and open to interpretation. Furthermore, the absence of strong, unwavering stance may be somewhat responsible for the continued proliferation of unique Automatic Test Systems despite published policy advocating its “minimization”. Clearly, the responsibility to implement the framework outlined in the Memorandum of Agreement belongs to the individual services; the interpretation of "unique system minimization" will be investigated further in the discussion of United States Air Force Automatic Test Systems acquisition policy and guidance.

United States Air Force Publications

Headquarters Air Force policy is largely a restatement of the existing Department of Defense acquisition guidance and Automatic Test Systems Executive Directorate Memorandum of Agreement procedures, tailored to the service's own organizational structure. First, Air Force Instruction 63-101 implements Air Force Policy Directive 63-1, Acquisition System, and the 5000 series of Department of Defense Acquisition Directives. This instruction outlines the responsibilities for the Secretary of the Air Force (SAF) and staff, System Program Directors, Air Force Materiel Command, Air Logistics Centers, as well as item and product group managers for any acquisition program (USAF-3, 1994).

Air Force Policy Directive 63-2, Automatic Test Systems and Equipment, established specific policy for the management and acquisition of Air Force Automatic Test Systems. In keeping with the Executive Directorate's published Memorandum of Agreement, it features direction to minimize development of new Automatic Test Systems and acquire common Automatic Test Systems. Specifically, it hierarchically places established Department of Defense Automatic Test Systems Families as the first alternative to meet new requirements, followed by commercial-off-the-shelf solutions. In fact, the policy specifies that weapon system unique testers will be the *last choice* and makes requisite approval for such deviation to policy before unique systems can be selected. In order to assess compliance with this policy, the policy directive provides a specific analysis tool as an attachment. Essentially, a Product Group Manager (PGM) is to quantify Automatic Test System proliferation as a measure of the percentage of peculiar Automatic Test System developments authorized per total new Automatic Test System requirements, as illustrated in Figure 3 (USAF-1, 1994:1-4).

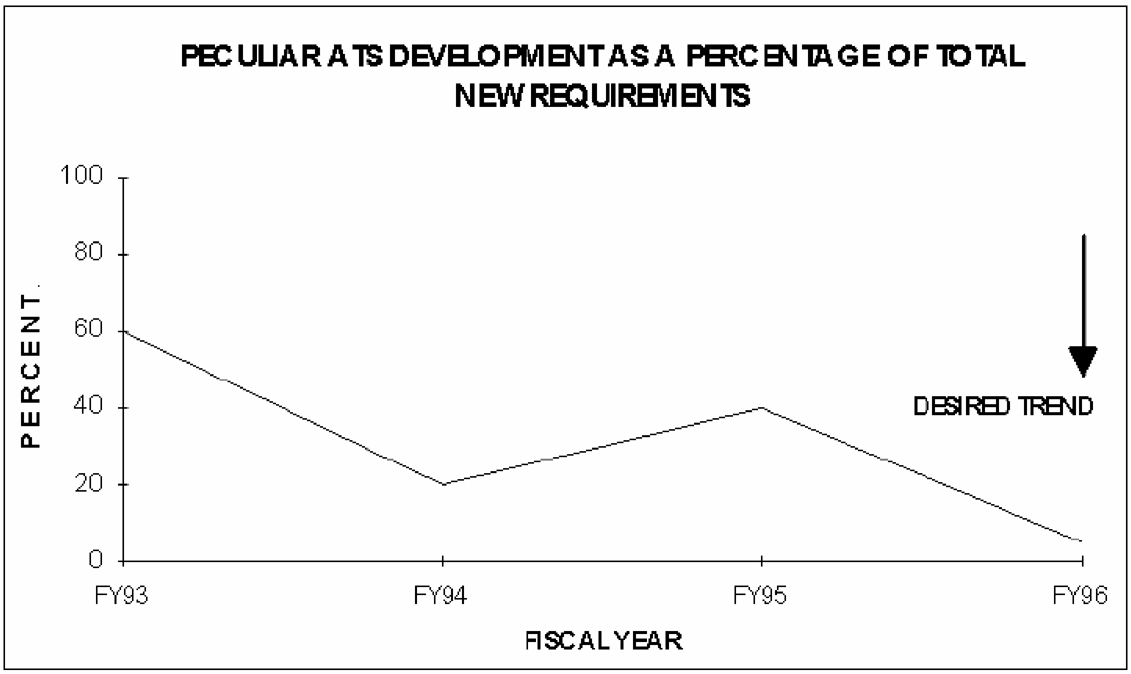

Figure 3. Measuring Compliance With ATS Non-proliferation Policy

(USAF-1, 1994)

The Automatic Test Equipment Product Group Manager is the singular point of accountability for all cost, schedule and performance aspects of Air Force Automatic Test Equipment and related sustainment. Per the policy directive, the Product Group Manager is also given the co-authority to make Automatic Test System selection decisions along with the individual System Program Director establishing an Automatic Test System requirement. The current Automatic Test System Product Group Manager is located at Warner-Robins Air Logistics Center, Robins Air Force Base, Georgia, designated as WR-ALC/LEA. This office, the Automated Test Systems Division, serves to promote acquisition and maintenance of Air Force test equipment to meet current and future requirements. The Division Chief represents the United States Air Force to the Executive Directorate and serves as the central point for Air Force Common Automatic Test Systems policy and management (Johnson, 2004:1-6; Vandenberg, 2004:13).

Air Force Instruction 63-201, Automatic Test Systems and Equipment Acquisition, established procedures for centralizing Automatic Test System management at the Product Group Manager. This instruction required the Automatic Test System Product Group Manager to: 1) establish a database identifying existing and preferred Automatic Test Systems throughout the Air Force, 2) consolidate all Air Force Automatic Test System requirements, 3) track detailed Automatic Test System capability and unit-under-test requirements, and 4) develop an Automatic Test Systems Master Plan to standardize Automatic Test Systems into families of testers. System Program Directors (SPDs), meanwhile, are tasked to identify Automatic Test System requirements early in the product development process, provide updates throughout the evolution of an system acquisition project, and most importantly, budget and provide funds to the Automatic Test System Product Group Manager (who, ultimately, will acquire the Automatic Test System) (USAF-3, 1994:2-3). As stated previously, the selection of weapon system unique testers is to be the last option among the evaluation of alternative choices for Automatic Test Systems. Air Force Instruction 63-201 establishes the following sequential methodology for Automatic Test System selection:

> 1. The Automatic Test System Selection Evaluation Team considers all User Automatic Test System requirements in the context of total Air Force Automatic Test System requirements.
> 2. The Department of Defense inventory of Automatic Test System Standard Families, or modifications to these systems, are the first alternatives evaluated for satisfying Automatic Test System requirements.
> 3. The second alternative evaluated is procurement of existing items within the Department of Defense inventory of Automatic Test Systems and Equipment.
> 4. The third alternative evaluated is a modification to existing items within the Department of Defense inventory Automatic Test Systems.
> 5. If previous solutions do not cost effectively meet the user's needs, the fourth alternative evaluated is commercial off the shelf equipment, appropriately modified. A waiver is required unless this equipment is for depot use only.
> 6. If none of the above alternatives can satisfy the requirements, new development may be authorized upon approval of a waiver request in accordance with Department of Defense policy.
>
> (USAF-3, 1994)

At this point, it becomes readily apparent that sufficient literature and policy exists to effectively minimize the proliferation of weapon system unique Automatic Test Systems to all but the most necessary and unavoidable cases. Given this reality, why has there been little movement in the way of commonality, and why have weapon systems largely maintained the status quo of unique Automatic Test Systems? To investigate this question, we examine published literature regarding the current state of affairs within United States Air Force Automatic Test Systems.

Current State of USAF ATS/ATE

2003 General Accounting Office (GAO) Automatic Test Systems Report

In March of 2003, the United States General Accounting Office published the findings of its investigation of Department of Defense Automatic Test Systems. The motivating factor behind this study largely concerned answering the question outlined above. Specifically, in regards to the Air Force, the office stated "…little evidence suggests that consideration is being given to the acquisition of equipment that would have common utility for more than one weapon system as Department of Defense policy advocates. For procurement of new weapon systems, the Air Force is giving little consideration to the use of a common tester…" (GAO, 2003). The report discussed several findings to which this lack of progress can be attributed. First, the office suggested that the Executive Directorate does not, in practice, possess sufficient authority to enforce existing Department of Defense policy regarding the minimization of unique Automatic Test Systems at the service- or office-level. Within the United States Air Force, the "ownership" of modernization planning by each System Program Office may be largely to blame:

> Since individual aircraft program offices have been doing their own planning for modernization, the Air Force has given little consideration to having common Automatic Test Equipment or testers that are interoperable with those of other services. Planning for the Air Force's latest aircraft acquisition, the F/A-22, calls for the development of automatic test equipment that will be unique to that aircraft."
>
> (GAO, 2003).

Additionally, since existing policy pertains to the acquisition of new systems, and the Air Force has frequently upgraded existing systems, an effective "loophole" has emerged to avoid commonality requirements, regardless of intentions. The report does state that the Automatic Test Systems Division of WR-ALC/LEA was formed to alter this trend, but in the same fashion as the Department of Defense Executive Directorate, this office does not possess *practical* authority over Automatic Test System decisions at individual System Program Offices. Moreover, they do not influence Automatic Test System funding to enforce such requirements or counteract historical behavior. Additionally, the General Accounting Office determined that waivers to Automatic Test System acquisition policy had, in many cases, not been requested from the Executive Directorate as required in the previously mentioned Memorandum of Agreement. When waivers were requested, the Executive Directorate could only *recommend* disapproval, lacking firm authority at the System Program Office level (GAO, 2003).

According to the General Accounting Office, the placement of final authority at the individual program offices is largely responsible for the lack of significant progress towards Automatic Test System commonality in the Air Force. This researcher would add that the existing published policy does not help matters, given its open-ended verbiage and unequivocal placement of decision-making authority at the level of individual weapon system program offices. As an illustration, the General Accounting Office identified several key observations that seem, on the surface, to be quite contradictory to unique Automatic Test System minimization efforts:

- "The Air Force is spending over $15 million for an interim modernization of its intermediate automatic test equipment for its B-1 aircraft while, at the same time, a new tester is being developed. If the Air Force had taken the necessary steps to replace this obsolete tester in a timely manner, these duplicative costs could likely have been avoided, and overall Automatic Test Equipment modernization costs reduced. According to an Air Force official, the program office should have begun the acquisition of a replacement tester several years ago, but funding was not available. The service is now considering acquiring a replacement tester estimated to cost $190 million".

- "Air Force F/A-22 program officials told us that they have not made a decision as to what testers will be used to support this new aircraft, which

> began development in 1991. The project office has not ensured that all components for the F/A-22 can be tested with a single tester. Project officials told us that the F/A-22 is a very complex aircraft and that opportunities to take advantage of common equipment will be limited. Yet, the same contractor that is developing the F/A-22 is also involved in the JSF **[Joint Strike Fighter],** which is also very advanced and complex and which uses a common family of testers. While current projections of Automatic Test Equipment costs are not available, estimates made early in the F/A-22 development phase exceeded $1.5 billion."
>
> (GAO, 2003).

The General Accounting Office offered several recommendations in summary at the report's conclusion, including recommendations including: 1) a top-down reemphasis of existing Department of Defense acquisition policy, 2) reconsideration of the Navy (or any uniformed service) for appointment as Executive Agent, 3) granting the Executive Agent increased authority and resources and 4) directing the services to develop modernization plans (GAO, 2003).

2002 Air Force Common Automatic Test Equipment (AFCATE) Report

This study was completed by a contractor, MacAulay Brown, Inc., to provide an overview of the current status of intermediate-level Automatic Test Systems, as well as to suggest direction for future sustainment and capability development. The authors of this report sought to provide a vision for the Air Force that will allow the evolution of "program specific automatic test equipment to more common standard Automatic Test System platforms" (MacAulay Brown, 2002: 15). Not surprisingly, they suggest that decision-makers be flexible to support the current needs of the warfighter, and mindful of pressing logistical issues, such as deployment needs or concerns that may impact the physical specifics of a given test system. More importantly, however, the authors shed light on a very important reality within defense acquisitions and business strategy in general – suboptimization. Specifically, the report states, "it must be recognized that the benefits of short-term expediency can often outweigh the long-term benefits of rigid adherence to a global strategy. Each decision should be made in the dual contexts of the roadmap and the supported weapon system requirements" (MacAulay Brown, 2002: 15). In its current state, program offices are posed against each other in competition for sustainment dollars and budget approvals. While in principle, representatives from individual weapon system programs should collectively make the best use of scarce resources for the "greater good", the reality is more along the lines of "every program for itself". Accordingly, one of the elements this research intends to address is the historical funding of multiple Automatic Test System programs.

After providing substantive background information and the suggested roadmap for future Automatic Test System portfolio management, the report progressed to a review, by weapon system, of the current state of existing intermediate level testers. As this research is a case study for the F-15 platform, the relevant discussion for this weapon system will be summarized below.

The F-15A/B aircraft declared Initial Operational Capability (IOC) nearly three decades ago, in July of 1975. At this point, the array of test equipment included a set of six stations called the Avionics Intermediate Shop (AIS) and the Tactical Electronic Warfare System (TEWS) Intermediate Test Equipment (TITE). In the early to mid-1980's, the AIS stations had their processors and many controllers upgraded. Not long afterward, the F-15E, known as the Strike Eagle, was introduced into operational usage. In conjunction with this introduction, the TEWS Intermediate Support System (TISS) replaced TITE for all F-15 units. Additionally, the Mobile Electronic Test Set (METS) replaced three of the original AIS stations, and the Aircraft Radar Test Station (ARTS) replaced another. Finally, in the 1990s, ARTS was upgraded to the Enhanced ARTS (EARTS). Initially, field users had good success with this array of support equipment. Unfortunately, worsening obsolescence and diminishing manufacturing sources are plaguing the F-15 community, resulting in numerous parts availability problems today, particularly with the AIS. To address this problem, development of the Electronic System Test Set (ESTS) was begun in 1992. This tester was intended to provide support for the bulk of the workload occupied by AIS and METS. Initial fielding began in 2000; however this replacement tester already encountered obsolescence issues (MacAulay Brown, 2002: 57).

A snapshot of MacAulay Brown's 2002 summary of planned F-15 intermediate level tester upgrades or modifications actions is included in Figure 4.

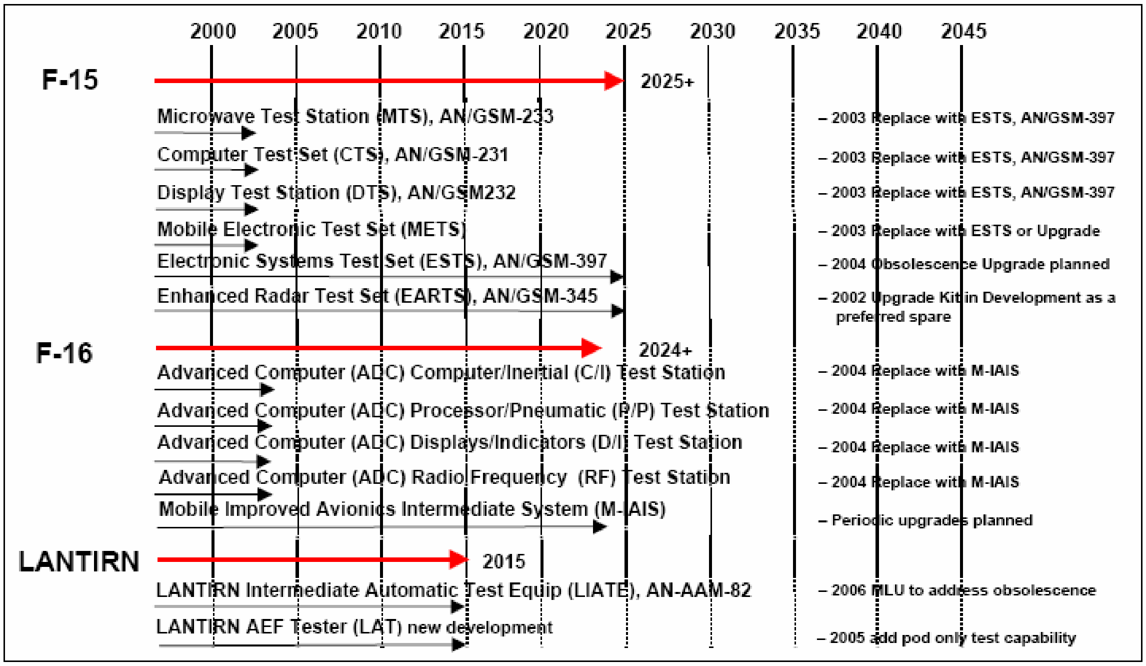

Figure 4. F-15 Test Equipment “Road-Ahead” Timeline (MacAulay Brown, 2002).

ATS Obsolescence and DMSMS Issues

Consensus opinion would suggest that parts obsolescence is one of the greatest problems plaguing Automatic Test Systems today. The 2003 General Accounting Office report suggested three factors that contribute to the continuing problem: first, the simple fact of time and the increasing Automatic Test Systems age; second, explosive advances in technology that can make new versions of Automatic Test Systems obsolete before reaching the field; and third, parts scarcity due to assembly line closures commercial manufacturing source elimination, commonly known as Diminishing Manufacturing Sources and Materiel Shortages (DMSMS). As an illustration, the Automated Test Systems Division at Warner-Robins Air Logistics Center anticipates two-, five-, and ten-year projections of 14%, 31%, and 55% obsolescence rates for systems under their management (Johnson, 2004). Within the Air Force's airborne electronic warfare, common avionics and global positioning system domains, 23,550 parts are now classified as obsolete, with the total number expected to grow to 30,994 by 2014 (Griffith, 2004). The common practice of extending weapon system life-cycles raises the propensity for obsolescence and scarcity, not only for the aircraft, but also for the supporting elements, such as associated Automatic Test Systems (Griffith, 2004). In regards to the rapid progress of electronic technology, some suggest that components developed with current technology will be obsolete within five years. It has been estimated that 200,000 commercial electronic items became obsolete in 2003. Clearly, obsolescence issues must be considered throughout a product life-cycle, from conceptual idea and acquisition through modernization and sustainment practices (Taylor, 2004).

Additional evidence suggests that commercial manufacturers are considering obsolescence as an inevitable truth at the product development stage. One author comments on the implications this has for equipment users:

> "Manufacturers are adopting a 'planned obsolescence' marketing approach. By introducing newer and better features in new models, the manufacturer can leapfrog his competitor with a unique product. This feature shift makes it difficult to identify an appropriate replacement unit and makes it significantly more costly to repair or directly replace with an item from the original equipment manufacturer."
>
> (Ostrow, 2003).

Complications are not limited to the whole replacement of equipment, but also the replacement of subassemblies or repair components. Once a repair or replacement diagnosis has been made by users in the field, manufacturers often develop a "next-generation" replacement instrument, which is often not form, fit or function compatible with the original system (Ostrow, 2003). In either case, equipment and item obsolescence can and does result in exhaustive challenges and difficulties for managers of defense test equipment. The next section presents specifics regarding the United States Air Force F-15 weapon system and its management structure.

F-15 Automatic Test Systems and Equipment

We provide the reader with a brief background of traditional acquisition and procurement processes within the F-15 test equipment community, as well as initial descriptions of the equipment and offices under study in this research.

F-15 System Program Office

The F-15 aircraft is currently flown by 21 United States Air Force and Air National Guard units and three foreign countries: Israel, Japan and Saudi Arabia. Its management community is located at two different geographic locations: Wright-Patterson Air Force Base, Ohio and Warner-Robins Air Force Base, Georgia. Still, the System Program Office is principally structured as one organization with a single lead manager – the System Program Director (SPD). This individual serves as the lead interface with combat customers; for the F-15 community, these are Air Combat Command (ACC), United States Air Forces in Europe (USAFE), Pacific Air Forces (PACAF), Air Education and Training Command (AETC) and the Air National Guard (ANG). The concept of presenting a single management interface to the warfighter is known as Integrated Weapon System Management (IWSM). This concept was initiated when the Air Force Systems Command (AFSC) and Air Force Logistics Command (AFLC) integrated under the new Air Force Materiel Command in the early 1990s. Before this merger, the responsibilities of the two commands could be summarized as follows: Air Force Systems Command was responsible for initial research, development and acquisition, while Air Force Logistics Command was largely responsible for logistics support and sustainment. Under the Integrated Weapon System Management concept, Air Force Materiel Command would be responsible for all aspects without division – commonly known as "cradle-to-grave" weapon system management (F-15 SPO-2, 2004).

As a result, the F-15 System Program Director today has formal responsibility oversight for every component of the F-15 platform. However, the historical management divisions identified above are still more or less in place today. Chances are that a system in the acquisition phase will have lead management focused at the North Office (Wright-Patterson), while components in sustainment are more likely to have principal oversight located at the South Office (Warner-Robins). Clearly, the intention of the Integrated Weapon System Management concept and the F-15 System Program Office is to create a shared ownership at both locations (F-15 SPO-2, 2004).

Commodity Class Consignment

The F-15 System Program Office clearly defines Commodity Class Consignment (C^3) within its own operating instruction 63-103. It is defined as follows:

> The process of transitioning systems/functions from the developing organization to the supporting organization. While a system may be entrusted to the care of the supporting organization, an avenue exists for the supporting organization to receive technical and management support from the developing organization. C^3 establishes a partnership between the F-15 SPO and supply chain management organizations.
>
> (F-15 SPO-1, 2002)

Commodity Class Consignment replaced in nomenclature the process of Program Management Responsibility Transfer (PMRT). Essentially, this process marks the handover of day-to-day management for a given commodity (line-replaceable unit, support equipment, etc.) from one group to another. The first group, the developing organization, is responsible for a system's acquisition, design and implementation. The second group, the supporting organization, is responsible for the sustainment and management of that system after initial development and fielding (Robinson, 2004). Within the F-15 community, *internal* consignment is defined as the transition from the Aeronautical Systems Center at Wright-Patterson AFB (ASC/FBA) to the South F-15 System Program office at Warner-Robins (WR-ALC/LF). *External* consignment is defined as the transition from ASC/FBA to a supply chain manager at one of the Air Force's Air Logistics Centers.

F-15 Automatic Test Systems are subject to the same requirements as other systems eventually bound for consignment. Next, we provide a brief introduction to the two test equipment systems that were examined within this case study.

Tactical Electronic Warfare System Intermediate Service Station (TISS)

TISS performs intermediate level maintenance support for all of the F-15 electronic warfare line-replaceable units. Currently a six-bay system as illustrated in Figure 5, the execution of an ongoing technology upgrade will reduce the station's footprint to three bays (Ellis, 2004).

Figure 5. TISS Station

(Ellis, 2004)

The TISS management and support staff is distributed at both the F-15 System Program Office North (Wright-Patterson), and at Warner-Robins Air Logistics Center (WR-ALC). The relevant personnel at the North office support issues relating to engineering, logistics, technical orders, configuration and data. Additionally, the lead Major Command, Air Combat Command, has a liaison on staff at the North System Program Office (Wright-Patterson). WR-ALC/LSRAC is responsible for the management of associated electronic warfare line-replaceable units that are tested by TISS. Finally, TISS spares and repairs are overseen by WR-ALC/LEACC. Generally speaking, the F-15 North System Program Office has overall management of the TISS program to include funding all modifications (software and hardware), technical orders, field engineering support and system configuration management. The TISS staff at the Automated Test Systems Division at WR-ALC (WR-ALC/LEACC) is responsible for funding and management of an ongoing repair contract with a manufacturer, as well as resolving obsolescence issues that do not affect the form, fit or function of the TISS, such as replacing an obsolete component on a circuit card assembly.

Avionics Intermediate Shop (AIS)

The F-15 Avionics Intermediate Shop is a complement of eight stations that are used to test and fault line-replaceable units that monitor airframe, engine, navigation, combat and pilot safety systems. The complement consists of the following: Antenna Test Station, Indicators and Controls, Communication, Navigation and Identification, Computer Test Station, Display Test Station, Microwave Test Station, Enhanced Aircraft Radar Test Station and Mobile Electronics Test Set. The Enhanced Aircraft Radar Test Station and Mobile Electronics Test Set are used to test selected line-replaceable units on F-15E model aircraft only. The Enhanced Aircraft Radar Test Station replaced the Antenna Test Station for the F-15E, while the Mobile Electronics Test Set replaced the Computer Test Station, Indicators and Controls, and Communication, Navigation and Identification for the F-15E. The typical layout of the AIS is illustrated in Figure 6.

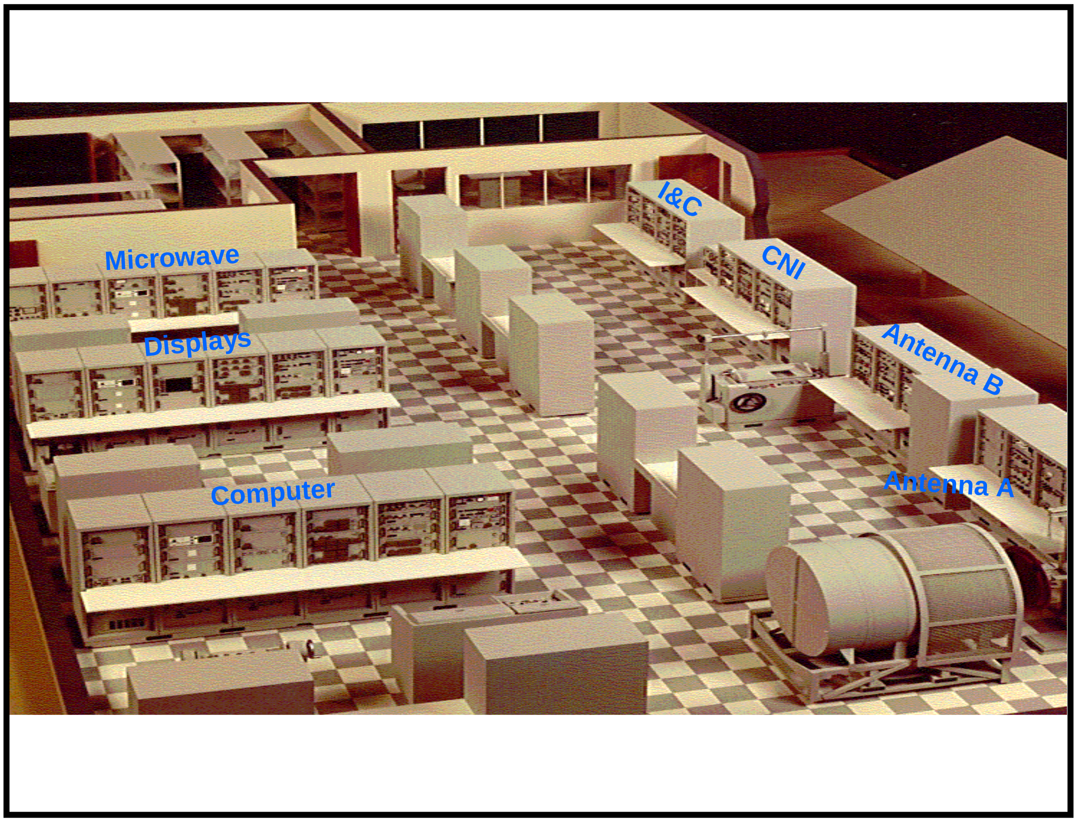

Figure 6. Typical AIS Layout

(Mathis, 2004)

Unlike TISS, the AIS is entirely managed at the Automated Test Systems Division at Warner-Robins Air Logistics Center. The support staff consists of the Integrated Product Team: the logistics manager, item manager, equipment specialist, production manager, engineer and contracting officer. Together, this staff manages the AIS program.

Summary

This chapter examined the related literature in order to establish familiarity with the definition and scope of Automatic Test Systems and Equipment. The component interplay between Automatic Test Systems and Test Program Sets was discussed, and the existing guidance for both the Department of Defense and the United States Air Force was reviewed. Next, background was provided on the current state of Automatic Test Systems and Equipment inventory and management, including shortfalls and challenges facing the test equipment community. Finally, the F-15 weapon system management structure was introduced, as well as the specific equipment programs under study within this research effort.

Next, chapter three discusses the selection and evolution of a research methodology for this study.

III. Methodology

Chapter Overview

The purpose of this chapter is to describe the chosen methodology for organizing the research design and collecting relevant data. In regards to organizing the study, this researcher reviewed literature from Creswell (1998, 2003), Leedy et al (2001) and Yin (2003), and selected a qualitative approach with a case study as the specific tradition of inquiry. Using guidance from Yin (2003), a series of protocol questions were constructed which served as the foundation for targeted questionnaires. The resultant interviews generated from these questionnaires served as the primary source of data collection. Once the data were gathered, a variety of case study analytical tools described by Yin (2003) and Creswell (1998) were employed, including pattern-establishment, categorical aggregation and direct interpretation. These strategies were used to draw the conclusions outlined in chapters four and five.

At this point, it should be noted that this research was conducted in parallel with a similar study (Ford, 2005). Given that there are numerous Automated Test Systems within the United States Air Force and Department of Defense inventories, we sought to develop their methodological framework as a foundation template for future inquiries into other Automated Test Systems. As a direct consequence, the researchers structured their studies in parallel; the only difference being the associated ATS under study (i.e. F-15 Automated Test Systems vs. Strategic Missile Automated Test Systems). Specifically, the investigative questions, protocol questions and interview questionnaires were designed to be identical across these parallel studies. Both researchers contend that this standardization will afford valuable opportunity for future cross-comparison and serve as a baseline for further analyses. In fact, future researchers may choose to investigate additional equipment management strategies using this existing framework for data collection. Specific commentary on future research possibilities is provided in chapter five. This being said, the next section discusses the process of research design.

Research Design

Creswell identifies three distinct approaches to research design: quantitative, qualitative, and mixed method (Creswell, 2003:17). He defines *quantitative research* as:

> ...One in which the investigator primarily uses postpositivist claims for developing knowledge (i.e. cause and effect thinking, reduction to specific variables and hypotheses and questions, use of measurement and observation, and the test of theories), employs strategies of inquiry such as experiments and surveys, and collects data on predetermined instruments that yield statistical data (Creswell, 2003:18).

In contrast to quantitative research, he defines *qualitative research* as:

> An inquiry process of understanding based on distinct methodological traditions of inquiry that explore a social or human problem. The researcher builds a complex, holistic picture, analyzes words, reports detailed views of informants, and conducts the study in a natural setting (Creswell, 1998:15).

In similar fashion, Leedy et al (2001) describe qualitative methods in terms of being "used to answer questions about the complex nature of phenomena, often with the purpose of describing and understanding the phenomena from the participants' point of view" (Leedy and Ormrod, 2001:101).

Finally, Creswell identifies the mixed method approach to research design that includes elements of both qualitative and quantitative methodologies, defined as:

> …One in which the researcher tends to base knowledge claims on pragmatic grounds (e.g. consequence-oriented, problem-centered, and pluralistic). It employs strategies of inquiry that involve collecting data either simultaneously or sequentially to best understand research problems. The data collection also involves gathering both numeric information (e.g. on instruments) as well as text information (e.g. on interviews) so that the final database represents both quantitative and qualitative information (Creswell, 2003:18-19).

To select an appropriate research approach for a given study, one should be able to logically and clearly define the relationship between the problem and a particular research approach. As an example, a researcher seeking to identify or explain the relationship between measured variables (e.g. numerical quantities) would likely be best suited to select a quantitative approach (Leedy and Ormrod, 2001). In contrast, if the researcher's aim is to explore and characterize existing phenomena, or to develop a theory regarding such phenomena, a qualitative method would likely be the better choice (Leedy and Ormrod, 2001). In summary, Table 1 identifies the three types of approaches available to researchers.

Table 1. Research Method Procedures

Quantitative	**Qualitative**	**Mixed Methods**
- Predetermined - Instrument based questions - Performance data, attitude data, observational data, and census data - Statistical analysis	- Emerging methods - Open-ended questions - Interview data, observation data, document data, and audiovisual data - Text and image analysis	- Both predetermined and emerging methods - Both open- and closed-ended questions - Multiple forms of data drawing on all possibilities - Statistical and text analysis

(Creswell, 2003:17)

As a final note on methodology selection, perhaps the strongest indicators are the data themselves. Leedy et al (2001) clarify: "Data and methodology are inextricably interdependent…the methodology to be used for a particular research problem must always take into account the nature of the data" (Leedy and Ormrod, 2001:100). As a consequence, this researcher was careful to consider the motivation behind the study, the questions to be answered, and what data would be required to draw conclusions. Moreover, the same set of data, when analyzed with varying methodologies, might suggest quite different conclusions, each of which may vary both from each other and, more importantly, from the truth.

Qualitative Method

This section seeks to identify the distinguishing characteristics that separate qualitative research from the other approaches. First, whereas quantitative studies are often conducted with existing data at an enclosed, defined location (e.g. laboratory), qualitative studies are often executed in "the field"; that is, within the existing surroundings of the subject of study. Here, the researcher can gather extensive data and valuable insight due to her or his direct, active involvement with the experiences of the subject(s) (Creswell, 1998:16; 2003:181). As with any research, the researcher's personal involvement in conducting the study makes very real the possibility of introducing bias. Indeed, Leedy et al (2001) suggest that "in the research environment, the researcher cannot avoid having data contaminated by bias of one sort or another" (Leedy and Ormrod, 2001:222). Still, all is not lost, as bias is expected in research, provided the researcher acknowledges the likelihood of biased data or the specific possibilities of bias within the study (Leedy and Ormrod, 2001:222 to 223).

A second feature of qualitative research is found within the role of the researcher. Within this approach, the researcher serves as the “key instrument of data collection”, as the “bulk of the data is dependent on their personal involvement” (Creswell, 1998:16; Leedy and Ormrod, 2001:102). As a result, throughout the study, from data collection to analysis, the researcher must carefully monitor personal biases and behaviors, making every effort to prevent any negative influence on the overall study (Creswell 2003:184). Furthermore, since conclusions drawn from qualitative research are dependent on the researcher’s interpretations of the collected data, Creswell (2003) suggests identifying possible biases at the earliest opportunity, and rigorously using multiple validity strategies to establish credibility and confidence in the research findings (Creswell, 2003:184).

Third, the researcher may employ one or more inquiry strategies as a procedural guide for conducting a qualitative study (Creswell, 2003:183). Example inquiry strategies identified by Creswell are: narrative, phenomenology, ethnography, case study, and grounded theory (Creswell, 2003:183). In purpose, these strategies are intended to aid the researcher and provide focus on data collection, data analysis, and structured writing (Creswell, 2003:183). Still, the inquiry strategies are not sets of step-by-step instructions. Leedy et al (2001) reemphasize this point, “There are no magic formulas, no cookbook recipes for conducting a qualitative study” (Leedy and Ormrod, 2001:149). He further states that books written about qualitative research offer “general guidelines based on the experiences of those qualitative researchers" and the specific methods used are only constrained by the researcher's imagination (Leedy and Ormrod, 2001:149).

Rationale for Selecting a Qualitative Methodology

For this study, the primary motivation for selecting a qualitative methodology was the particular nature of the research questions and type of data being collected. As a review, this study began by identifying an overarching research question followed by four supporting investigative questions, each possessing associated sub-questions:

Research Question

This research seeks to answer the question: Is F-15 automatic test equipment more supportable and efficient when managed by a separate support office or when managed by the supported weapon system?

Investigative Questions

1. What are the differences in how Automated Test Systems are being managed by the two programs?
2. How much sustainment funding is budgeted/funded in the Program Objective Memorandum (POM) and Future Year Defense Plan (FYDP) for each?
3. What are System Program Office, depot and Major Command assessments of Automated Test System sustainability for the two programs?
4. What are Major Command assessments of field units' abilities to support assigned equipment with resources provided by the System Program Office and depot?

Based on Creswell's (2003) guidance, the above research questions meet the description of qualitative research questions due to their structure: a central question followed by associated sub-questions (Creswell, 2003:105). Central questions are often designed to be broad in form "so as to not limit the inquiry" (Creswell, 2003:105). Sub-questions are then employed to narrow the researcher's focus and identify the information needed to conduct analysis (Creswell, 1998:101; 2003:106).

Once the decision was made to conduct this study using a qualitative methodology, it was necessary to select an appropriate corresponding tradition of inquiry (Creswell, 1998:21). Again, the selection of an appropriate tradition of inquiry is very important for any study, as it lays the groundwork for data collection, data analysis, and the writing of the research report (Creswell, 1998: 37; 2003:183). Within the qualitative research approach, the five traditions of inquiry are ethnography, grounded theory, case study, phenomenological research, and narrative research (also known as bibliography from his previous work) (Creswell, 1998:7; 2003:15). Each tradition is defined according to the descriptions below:

- Ethnography: the study of an intact cultural or social group (or an individual or individuals within the group) based primarily on observations and a prolonged period of time spent by the researcher in the field (Creswell, 1998:246)

- Grounded Theory: the researcher generates an abstract analytical schema of a phenomenon, a theory that explains some process, action, or interaction grounded in the views of participants in a study (Creswell, 1998:241; 2003:14)

- Case Study: the researcher explores in depth a program, an event, an activity, a process, or one or more individuals. The case(s) are bounded by time and activity, and researchers collect detailed information using a variety of data collection procedures over a sustained period of time (Stake, 1995:2; Creswell, 1998:249; 2003:15)

- Phenomenological Research: the researcher identifies the "essence" of human experiences concerning a phenomenon, as described by the participants in a study (Creswell, 1998:236; 2003:15)

- Narrative Research: a form of inquiry in which the researcher studies the lives of individuals and asks one or more individuals to provide stories about their lives (Creswell, 2003:15)

Additionally, Creswell's (1998) diagram, illustrated in Figure 7, is a useful tool in helping to clarify both the relationship and distinction between each of the traditions (Creswell, 1998:37).

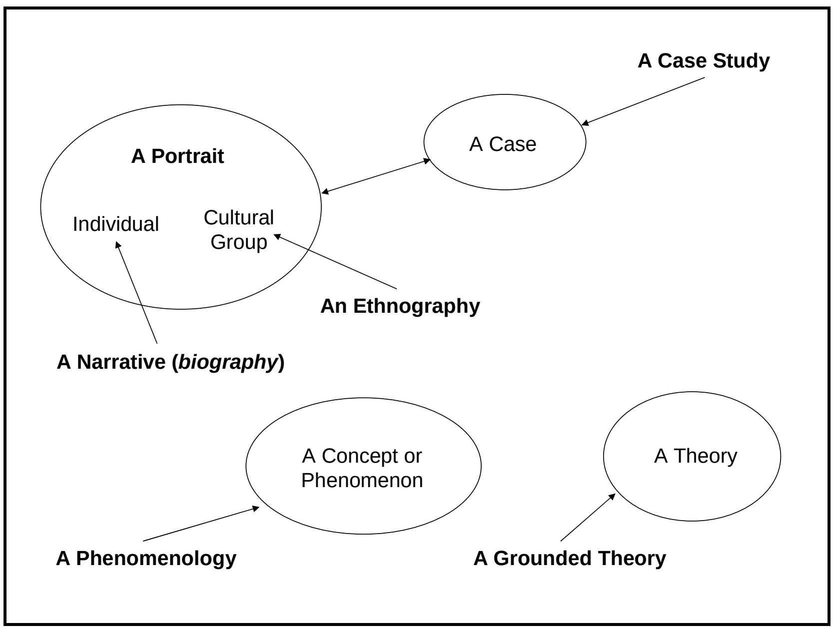

Figure 7. Differentiating Traditions by Foci (Creswell, 1998:37)

After reviewing the related literature for qualitative studies (Creswell, 1998, 2003; Leedy et al, 2001; Yin, 2003), this researcher selected the case study strategy as the tradition of inquiry for this research. Creswell (1998) suggests that a case study is an “exploration of a ‘bounded system’” (Creswell, 1998:61). More specifically, he defines the bounded system as the case under study, and notes that “several programs or a single program might be selected for study” (Creswell, 1998:61). Given that the aim of this research effort is to study the management approaches of two test equipment programs, the case study tradition seems a logical and sound selection. It should be noted that the relevance and potential applicability of the Grounded Theory tradition was considered, since one of the goals of this research was to *explore and explain* the phenomena of two distinct managerial approaches. However, as this work is an initial study built to serve as a *foundation* for future inquiries, it was determined that the broader scope of a case study analysis would be a more appropriate choice.

Case Study Approach

After selecting the case study approach as the guiding tradition of inquiry, we examine in greater depth the characteristics of this particular method. The choice for seeking specific case study guidance from Yin was made due to his wide recognition as one of the foremost authorities on case study research. The selection of the case study approach was reinforced after reviewing the three conditions outlined by Yin (2003) in determining an appropriate research strategy. The three conditions are: 1) the types of research questions, 2) the extent of control an investigator has over actual behavioral events and 3) the degree of focus on contemporary as opposed to historical events (Yin, 2003:5-7). Table 2 outlines the recommended research strategy based on these conditions.

Table 2. Different Research Strategies

Strategy	Form of Research Question	Requires Control of Behavioral Events?	Focuses on Contemporary events?
Experiment	How, why?	Yes	Yes
Survey	Who, what, where, how many, how much?	No	Yes
Archival Analysis	Who, what, where, how many, how much?	No	Yes/No
History	How, why?	No	No
Case Study	How, why?	No	Yes

(Yin, 2003:5)

The research and investigative questions stated in chapter one consist of questions characterized by "how" and "what" interrogations. Although Yin (2003) highlights that a case study strategy should feature research questions of the form "how" and "why", he notes that "what" type questions can also be used, primarily because they can be considered exploratory in nature (Yin, 2003:5 to 6). In addition to the types of questions being asked and the qualitative nature of this study, the control of behavioral events is not required – the purpose of this study is to describe and explore. Furthermore, this study does focus on contemporary events; specifically the current management strategies employed by two different test equipment programs.

Once the case study methodology was selected, this researcher began to structure the specific research design. Yin (2003) outlines five components that are important in this regard. The five components are: 1) a study's questions, 2) its propositions (if any), 3) its unit(s) of analysis, 4) the logic linking the data to the propositions and 5) the criteria for interpreting the findings (Yin, 2003:21). The research and investigative questions mentioned above and, more specifically, the protocol questions and sub-questions addressed later in this chapter, satisfy the first component of the research design.

The second component, study propositions, is used to direct the researcher towards more focused areas of study that should be examined as part of the overall research effort (Yin, 2003:22). In terms of defining the study's focus, the investigative questions outlined in chapter one perform this function. An additional benefit of using propositions is that they help guide the researcher to appropriate sources of data or evidence, which are crucial to developing a case (Yin, 2003:22).

In addressing the third component, the unit of analysis defines the particular case being studied (Yin, 2003:22). The case or unit of analysis could consist of an individual (single case study) or group of individuals (multiple-case study) (Yin, 2003:22 to 23). Likewise, the same analogy could be applied to studying an event or multiple events (Yin, 2003:23). For the purposes of this study, we define the unit of analysis as the management approach to a specific automated test system within the F-15 weapon system community. These pieces of equipment were introduced in chapter two.

According to Yin (2003), the fourth and fifth components are "the least well developed in case studies" (Yin, 2003:26). This contention may be attributed to the possibility of researcher-induced bias or subjectivity. He further states that "these components represent the data analysis steps in case study research, and a research design should lay the foundations for this analysis" (Yin, 2003:26). Accordingly, a variety of commonly accepted analysis strategies were employed, including pattern-matching and explanation-building (Yin, 2003:106-110). Creswell (1998) states that case study analysis "consists of making a detailed description of the case and its setting" (Creswell, 1998: 153). Furthermore, Creswell (1998) and Stake (1995) describe four forms of data analysis and interpretation that may be used in case study research (Creswell, 1998: 153). These forms are: categorical aggregation, direct interpretation, pattern identification and naturalistic generalizations (Creswell, 1998:154). As a vehicle for these particular tools of data analysis, the researcher, in partnership with the fellow researcher conducting a parallel study (Ford, 2005) developed a data categorization and evaluation matrix. An example of this matrix is shown in Figure 8.

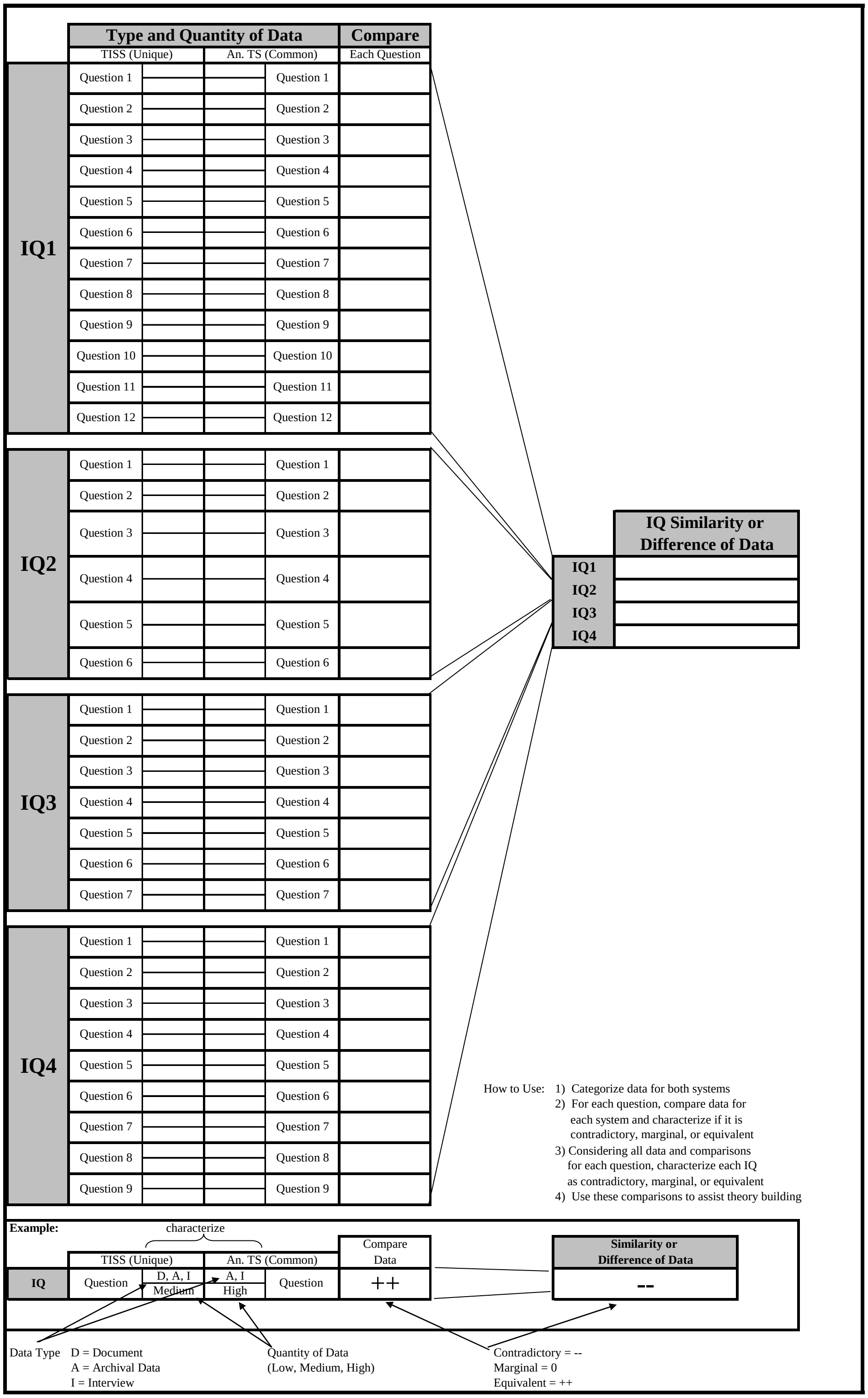

Figure 8. Data Categorization and Evaluation Matrix
(Ford & Howe, 2005).

Case Study Design

After laying out the research design, the next task was to choose a case study design. The four types of designs are single-case (holistic), single-case (embedded), multiple-case (holistic), and multiple-case (embedded) (Yin, 2003:39). A multiple-case (holistic) design was chosen based on the researcher's decision to compare the management strategies for two systems, AIS and TISS.

Case Study Protocol

Since this research will be using a multiple-case study design, it is important to address developing the case study protocol for this research. Yin (2003) states "a case study protocol is desirable under all circumstances, but it is essential if you are doing a multiple-case study" (Yin, 2003:67). The case study protocol helps guide the researcher throughout the data collection and analysis process, in addition to increasing research reliability (Yin, 2003:67). Yin outlines four areas that case study protocol needs to address (Yin, 2003:68):

1. Introduction to the case study and purpose of protocol
2. Data collection procedures
3. Outline of case study report
4. Case study questions

In order to properly prepare for formal data collection, the researcher developed a specific protocol for each of the investigative questions. These protocols can be found in their entirety in Appendices A, B, C and D. Next, we will discuss the design of each investigative question's research protocol in greater detail.

Protocol Development: Investigative Questions and Sub-questions

Investigative Question One

The aim of the first investigative question is to identify any primary differences in actual management practices; that is, personal behaviors or actions in the conduct of day-to-day business. These practices may involve directly or indirectly supporting critical needs issues from test equipment users in the field, or they may be actions of a “behind the scenes” nature, such as planning for future concerns, organizing data or preparing reports. This researcher chose the protocol sub-questions in Appendix A to capture differences in individual behavior regarding typical managerial actions. As an example, how broad is the communication network for personnel involved in the support of this piece of test equipment? Is one management staff involving different people in the decision-making process? Sub-questions one through four are focused on finding behavioral similarities and differences between the two management teams for TISS and AIS.

After conducting the literature review for this research effort, it became readily apparent that equipment and parts obsolescence is a major obstacle facing the test equipment community today. As a result, specific sub-questions were included regarding the impact of obsolescence on the two programs. Moreover, this researcher sought to identify any differences in approach as to how the management teams overcame or otherwise sought to counteract the effects of obsolescence.

As a final element of this investigative question’s protocol, this researcher included sub-questions addressing the managers’ level of familiarity with Department of Defense policy regarding the acquisition and development of common test equipment. Granted, the testers involved in this study are neither in the acquisition phase nor common, but the researcher theorized it might be useful to capture the perspectives of various test equipment community members on the subject of common Automated Test Systems. After all, the practical evaluation of Automated Test Systems management is the overarching goal of this research effort. That being said, this researcher wished to take into account the considerations and viewpoints of current test equipment managers.

Investigative Question Two

The design of investigative question two's case study protocol can largely be characterized as "the objective of investigative question one in terms of funding". The research question for this study addresses the comparison of test equipment management strategies in terms of "supportability" and "efficiency". The protocol for investigative question two is designed to address the "efficiency" portion. It should be noted that this protocol is not founded on the assumption that more dollars will always result in greater efficiency; rather, any effort to determine efficient use of funds must also incorporate the supportability aspects targeted by investigative questions one, three and four. Still, in the competitive world of defense program funding, the researcher felt it necessary to compare the two test equipment programs in terms of historical and current successes in terms of sustainment dollars. Specifically, has one program historically received a greater portion of its requested funds? If so, why?

Investigative Question Three

This investigative question addresses the "health" of the two test equipment programs as characterized by those involved in the sustainment of the equipment. This protocol and series of sub-questions was developed to better understand the major issues facing the equipment today (e.g. obsolescence, dwindling operational capability, hardware shortages, etc.) By asking the management teams to identify the most pressing issues facing their systems, one can better understand any significant differences in terms of volume and severity of future supportability challenges. To obtain an increased level of objectivity, this researcher also addressed these sub-questions to the lead Major Command personnel involved in the field support of this test equipment. Since these individuals are in a position to observe the field-level impact of supportability issues for *both* TISS and AIS, they could, in theory, offer an unbiased perspective on the two systems. One of the most significant sub-questions addresses the estimated timeline for reaching solutions to these supportability issues. Is there a difference between the two testers in terms of a projected fix? What are the obstacles to success?

Investigative Question Four

With similar intentions as investigative question three, this protocol is aimed at capturing the lead MAJCOM's evaluative perspective on the performance of the two management teams in terms of field level support. Whereas the primary impetus behind consolidating test equipment for management at a stand-alone office is one of cost savings, this researcher contended that no senior defense leader would wish to sacrifice support for the warfighter. Accordingly, it is believed that in order to fully understand the ramifications of any management strategy, one must certainly examine the impact of that strategy on the end users. In this case, the end users are the avionics technicians in the field who use this test equipment each and every day. The management staff at the lead Major Command is in a position to observe and address the frequency and rigor of supportability challenges faced by users in the field. To illustrate, consider the impact of parts shortages on field technicians…are those individuals more often plagued in this regard for one system than another? Do they encounter unexpected maintenance difficulties more often? In either case, the aim of this investigative question's protocol is to examine the similarities and differences of managerial approach as they affect the field users of the equipment.

Data Collection

Depending on the specific qualitative study used for the research, data can take multiple forms. Creswell (1998) identifies the four basic forms of qualitative data as: 1) observations, 2) interviews, 3) documents and 4) audio-visual materials (Creswell, 1998:121). Importantly, he notes that each form of data has both advantages and limitations that the researcher should consider when planning the research design (Creswell, 2003:186-187). For this particular study, the data collected consisted primarily of various documents, structured and open-ended interviews. Examples of documents reviewed in this study included internal System Program Office memorandums, Major Command and depot equipment status briefings and integrated product team meeting minutes. Selected sample data obtained from interview notes and reviewed documents is provided in Appendices I through P. Table 3 contains Creswell's advantages and limitations for each type of data used in the study.

Table 3. Advantages and Limitations for Data Collection Types

Data Collection Used in Study	Advantages	Limitations
Documents	- Enables a researcher to obtain the language and words of participants - Can be accessed at a time convenient to the researcher- an unobtrusive source of information - Represents data that are thoughtful, in that participants have given attention to compiling - As written evidence, it saves a researcher the time and expense of transcribing	- May be protected information unavailable to public or private access - Requires the researcher to search out the information in hard-to-find places - Requires transcribing or optically scanning for computer entry - Materials may be incomplete - The documents may not be authentic or accurate
Interviews	- Useful when participants cannot be observed directly - Participants can provide historical information - Allows researcher "control" over the line of questioning	- Provides "indirect" information filtered through the views of interviewees - Provides information in a designated "place" rather than the natural field setting - Researcher's presence may bias responses - People are not equally articulate and perceptive

(Creswell, 2003:186 to 187)

In preparation for the analysis of resultant data, the type and quantity of data obtained for each protocol question were carefully monitored and documented. To accomplish this, the researcher used the matrix shown in Appendix F.

The use of multiple data sources offers the critical advantage of triangulation when seeking conclusions. Specifically, Yin states "the most important advantage presented by using multiple sources of evidence is the development of *converging lines of inquiry*…any finding or conclusion in a case study is likely to be much more convincing and accurate if it is based on several different sources of information, following a corroboratory mode" (Yin, 2003:92). A diagram illustrating the concept of converging lines of inquiry is provided in Figure 9.

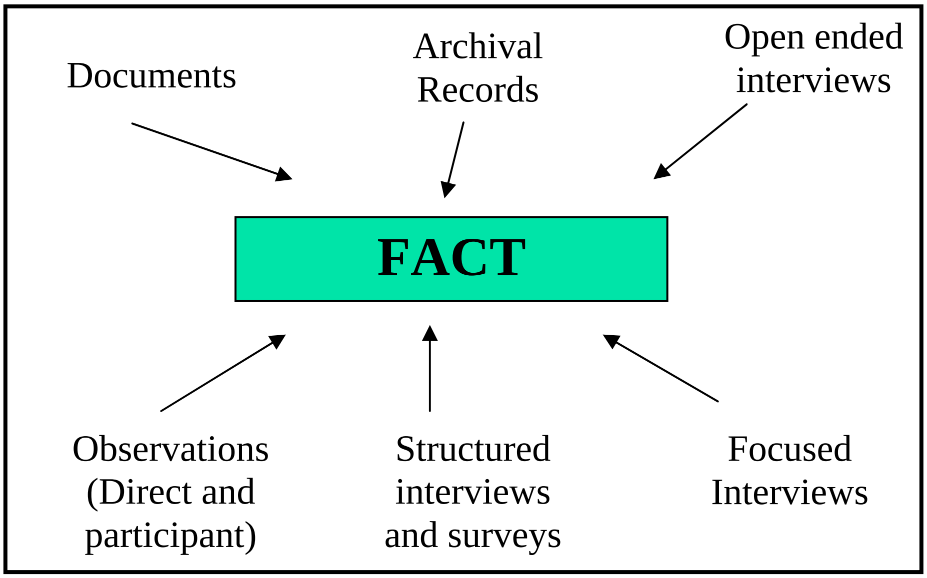

Figure 9. Convergence of Multiple Sources of Evidence (Yin, 2003: 93)

Additionally, Yin notes that the researcher may also identify non-convergence, that is, "multiple sources that nevertheless address *different* facts" (Yin, 2003: 92). The visual depiction of non-convergence is illustrated in Figure 10.

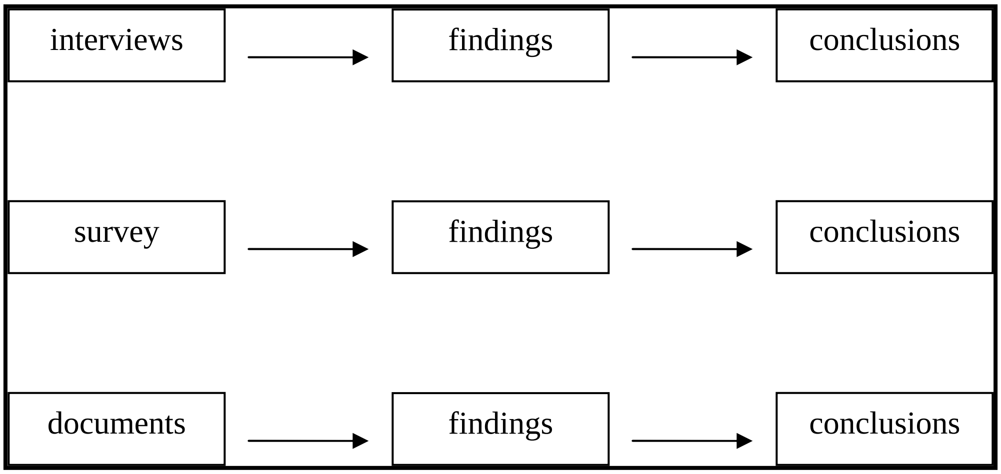

Figure 10. Non-convergence of Multiple Sources of Evidence (Yin, 2003: 93).

Again, this researcher's strategy for collecting the data was based primarily on Creswell's (1998) Data Collection Activities diagram in Figure 11 (Creswell, 1998:110). This diagram depicts a "series of interrelated activities aimed at gathering good information to answer emerging research questions" (Creswell, 1998:110).

Although Creswell points out that a researcher may start from any point located around the circle, he usually begins with the "Locating Site/Individual" node (Creswell, 1998:110).

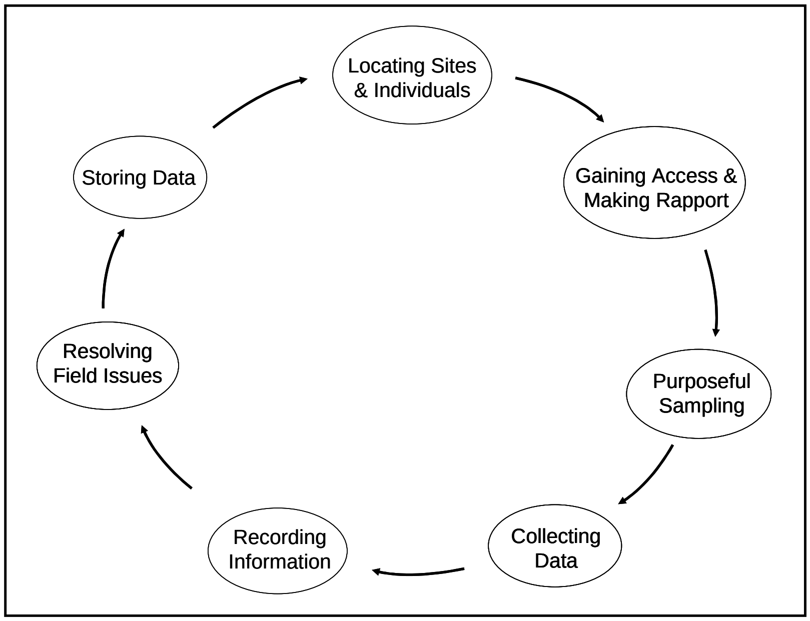

Figure 11. Data Collection Activities (Creswell, 1998:110)

1. Locating Sites & Individuals

The motivation for this study was to establish a baseline framework for further inquiries. As a stepping-off point, the initial sites (within this study, defined as specific management strategies for individual ATS) were limited only to the existing USAF inventory of ATS. Initial discussions and collaboration with advisers and subject matter experts led to the decision to examine the ATE within a legacy aircraft platform – specifically, F-15 ATE. In designing the case study protocol, the relevant sources of data were identified that would be best suited for a particular investigative question.

2. Gaining Access & Making Rapport

This researcher relied on existing commercial and USAF communication networks, as well as personal contacts to identify key management personnel within the systems under study. Once initial contacts were made within a given equipment community, this researcher asked those subject matter experts to identify additional personnel that might yield further insight into the research effort.

3. Purposeful Sampling

Creswell (2003) states the objective of purposeful sampling is to “purposefully select participants or sites (or documents or visual material) that will best help the researcher understand the problem and the research question” (Creswell, 2003:185). For this study, we selected the two subjects (AIS and TISS) at the recommendation of subject-matter experts in the field. This researcher spoke with these individuals at length both in person and over electronic communication. After providing them with a comprehensive background on the aim of the study, both individuals concurred on the two selected systems as suitable candidates for this research.

4. Collecting Data

As previously mentioned, data were collected from documents and interviews. The documents primarily came from managers at the System Program Office, depot and Major Command levels. Prior to conducting interviews, this researcher requested and obtained approval for the use of volunteers in research from the Air Force Research Laboratory Human Use Administrator.

5. Recording Information

When possible, during targeted interviews, we employed a third-party observer to transcribe data during interviews. This practice provided additional rigor to the accuracy of data collected. Furthermore, interviewees were provided with summary transcripts of the collected data to verify accuracy and authenticity.

6. Resolving Field Issues

This researcher maintained open communication with field personnel and interviewees throughout the research effort. Existing or unresolved field issues are discussed in chapter five of this report.

7. Storing Data

Multiple copies of the data collection were made in order to prevent the accidental deletion or corruption of files. When warranted, hard copies of the information were printed and stored with the rest of the research documentation.

Validity and Reliability

The last area of research design to be addressed is the validity and reliability of the research method. Validity is described by Leedy et al (2001) as "the accuracy, meaningfulness, and credibility of *the research project as a* whole" (Leedy et al, 2001:103). Reliability, however, is defined as "the consistency with which a measuring instrument yields a certain result when the entity being measured hasn't changed" (Leedy et al, 2001:31).

In dealing with validity and reliability, four tests have been identified as being relevant to case study research: construct validity, internal validity, external validity, and reliability (Yin, 2003:33). Table 4 outlines the four tests and tactics used to address each of the tests. The validity and reliability of this study will be discussed at length within Chapter four.

Table 4. Case Study Tactics for Four Design Tests

Tests	Case Study Tactic	Phase of research in which tactic occurs
Construct Validity	- Use multiple sources of evidence - Establish chain of evidence - Have key informants review draft of case study report	Data collection Data collection Composition
Internal Validity	- Do pattern-matching - Do explanation-building - Address rival explanations - Use logic models	Data analysis Data analysis Data analysis Data analysis
External Validity	- Use theory in single-case studies - Use replication logic in multiple-case studies	Research design Research design
Reliability	- Use case study protocol - Develop case study database	Data collection Data collection

(Yin, 2003:34)

Summary

This chapter described the research design and specific methodology selected to conduct the thesis study. A multiple-case study design was chosen for researching the management strategies in practice for the oversight of TISS and AIS. The data were collected primarily from archival data, documents and interviews. Once all the relevant information was identified, this researcher used a variety of case study analytical tools, including pattern-establishment, categorical aggregation and direct interpretation for the purposes of trend identification and theory building. Next, Chapter 4 will discuss the findings of the research.

IV. Analysis and Results

Chapter Overview

Within this chapter, we present and explain the analysis and results of this case study. First, the chapter discusses the answers to the investigative questions posed at the beginning of the study, each of which are followed by a summary of specific findings. Prior to the chapter's conclusion, issues of validity and reliability are addressed for this study.

Investigative Question One

What are the differences in how Automated Test Equipment is being managed?

In preparing for this study, it was theorized that there may have been dissimilarity in the day-to-day management techniques and procedures performed by members of the System Program Office (TISS) and depot (AIS) staffs. Appendix A outlines the specific case study protocol questions that are relevant to this investigative question.

Management Structure

Both programs utilize an integrated product team (IPT) management structure to oversee the management of their equipment. The integrated product team structure involves different team members as specialists in a given area to collectively address managerial issues of concern. Examples of positions represented on an integrated product team include: program manager, logistics manager, item manager, equipment specialist, engineer, contracting officer, equipment contractors, Major Command staff members and technical training school representatives. (See Appendices I, J)

Collectively, these individuals determine and provide solutions to field users of their respective equipment as they arise. Varying groups of these individuals may meet together at different intervals to discuss new developments and managerial actions. All respondents from the System Program Office indicated that the field user's perspective was genuinely sought and considered when managerial actions were being taken regarding engineering or logistical solutions. (See Appendix I) One significant difference observed during the collection of data was the "involvement by proximity" of a lead Major Command liaison at the System Program Office. This individual is assigned to the F-15 acquisition System Program Office as a direct interface for the lead Major Command F-15 avionics staff, and is largely responsible for monitoring progress on Major Command interests currently in development. Although the TISS program is in sustainment phase, its primary management is collocated with the acquisition System Program Office, and the lead Major Command liaison is physically present to serve as an advocate for TISS sustainment issues and decisions that affect field units. (See Appendix I) There is not an equivalent position at the depot, as the Major Command liaison is primarily targeted towards monitoring programs in the acquisition, not sustainment, phase of product development.

Planning, Obsolescence and the Impact of Next Generation Equipment

The presence of a near-term replacement for certain components of the AIS has an impact on the intensity and level of planning activities performed by its managers. Specifically, there is another test equipment system, known as the Electronic Systems Test Set (ESTS), which has been designed and introduced as a replacement system for six of the eight components of the Avionics Intermediate Shop. (See Appendix J) The

Electronic Systems Test Set began development in 1992 and was first introduced to the field in 2000, but encountered obsolescence and diminishing manufacturing source issues before it was fielded. This researcher learned from avionics personnel that while the Electronic Systems Test Set *is* being used in the field, it has not yet fully replaced in practice the six intended components of AIS – indeed, these are also being used by field avionics technicians to meet mission demands. (See Appendix J) Unfortunately, despite the shortcomings of the Electronic Systems Test Set, its existence as the intended next-generation replacement has had a paralyzing effect on funding support for the original AIS testers. Not surprisingly, it would seem that Air Force decision-makers are disinclined to offer continued support for a system that, in principal, has already been "replaced". The specific impact and contribution of the Electronic Systems Test Set to the F-15 avionics community is beyond the scope of this research, but additional implications of the Electronic Systems Test Set, its commodity consignment and obsolescence are discussed as a possibility for future research in chapter five.

A more pressing concern for the AIS management team is the sustainment of the other two components, the Antenna Test Station and Enhanced Aircraft Radar Test Station, both of which are *not* being replaced by the Electronic Systems Test Set and must be sustained until 2025. (See Appendices J, L) AIS managers and lead Major Command avionics personnel have already posited several scenarios for mission degradation as a result of projected obsolescence; it is expected that a continuation of normal obsolescence rates will bear witness to aircraft groundings by 2007 (Elliott, 2004). Respondents cited a variety of reasons for this projected impact, including limited repair sources, inability to procure component level parts and limited inventory spares. (See Appendices J, N)

By contrast, the TISS program is in the midst of a sizeable technology insertion program to upgrade the existing inventory of 35 test stations. At the time of this publication, the successful execution of this technology insertion program is the primary focus of the TISS integrated product team. Just as the Antenna Test Station and Enhanced Aircraft Radar Test Station management team is doing currently, the TISS management team performed internal case study projections in 2002 that projected a loss in mission capability in 2007. After completing these studies, the TISS program failed to obtain funding approval in the 2002 program objective memorandum, but secured the requested funding two years later. Additionally, the TISS Technology Insertion Program input was one of only two F-15 inputs to receive funding approval in the 2004 program objective memorandum. (See Appendix I)

The main objectives of the TISS Technology Insertion Program were to replace commercial off-the-shelf (COTS) equipment from the original TISS stations dating from 1988 to 1992, as well as transition to VXI (Versa Module Eurocard Extensions for Industry) card-based technology. First, a wide array of commercial-off-the-shelf component manufacturers advised TISS managers that their components would not be supported beyond 2007. According to collected interview data, the TISS Technology Insertion Program addresses and solves this problem. (See Appendix I) Secondly, put in simple terms, card-based technology capitalizes on the use of smaller “plug and play” card components instead of entire drawers in rack test equipment systems. At the completion of the TISS Technology Insertion Program, the number of bays in a complete

TISS station will be reduced from six to three. This will provide logistical benefits in terms of shipping and transportation repair (less cost to ship a card versus a drawer) while also decreasing the overall size of the station (deployable footprint). More specific discussion of TISS Technology Insertion Program funding and execution, as well as F-15 test equipment funding matters in general is addressed below in the findings for Investigative Question Two.

To summarize, the impact of obsolescence appeared to be a much greater and more persistent concern for the AIS management team than the TISS management team. (See Appendices I, J, K, L, M, N) The disparity in system age is likely a major contributor to this fact (AIS was first introduced in the early 1970s, while TISS was initially fielded in 1992), but there was also a perceived difference in the management teams' assessment of their own greatest challenges. The AIS management team overwhelmingly cited obsolescence as their greatest challenge, whereas the TISS respondents instead suggested that the overall complexity of the supported electronic warfare components was the greatest challenge. (See Appendices I, J) Both programs, however, stressed the importance of forecasting and planning as the best means for combating parts and equipment obsolescence. Additionally, both described the development of studies projecting shortfalls in operational capability or aircraft groundings as essential to being competitive in the funding approval process. More specific commentary on the topics of management planning and obsolescence will be provided in chapter five.

Communication and Information Flow

Two significant differences were observed between the two test equipment programs that relate to communication. First, the TISS community maintains and uses extensively a secure website for the documentation of historical and ongoing management issues. This website is broad in scope, containing information regarding field problem reports, software configuration, personnel contacts, meeting minutes and system history. The website is secure and accessible only by user login and password. All personnel who are part of the TISS integrated product team have access to this resource. (See Appendix I) This researcher observed the maintenance and upkeep of this website as not only a valuable communication tool, but also an excellent historical reference.

Additionally, the TISS program is eligible to utilize the Air Warfare Center Bulletin Board System (AWC BBS) at Eglin AFB, Florida for the distribution of all Test Program Set (TPS) software upgrades. This is a classified system used by both the Air Warfare Center and the Electronic Warfare Division of the Warner-Robins Air Logistics Center to send out classified aircraft flight programs. As a result, all F-15 field units have access. Essentially, this system allows users in the field to rapidly download entire updates to test program sets. Typically, field units wait days, weeks or months for hard copies of software to arrive via traditional transportation methods before manually loading the updates into their systems. The use of the Air Warfare Center Bulletin Board System greatly accelerates this process. The TISS program is able to take advantage of this mechanism because the majority of TISS software is classified. (See Appendix I) The same cannot be said for the Avionics Intermediate Shop software; as a result, its managers are not privy to its use.

Synopsis of Investigative Question One

What are the differences in how ATE is being managed?

- The TISS program benefits from the presence of a lead Major Command liaison working in the same facility as the primary management personnel
- Planning efforts are impacted by the two programs' different positions along the product life-cycle timeline. TISS has secured funding to combat projected shortfalls in operational capability; the AIS has suffered in this regard due to the apparent stagnation of the Electronic Systems Test Set program
- Obsolescence issues, while significant for both programs, are a more urgent concern for the AIS program, particularly for the Antenna Test Station and Enhanced Aircraft Radar Test Station – components which must be maintained until 2025.
- The TISS program benefits from having an extensive internal website, as well as the use of the Air Warfare Center Bulletin Board System secure server for test program software downloads to field users – AIS does not have similar systems.

Investigative Question Two

How much sustainment funding is budgeted/funded in the Program Objective Memorandum (POM) and Future Year Defense Plan (FYDP)?

The objective of this investigative question was largely the same as that of investigative question one, only in terms of funding. Primarily, the aim was to identify whether a significant difference existed between the two programs as it pertains to requested and received sustainment funds. Appendix B outlines the specific case study protocol questions that are relevant to this investigative question.

"Colors" of Money

During the course of this study, several distinct categories of funding were identified that are commonly used within the test equipment community. These categories are identified in Table 5.

Table 5. Categories of Funding Relevant to TISS and AIS

	EEIC	Description
Depot	583	DPEM Sustaining Engineering money used to investigate system level equipment problems
Depot	MSD Eng	Used to investigate component level problems that aren't considered "system" level
Depot	MSD UUT	Example: a multimeter in a multi-bay rack system would use MSD funds; the rack would use 583 $$
Depot	540	Depot Programmed Equipment Maintenance (DPEM) money used for software maintenance
Depot	545	DPEM money used to maintain exchangeables (core chargeable equipment)
Depot	Repairs	Material Support Division Repair - from the Air Force Working Capital Stock Fund
Depot	Spares	Material Support Division Buy (Spares) - from the Air Force Working Capital Stock Fund
SPO	3600	Development Funds
SPO	3010	Production Funds

For both of the test equipment programs under consideration in this study, Air Force Materiel Command is responsible for Material Support Division Engineering, Unit-under-test, 540 and 545 money, while the lead Major Command (ACC), Air National Guard and Air Force Reserve Command are responsible for funding 583 requirements. The 3600 and 3010 development and production monies flow directly through individual program offices – in this case, the F-15 System Program Office.

Some difficulty in obtaining specific funding data for both programs was encountered during this study. This difficulty is addressed in greater detail within chapter five. Nevertheless, there are several significant differences in terms of funded and unfunded requirements for the two programs. First, the TISS Technology Insertion Program is wholly funded through 2007, with managers working on 2008 program objective memorandum inputs at the time of this study's publication. The TISS

Technology Insertion Program received $41.6M from the 2004 Program Objective Memorandum, of which approximately $36M is targeted for the production and development contract with the manufacturer, with the remaining funds dedicated to engineering support and various program office operations. The $36M will be, for practical purposes, evenly distributed between 3010 production funds and 3600 development funds. Incidentally, it should be noted that the Technology Insertion Program was placed on the lead Major Command's mission essential funding list for the 2004 program objective memorandum, and would become one of only two F-15 program inputs to receive approval. (See Appendix K)

By contrast, the AIS program has a wide array of unfunded requirements. AIS respondents related the following inadequacies in terms of recent depot funding trends: for Material Support Division Engineering, funding has been at approximately 30% of the actual requirement; for 540 money, funding has been at approximately 80% of the actual requirement; and for 583 money, funding has been at approximately 15% of the actual requirement. This is in stark contrast to the equivalent figures for TISS depot sustainment funding, where respondents reported receiving all requested monies, with one exception during fiscal year 2005. (See Appendix L)

To draw more specific comparisons, the specific depot funding amounts for fiscal years 2001 through 2005 were obtained, compiled and analyzed for both programs. A summary of these values and analysis is included in Appendix E. This analysis identified several points that may suggest a historical funding difference between the TISS and AIS programs.

First, a simple trend examination of the data suggests that TISS sustainment funding at the depot has been more steady and consistent than that of AIS. Figures 12 and 13 illustrate this difference. For TISS, the dollar values in total suggest a continued upward trend in total funding, with individual categorical funding remaining largely consistent through the data range.

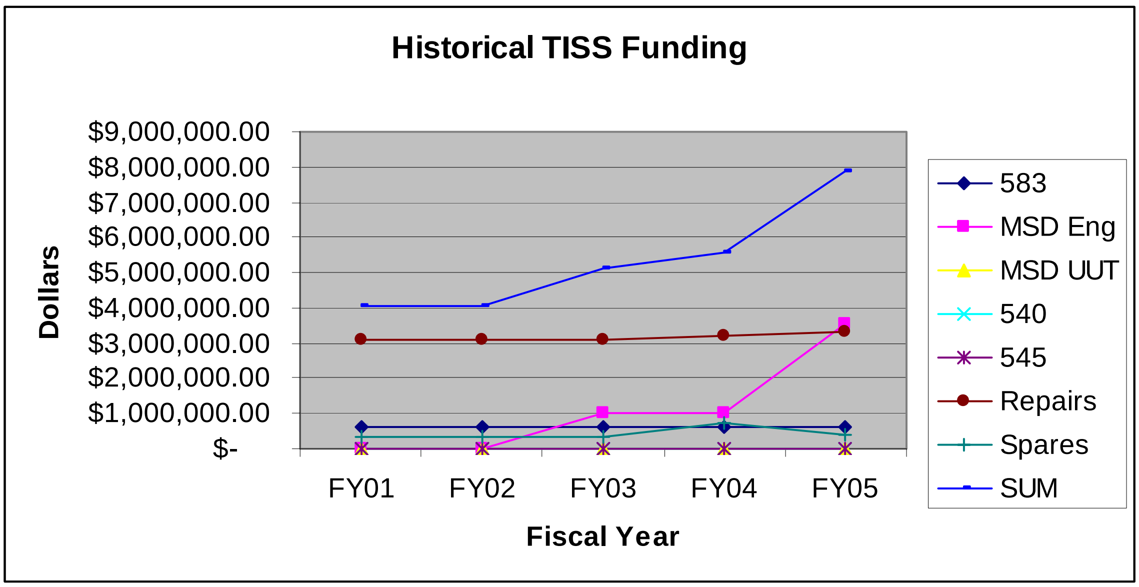

Figure 12. Historical TISS Sustainment Funding, FY01 – FY05

By contrast, the trend for AIS funding has been much more erratic, indicated in Figure 13. Individual categorical funding decreased, only to increase again, with tremendous funding spikes emerging in fiscal year 2005.

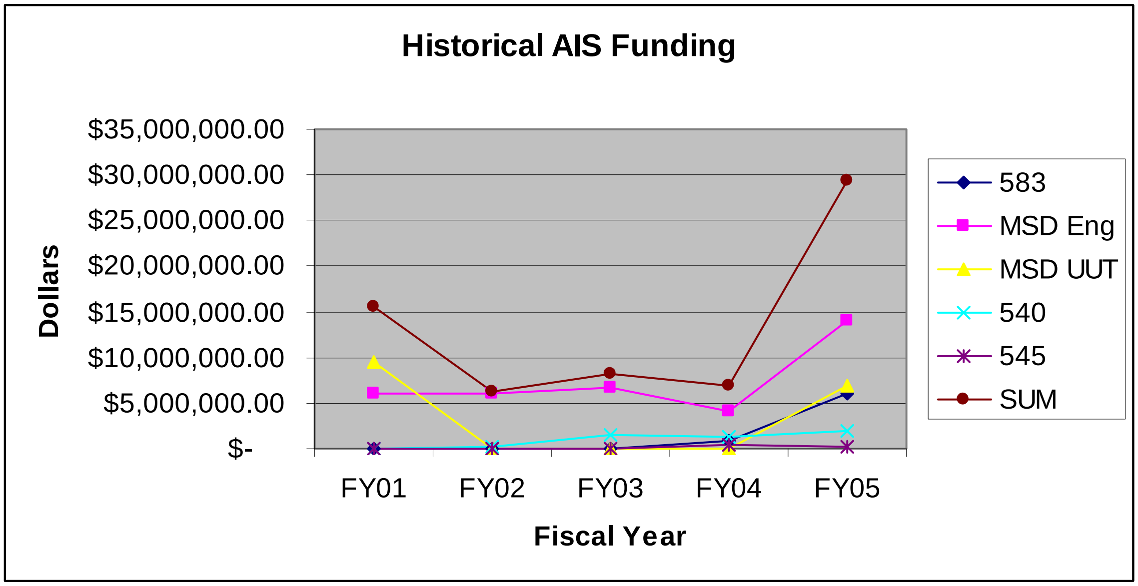

Figure 13. Historical AIS Funding, FY01 – FY05.

It is interesting to note that the largest categories of TISS funding were focused on the procurement of spares and system repairs, while the bulk of AIS funding was targeted towards sustaining engineering funds. This would suggest that the AIS program has a greater need than TISS to analyze component problems and develop solutions for obsolescence. (See Appendices K, L) Most importantly, however, is the success the TISS program has had in terms of accessing and obtaining 3010 and 3600 dollars from the F-15 program office. In effect, Program Objective Memorandum approval for the in-work technology insertion program has enabled TISS managers to preempt potential obsolescence problems in the coming years.

Managerial Perspectives on Adequate Funding

Perhaps the most dramatic difference in regards to program funding is found within respondents' own perspectives on the adequacy or inadequacy of funding support.

Simply put, respondents from the TISS program feel that they are receiving adequate funding, while respondents from the AIS program do not. In three interviews, the AIS program managers were most concerned with inadequate funding to support the Antenna Test Station and Enhanced Aircraft Radar Test Station – the two members of the Avionics Intermediate Shop that are not being replaced by the Electronic Systems Test Set and must be sustained until 2025. It was noted that fiscal year 2005 depot sustainment dollars showed a sharp increase for the AIS program over the previous year's funding – specifically, $22 million…an increase of more than 300%. (See Appendices K, L) While further research will be required to determine if this increase is an outlying occurrence or the start of a new, upward trend, it is quite possible that the dramatic change is the result of increased testimonials and case studies on behalf of the AIS, Antenna Test Station, and Enhanced Aircraft Radar Test Station community.

Synopsis of Investigative Question Two

How much sustainment funding is budgeted/funded in the Program Objective Memorandum (POM) and Future Year Defense Plan (FYDP)?

- Historical depot sustainment funding data was obtained for fiscal years 2001 through 2005; these values are included in Appendix E.
- The TISS program received approval in the 2004 Program Objective Memorandum for a $41.6M technology insertion program to replace obsolescent commercial-off-the-shelf equipment and reduce the logistical footprint of all existing test stations

- The AIS program has not yet secured funding to address growing obsolescence concerns for the sustainment of the Antenna Test Station and Enhanced Aircraft Radar Test Station through 2025
- Overall sustainment funding appears to have been more consistent for TISS than for AIS

Investigative Question Three

What are System Program Office, depot and Major Command assessments of Automatic Test Equipment sustainability for the two programs?

This investigative question was intended to explore the unique circumstances facing each test equipment program as they pertain to near- and long-term sustainability. This researcher collected interview data, program documents and archival figures from program managers and lead Major Command personnel to assess the nature and severity of sustainability issues facing the program, as well as managers' plans for addressing these problems. Additionally, this researcher sought to compare estimated timelines for reaching a solution. Appendix C outlines the specific case study protocol questions that are relevant to this investigative question.

Operational Capability and Diminishing Manufacturing Sources

Both test equipment program managers and Major Command personnel cited the impact of obsolescence and hardware shortages as the most significant sustainability issues. A significant difference, however, was observed in the management teams' overall outlook on the prognosis for addressing these issues. First, in regards to the TISS program, the only specific hardware or component shortage issues are not terribly severe, and are inclusively addressed as part of the approved technology insertion program, which is set for implementation in 2007. TISS respondents cited one power supply sustainment issue in particular, but noted that funding had already been secured to obtain suitable spares that will sufficiently cover user demand until the technology insertion program is in place. (See Appendix M)

On the contrary, the component sustainability issues facing the AIS program are significantly impacting tester operational capability. Specifically, current operational levels for the AIS are approaching fifty percent. Interview respondents indicated that thirty percent of major subassemblies for the Avionics Intermediate Shop can no longer be procured, with component repair turnaround times in excess of 120 days. As a result, the throughput of units under test (i.e. components from the aircraft) is slowed considerably. These issues are the focus of ongoing efforts on the part of AIS staff members and Major Command personnel to secure funding. (See Appendix N)

In regards to the prolonged severity of these sustainability issues, there is again a dramatic difference between the two test equipment programs. Several TISS respondents indicated that they are only recently beginning to encounter obsolescence issues, while AIS respondents indicated that these issues have been ongoing for approximately fifteen years. (See Appendices M, N) Additionally, a review of each program's history suggests another difference in terms of tester modifications and upgrades.

TISS was initially fielded in 1992 and, in June of 2002, received funding in the 2004 program objective memorandum for an extensive upgrade through a technology insertion program – an elapsed period of ten years. (See Appendix I) By comparison, the Antenna Radar Test Set, one of the components of AIS slated for sustainment until 2025, was fielded in the early 1970s and has been modified only once, in 1985. (See Appendix N) Nearly twenty years have elapsed without any significant improvements. Respondents from both the lead Major Command and the AIS program both responded that inadequate funding was the primary roadblock to the timely resolution of sustainability issues. (See Appendices N, O)

Synopsis of Investigative Question Three

What are System Program Office, depot and Major Command assessments of Automatic Test Equipment sustainability for the two programs?

- Obsolescence and diminishing manufacturing sources are the primary issues plaguing the two test equipment programs
- The AIS program faces a greater severity of obsolescence challenges
- Funding is generally considered to be the primary hurdle to overcome in the timely resolution of obsolescence and sustainment issues for both testers

Investigative Question Four

What are Major Command assessments of field units' abilities to support assigned equipment with resources provided by the System Program Office and depot?

This intent of this investigative question was to capture the impact of test equipment management teams on the performance of field units and avionics maintenance personnel. It was theorized that lead Major Command representatives would have a broad perspective and open access to the successes and difficulties encountered by field units, and would serve as an objective judge of mission impact. For this investigative question, this researcher relied almost exclusively on interview data collected from lead Major Command personnel. Appendix D outlines the specific case study protocol questions that are relevant to this investigative question.

Candid Feedback and Objectivity

First and foremost, it should be noted that a degree of resistance was encountered from respondents in regards to the protocol questions associated with this investigative question. This researcher expects that this is due to the candid nature of these particular protocol questions, and perhaps the respondents were uncomfortable with voicing particular opinions. Additional commentary on this experience is discussed further within chapter five.

Favorable Characterization of Field Unit Equipment Support

All in all, Major Command respondents commented favorably on the ability of field units to support their assigned test equipment, be it TISS or AIS components. (See Appendix P) When constructing the protocol for this portion of the study, there was a particular interest in determining the frequency with which field technicians are forced to rely on creative, higher-authority (e.g. System Program Office or depot) directed troubleshooting or maintenance procedures due to shortcomings in existing technical data. The reason for this interest was due to this researcher's previous personal experience within an Air Force maintenance unit, where the observation of such occurrences was not uncommon. Nevertheless, the study's respondents indicated that the propensity for such an occurrence within the F-15 avionics community is small. Furthermore, respondents indicated that when such a situation does occur, Major

Command personnel liaise with both SPO and depot managers to determine the best course of action.

Technical orders and time compliance technical orders were characterized to be of good quality for both programs, but respondents stressed the importance of coordination between all involved parties for success. Additionally, respondents described the level of troubleshooting support for both programs as adequate. (See Appendix P) Again, it is important to note that a lack of elaboration was observed as far as specific or judgmental comments on the support provided by either program, primarily from one respondent.

The final aspect of this investigative question revolved around the urgency and frequency of supplied parts and components to field units. It was theorized that a strong disparity between the two programs (i.e. much longer backorder periods for one system versus the other) would suggest a difference in terms of top-level management support. Data collected, however, and comments received from respondents did not reflect any dissimilarity in this regard between the two programs.

Perceptions and Additional Thoughts

Having addressed the issues of apparent reluctance and candor, a brief discussion of additional thoughts on this investigation are now presented. While specific supporting data were not obtained in the relevant data collection, there are a number of research observations made through other portions of the study that seem to suggest a distinction between the supportability of the two programs.

First, as previously mentioned, several TISS respondents commented on the importance of their internally-managed website as a communication tool for distributing information amongst both management personnel and users in the field. This website, in serving as a forum for the exchange of ideas and posting of timely and pertinent information, would seem to have direct relevance to the TISS management's ability to support users in the field, but no respondents from the lead Major Command made mention of this tool. A separate discussion with one of the TISS managers provides the following scenario. A field user encounters a supportability problem or issue and contacts a manager at the System Program Office. The manager then works in coordination with other members of the integrated product team to resolve this issue. During this period, a synopsis of the field issue, as well as relevant instructions for field users on interim workarounds are posted on the community website. This scenario arguably demonstrates a high level of support for technicians in the field and is certainly applicable to the objectives set forth within the fourth investigative question. (See Appendix I)

Additionally, the apparent disparity between TISS and AIS in terms of parts availability and lengthy repair turnaround was expected to be an indicator of varying levels of support for technicians in the field. TISS respondents indicated only minor obsolescence challenges, while AIS managers revealed very high non-availability rates for subassemblies, as well as excessive repair turnaround times. (See Appendix J and L) The specific reasons aside, user supportability should certainly be linked to this disparity, as the integrated product teams comprise the very personnel charged with pursuing solutions to these issues. Still, lead Major Command respondents did not suggest this disparity as a contributing factor to one test equipment program being more supportable than another, instead indicating that field users of both testers get the parts they need in a timely fashion. (See Appendix P)

All told, after reviewing collected data for the first three investigative questions, it was expected that a supportability disparity would be detected regarding Investigative Question Four. Specifically, it was expected that TISS users would enjoy a higher level of supportability than users of the AIS. Collected data from the lead Major Command, however, does not conclusively support this expectation, despite an array of related disparities found among data generated from the other investigative questions. Future research should be performed to investigate this phenomenon in greater depth.

Synopsis of Investigative Question Four

What are Major Command assessments of field units' abilities to support assigned equipment with resources provided by the System Program Office and depot?

- The overall characterization of field units' abilities to maintain TISS and AIS was positive
- This researcher detected a possible reluctance on the part of respondents to offer judgmental or critical assessments on the programs under study
- Critical analysis of data collected for the other investigative questions seems to suggest a supportability disparity between the two systems that was not traceable to collected Major Command responses

Research Findings

The collected data suggest that there are significant differences between the two test equipment programs, particularly within the areas targeted by investigative questions one, two, and three. The findings from investigative question four are inconclusive. Specific differences within each protocol question are identified within the matrix located in Appendix G.

Validity and Reliability

As introduced in chapter three, it is necessary to discuss the validity and reliability of these results. Again, Yin's three categories of validity are construct validity, internal validity and external validity (Yin, 2003:34) Leedy and Ormrod define constructs as "characteristics that cannot be directly observed but must instead be inferred from patterns in people's behavior" (Leedy et al, 2001: 98-99). For this study, an effort was made to ascertain the judgments and opinions of equipment users and Automated Test Equipment experts in the field regarding issues of supportability and efficiency. These issues, then, are the constructs for this study. In regards to construct validity, whenever possible, data were incorporated from multiple sources of evidence, including multiple interviews from different personnel and historical documents. Conclusions drawn from the collected data were made based on the repetitive claims made by more than one respondent from a given program, with single-instance occurrences documented as exceptions. Additionally, after personal face-to-face or telephone interviews were conducted, respondents were supplied with a copy of the notes from the interview. This was done in an effort to verify the accuracy of collected data.

To achieve internal validity, using the data collection matrix shown in Appendix F, pattern-matching and categorical aggregations were performed to cumulatively assess the data obtained. Likewise, this researcher sought to achieve convergence of fact and, consequently, external validity, by targeting responses that were replicated among different respondents. These responses were the primary basis for data analysis in chapter four as well as theory building in chapter five.

Finally, in regards to reliability, Yin's (2003) case study protocol guidance was used as a means to structure this case study. The protocol helped to provide a standardized format for data collection and transcription.

Summary

The purpose of this chapter was to discuss the analysis and results from the case study. Similarities and differences between the two test equipment programs under study were systematically identified and discussed in the order established by the case study protocol. We then addressed the validity and reliability of these results in reference to the case study tactics first introduced in chapter three.

Next, we present conclusions from the research in an attempt to address the overarching research question stated at the beginning of this study.

V. Conclusions

Chapter Overview

In this final chapter, additional findings are presented that were discovered during the course of this research that were not explicitly linked to the study's investigative questions, but otherwise present interesting and important implications for the management of F-15 test equipment. Next, we address the various findings as they relate to the overarching research question posed at the beginning of this study. Commentary on research limitations, field issues and data collection difficulties are discussed, followed by thoughts on related areas that may be suitable topics for future research.

Additional Discoveries

Several additional discoveries were made during the course of this research and are worth consideration when evaluating the management strategies for F-15 test equipment.

TISS and Historical Organizational Structure Decisions

When reviewing the histories of both pieces of test equipment observed in this study, it was discovered that a very specific managerial action was taken regarding the commodity consignment of TISS, originally scheduled for October 1997 (Raygor, 1996). Had this consignment occurred, the focal point of management responsibility for TISS test program sets would have been split apart from the management of the actual test equipment and hardware. Before this consignment occurred, a proposal was internally submitted and approved by the F-15 program office to prevent this action from happening. This proposal's recommendation centered on the fact that historically, management and configuration control responsibility for TISS had resided in one office at the Aeronautical Systems Center, and field users enjoyed the benefits of single point of contact interface with program management. A background paper included as part of this proposal suggested that the historical arrangement was a “validated management system”, and to reorganize the existing management structure through the proposed commodity consignment would be to jeopardize the level of support for field users. Indeed, the proposal suggested that “losing the TISS single point-of-contact would be disastrous for our customers” (Raygor, 1996).

This historical document was found to be supremely relevant to this case study, as the importance of communication and successful customer interface were described by respondents as essential elements of managerial support, regardless of the specific test equipment being managed. Furthermore, it was ascertained that TISS field users continue to enjoy the benefits of sustained, unchanging lines of communication with the program office to this day.

Continuity and Employee Turnover

An additional and significant difference discovered was one of personnel continuity and employee turnover. Although specific data regarding turnover was not collected as part of the case study protocol, this researcher casually observed that a disparity may exist between the two test equipment programs in terms of managerial continuity. In particular, a focal manager of the TISS program has maintained the position since the equipment’s inception in the early 1990s. By contrast, the particular position’s equivalent counterpart in the AIS program had been in the position for less than one year. Additionally, TISS respondents indicated that longstanding employee continuity has been maintained by the original TISS manufacturer. Specifically, a core group of engineers has been kept in place by the manufacturer since TISS was first developed, and these same individuals continue to work closely with program managers today. It should be noted that these engineers are not only accepted to be technical experts on the TISS system itself, but also on the supported electronic warfare line-replaceable units from the aircraft. The same cannot be said for the managers currently working to sustain existing AIS components as well as the Antenna Test Station and Enhanced Aircraft Radar Test Station. The Electronic Systems Test Set, the intended replacement for AIS, was not developed by the same manufacturer as the original AIS system. As a result, there is no pre-existing continuity between the manufacturer and the AIS program managers. While the specific, measurable impact of employee continuity on the level of managerial support is outside the scope of this research, it seems prudent to accept that higher continuity on a given program will lead to increased expertise regarding its workings. At any rate, it was believed that this topic warranted consideration for relevance to this study, as well as future efforts.

Roles and Responsibilities

Most respondents were eager to provide commentary and feedback regarding the typical roles and responsibilities of the F-15 System Program Office and the Automated Test Systems Division (WR-ALC/LEA) for the acquisition and life-cycle management of automated test equipment. In particular, feedback was provided on the commodity consignment process described in chapter two. As a review, generally speaking, the acquisition System Program Office initiates and develops a given piece of test equipment upfront, to include supporting equipment, spares, technical data and engineering drawings required to operate and subsequently maintain the test equipment system. By design, an integrated product team is formed with representatives from the System Program Office, Major Commands, Air Logistics Centers and contractors to oversee this process, thereby ensuring adequate support from "cradle to grave". Once a test equipment system enters the sustainment phase, practical management authority is typically consigned away from the System Program Office to the Air Logistics Center. For all intents and purposes, the present structure of TISS is an aberration – overall management has not been consigned.

Feedback regarding this consignment process was extremely varied among respondents. Some commented that consignment is a necessary reality – essentially saying that if the acquisition personnel never relinquished management authority they would eventually exhaust all capacity and lose the ability to take on and develop new projects. This certainly seems plausible, but then again, the TISS program exists as an exception. Other comments suggested a widespread belief that different and better capabilities exist at the System Program Office as opposed to the depot – specifically access to 3010 and 3600 funds. Additionally, some respondents suggested that Air Logistics Center representatives, while involved in the consignment process, are not involved enough during the initial acquisition phase, effectively limiting their ability to advocate for perceived future sustainment needs early on in product development. Another concern was the need for total procurement of engineering data and drawings. In particular, AIS respondents indicated that historical funding changes resulted in a failure to obtain this data upfront. Presently, AIS managers are suffering by not possessing this information, as they need to procure follow-on spares or replacements through reverse engineering efforts or expensive sole source acquisitions.

Clearly, there are many viewpoints and opinions regarding the commodity consignment process of F-15 test equipment. This researcher believes that this process alone would warrant further and more detailed study. In the next section, we provide concluding thoughts and commentary on the results of this study and address the original research question.

Addressing the Research Question

Is F-15 automatic test equipment more supportable and efficient when managed by a separate support office or when managed by the supported weapon system?

After conducting the study, it has been determined that sufficient evidence exists to suggest that there are key differences between the two F-15 automatic test equipment management strategies that affect the supportability and efficiency of the managed equipment. The completed data collection matrix, shown in Appendix G, was evaluated and assessed in conjunction with other relevant findings presented above to generate the consolidated figure below. Figure 14 identifies which of the two test equipment programs was determined to be more supportable and efficient when viewed in terms of each investigative question.

	IQ Similarity or Difference of Data	Conditions Favor
IQ1	--	TISS
IQ2	--	TISS
IQ3	--	TISS
IQ4	++	Neither

KEY		
KEY	Contradictory	--
	Marginal	0
	Equivalent	++

Figure 14. Summary of Protocol Question Findings

This researcher wishes to emphasize that the above characterization is *not* intended to criticize the performance of any individuals within the AIS program – indeed, there is no such claim being made. Rather, this researcher believes that there are certain benefits to be gained when test equipment is managed primarily by the supported weapon system. Investigative questions one through three addressed individual management approach, success with funding, and overall health of each program. The results of chapter four indicate that TISS has traditionally been more successful in each of these areas. Investigative question four did not yield conclusive results, but will be addressed in the limitations and field issues section below.

Clearly, there are certain characteristic differences between the two test equipment systems that have an impact on their managers' ability to support them, such as system age and different supported line-replaceable units. To be sure, one must consider that we are not evaluating the same system managed by two different entities (e.g. comparing "apples to apples")…indeed, these are different pieces of test equipment, and that fact alone has its implications. That being said, this researcher contends that TISS management has capitalized on the benefits of collocation with the weapon system program office. Evidence indicates that the TISS program has executed sound planning for projected equipment obsolescence, to include successfully justifying and securing funding in the competitive program objective memorandum process.

Research Limitations, Field Issues and Bias

During the course of this study, several limitations and issues were encountered that could have either introduced bias or limited the scope of research. This section will address each of these concerns:

1. Limitation: Analysis Limited to Two Test Equipment Systems

First and foremost, this case study analysis was limited to an examination of only two test equipment programs within the F-15 community: TISS and AIS. The results of this study are therefore limited only to these two systems; similar assessments of other test equipment programs in other weapon systems should be made before making broader assumptions regarding managerial strategies.

2. Field Issue: Budget and Expenditure Data

This researcher was only able to obtain historical funding data for the past five fiscal years. With a greater volume of data, a more robust analysis could be performed in regards to funding trend determinations, to include possible statistical testing. Additionally, this researcher encountered difficulty in obtaining the historical funding dollar values through military archives or records. That is, other individuals from the respective test equipment programs were relied upon to provide the relevant funding data.

As a consequence, this researcher was not in a position to verify the accuracy of the figures presented.

3. Field Issue: Encountering Reluctance on the Part of Respondents

Particularly in regards to data collection for Investigative Question four, this researcher sensed a general hesitance on the part of respondents to speak candidly about the performance of both the program office and depot in terms of supporting field units. This researcher *did* undergo the necessary protocol to ensure anonymity and non-retribution, but was only able to ascertain limited feedback pertaining to this investigative question. In hindsight, this researcher suspects that due to the tight-knit nature of the weapon system community, respondents were reluctant to offer comments that may have been construed (or misconstrued) to be critical of others.

4. Limitation and Potential Bias: Data Collection

It should be noted that there was a disparity in the means of data collection from all respondents. This researcher was able to interview and collect data from the TISS program office in person, being located on the same installation. Other respondents at separate geographic locations were interviewed both by telephone and through electronic communication. As a result, bias could have been introduced due to the ability to observe non-verbal communication in face-to-face discussions.

5. Limitation and Potential Bias: Researcher Experience

This researcher, while having prior maintenance experience in the Air Force, had no previous experience working within the F-15 weapon system community. While this fact alone suggests that this researcher would be an apropos choice in terms of objectivity, this researcher did have experience working with test equipment and obsolescence, albeit under a different weapon system platform. As a result, this researcher had prior knowledge and experience with the Automated Test Systems Division; these experiences may have introduced preconceived notions and bias into this research.

Recommendations for Future Research

While conducting this study, three areas were noted that may be suitable candidates for future topics of research. First, as stated previously, this research was conducted in part to serve as a foundation and baseline template for similar inquiries into the management strategies for test equipment systems employed by other weapon systems. This researcher developed the case study protocol for this effort in tandem with another researcher examining strategic missile test equipment (Ford, 2005). It is certainly plausible, therefore, that future researchers may build upon the structure presented in this study and pursue separate inquiries into the management of other test equipment programs. Next, during the course of this study, it was determined that it would be useful to build a separate comparison study between similar test equipment systems using reliability, maintainability and life-cycle costing techniques. For this study, the protocol did not explicitly request historical reliability data, but such an endeavor certainly seems feasible. Moreover, TISS and AIS are used to test very different line-replaceable units; a reliability and maintainability study may be better suited for comparing two test equipment systems that support similar line-replaceable units for different weapon systems. Finally, it may be worthwhile to critically evaluate the oft-encountered choice between staying with the original equipment manufacturer for all future sustainment needs versus opening up repair, support or next-generation contracts to new providers. On a topical level, it is possible that there may be a positive correlation between long-term sustainability and uninterrupted support from the original equipment manufacturer.

Research Summary

The purpose of this research was to examine the implications of two alternative strategies regarding the management of automated test equipment: single-point management under the weapon system ownership of a System Program Office, or separate management at an existing stand-alone automated test systems support office. Using a case study methodology, we developed a protocol and collected information on the management of two separate test equipment systems used to support the F-15 platform: the Tactical Electronic Warfare System Intermediate Service Station (TISS), which is primarily managed at the F-15 System Program Office, and the Avionics Intermediate Shop (AIS), which is managed at the Automated Test Systems Division at Warner-Robins Air Logistics Center. Results of the research suggest that the equipment managed by the system program office (TISS) has historically been more supportable and efficient than the equipment managed by the stand-alone automated test systems support office (AIS).

Recommendation

Consider the initial charge found within Air Force Policy Directive 63-2, previously introduced in chapter one of this thesis: "Standardized automatic test systems (ATS) and equipment can provide efficiency and reduced cost by minimizing the proliferation of system-unique test equipment *while ensuring that the maintenance and deployment* *requirements of existing and developing weapon systems and equipment are met*." (USAF-1, 1994). If we are to accept common test equipment as a viable solution for future test equipment needs, managerial support for that equipment must be responsive and non-hindering to the maintenance abilities of supported aircraft and weapon systems. Obsolete, ill-funded test equipment such as the Avionics Intermediate Shop has hampered its managers' ability to meet this endeavor. While all efforts are made to make the best use of scarce resources, sacrificing the level of support for product end-users should be avoided if at all possible. What then, can be done to improve the viability of the current approach of consolidating test equipment sustainment management at a stand-alone office?

First, there needs to be a more rigorous, dedicated effort to providing adequate funding for test equipment in the post-acquisition phase. The AIS program is representative of numerous testers in sustainment at the Automated Test Systems Division that suffer due to repeated partial funding of requirements. The TISS program has benefited from access to production and development funds that are only available at the System Program Office; the depot is not privy to 3600 and 3010 monies. This is one factor that has enabled TISS managers to better confront the problems of increased obsolescence. When weapon system service lives are extended, the test equipment used to support those weapon systems must be correspondingly extended, upgraded or replaced. If projected improvement funds are not budgeted for in the acquisition phase, the funds must be provided to the management programs in the sustainment phase.

Next, the Automated Test Systems Division must be more actively involved in the acquisition and development process for next-generation or replacement testers. Initial findings in the 2003 General Accounting Office report suggested that depot personnel are not involved to the level they should be in order to address essential components of future sustainment for a new system. As an example, depot personnel indicated that the AIS program has suffered today as a result of not procuring certain maintenance specifications and engineering drawings during the acquisition phase; this information would have been extremely valuable in terms of obtaining replacement spares or obsolete components. Dwindling production lines and manufacturing sources complicate this problem, and the lack of internally owned engineering documentation from the original manufacturer can result in less than desirable reverse engineering efforts or exorbitant sole-source purchases. Moreover, the Automated Test Systems Division, as the Air Force's Product Group Manager has been charged with a degree of oversight in the acquisition process, both to minimize the proliferation of unique testers and capitalize on opportunities for common capability across weapon systems. If System Program Offices do not involve the Automated Test Systems Division in their acquisition decision-making, any anticipated benefits espoused by service-level policy are likely to go unrealized.

Finally, Major Command leadership should consider the establishment of a liaison position at the Automated Test Systems Division to serve as an advocate for managed test equipment in the sustainment phase. Often, this liaison is in close communication with field users regarding the day-to-day challenges encountered in maintenance units. A depot-placed experienced career technician who is well-versed in the particular test equipment could perhaps serve as a more effective lobbyist to Major Command decision-makers. This position has already been established at the System Program Office to monitor the development of products in the acquisition phase; it seems conceivable that benefits would be gained from establishing a mirror position at the depot.

In summary, this research suggests that test equipment programs managed by their program offices through sustainment are more successful than those which are distanced from the supported platform and consigned to a stand-alone office. Although existing Air Force policy advocates against the proliferation of unique test equipment and espouses perceived benefits of consolidated, common test equipment, any decision to separate formal management responsibility from the owning weapon system platform must take into consideration the other ramifications associated with taking such action.

Appendix A: IQ 1 Case Study Protocol

Investigative Question #1: What are the differences in how ATE is being managed?

Sources of Data:

SPO and Depot

Program Managers

Equipment Specialists

Organizational Charts

Supporting Questions:

(Please type answers directly below each question and use as much space as required)

1. What is your duty title and job description?
2. What activities are part of your daily work that pertain to the management of this equipment?
3. What activities do you perform that pertain to short-, mid- and long-term planning for this equipment?
4. What activities do you perform in support of or in response to issues that arise from field-level users of this equipment?
5. When was this equipment initially fielded?
6. What did this equipment replace, if applicable?
7. Have you encountered any obsolescence issues pertaining to this equipment? If so, please explain.
8. What managerial challenges do you perceive as unique to this equipment?
9. With whom do you routinely work in support of managing this equipment? (duty titles and job descriptions)

10. Are you familiar with DoD policy regarding the acquisition and development of common test equipment? (AFPD 63-2)
11. How does this DoD policy affect this equipment, if at all?
12. Please add any additional information you feel would aid in answering Investigative Question #1.

Appendix B: IQ 2 Case Study Protocol

Investigative Question #2: How much funding is budgeted/funded in the Program Objective Memorandum (POM) and Future Year Defense Plan (FYDP) for your ATS program?

Sources of Data:

MAJCOM and SPO/depot financial managers
MAJCOM and SPO/depot subject matter experts
Budget reports
Budget Estimate Submissions (BES)

Supporting Questions:
(Please type answers directly below each question and use as much space as required)

1. Who is responsible for funding your related equipment?
2. Are there any funded/unfunded requirements for the equipment? Please explain.
3. What equipment funding requirements were included in the last 2 POM cycles? Please include the associated BES input.
4. Do you get the funds needed to adequately support your equipment program? Please explain.
5. Are your equipment POM inputs funded? If not, how far below the Air Staff/MAJCOM funding line did the requirements fall?
6. Please add any additional information you feel would aid in answering Investigative Question #2.

Appendix C: IQ 3 Case Study Protocol

Investigative Question #3: What are ATE SPO, depot, and MAJCOM assessments of ATE/ATS sustainability for the two programs?

Sources of Data:

MAJCOM Staff
SPO/depot program managers
SPO/depot equipment specialists

Supporting Questions:
(Please type answers directly below each question and use as much space as required)

1. What specific sustainability issues (e.g. hardware, components) does this equipment have?
2. Is there an action plan to address these issues? Please explain.
3. Are these issues solvable? If not, why? What roadblocks, if any, are hindrances to reaching a solution?
4. Are there timelines for reaching a solution? Please explain.
5. When did these issues first arise?
6. How urgent of a priority are these issues?
7. Please add any additional information you feel would aid in answering Investigative Question #3.

Appendix D: IQ 4 Case Study Protocol

Investigative Question #4: What are MAJCOM assessments of field units' abilities to support assigned equipment with resources provided by SPO/depot?

Sources of Data:

MAJCOM subject matter experts
Memorandums documenting ATE/ATS problems

Supporting Questions:
(Please type answers directly below each question and use as much space as required)

1. Do units get the parts they need to support their assigned equipment? Please explain.
2. Do units get the replacement parts in a timely fashion? Please explain.
3. How often do technicians have to rely on technical procedures (at the direction of the SPO) not provided in established TO procedures? Who proposed the solution (field, MAJCOM, or SPO/depot)? Please explain.
4. Are TOs of good quality? Please explain.
5. Are TCTOs of good quality? Please explain.
6. Do units receive adequate SPO troubleshooting support when formal technical data is exhausted? Please explain.
7. Are there relatively more, fewer, or about the same number of MICAPs as in the past? Please explain.
8. Are backorders longer than 30 days common? Give examples of recurring problems.
9. Please add any additional information you feel would aid in answering Investigative Question #4.

Appendix E: Historical Sustainment Funding for TISS and AIS, FY01-FY05

AIS	583	MSD Eng	MSD UUT	540	545	SUM
FY01	$ -	$ 6,100,000.00	$ 9,400,000.00	$ -	$ -	$ 15,500,000.00
FY02	$ -	$ 6,100,000.00	$ -	$ 118,000.00	$ -	$ 6,218,000.00
FY03	$ -	$ 6,600,000.00	$ -	$ 1,600,000.00	$ -	$ 8,200,000.00
FY04	$ 933,000.00	$ 4,200,000.00	$ -	$ 1,400,000.00	$ 463,000.00	$ 6,996,000.00
FY05	$ 6,000,000.00	$ 14,000,000.00	$ 7,000,000.00	$ 2,000,000.00	$ 300,000.00	$ 29,300,000.00
SUM	$ 6,933,000.00	$ 37,000,000.00	$ 16,400,000.00	$ 5,118,000.00	$ 763,000.00	**$ 66,214,000.00**

TISS	583	MSD Eng	MSD UUT	540	545	Repairs	Spares	SUM
FY01	$ 600,000.00	$ -	$ -	$ -	$ -	$ 3,120,000.00	$ 350,000.00	$ 4,070,000.00
FY02	$ 600,000.00	$ -	$ -	$ -	$ -	$ 3,120,000.00	$ 350,000.00	$ 4,070,000.00
FY03	$ 600,000.00	$ 1,030,000.00	$ -	$ -	$ -	$ 3,120,000.00	$ 350,000.00	$ 5,100,000.00
FY04	$ 635,000.00	$ 1,030,000.00	$ -	$ -	$ -	$ 3,192,000.00	$ 723,000.00	$ 5,580,000.00
FY05	$ 635,000.00	$ 3,550,000.00	$ -	$ -	$ -	$ 3,320,000.00	$ 370,000.00	$ 7,875,000.00
SUM	$ 3,070,000.00	$ 5,610,000.00	$ -	$ -	$ -	$ 15,872,000.00	$ 2,143,000.00	**$ 26,695,000.00**

Appendix F: Data Collection Matrix Template

	Type and Quantity of Data				Compare	Comment/Theme/Note/Trend
	TISS		AIS		Each Question	Each Question
IQ1	Question 1			Question 1		
	Question 2			Question 2		
	Question 3			Question 3		
	Question 4			Question 4		
	Question 5			Question 5		
	Question 6			Question 6		
	Question 7			Question 7		
	Question 8			Question 8		
	Question 9			Question 9		
	Question 10			Question 10		
	Question 11			Question 11		
	Question 12			Question 12		
IQ2	Question 1			Question 1		
	Question 2			Question 2		
	Question 3			Question 3		
	Question 4			Question 4		
	Question 5			Question 5		
	Question 6			Question 6		
IQ3	Question 1			Question 1		
	Question 2			Question 2		
	Question 3			Question 3		
	Question 4			Question 4		
	Question 5			Question 5		
	Question 6			Question 6		
	Question 7			Question 7		
IQ4	Question 1			Question 1		
	Question 2			Question 2		
	Question 3			Question 3		
	Question 4			Question 4		
	Question 5			Question 5		
	Question 6			Question 6		
	Question 7			Question 7		
	Question 8			Question 8		
	Question 9			Question 9		

Example:

characterize

	TISS		AIS		Compare Data	Similarity or Difference of Data
IQ	Question	D, A, I Medium	A, I High	Question	++	--

Data Type D = Document
A = Archival Data
I = Interview

Quantity of Data
(Low, Medium, High)

Contradictory = --
Marginal = 0
Equivalent = ++

Appendix G: Completed Data Collection Matrix

	Type and Quantity of Data				Compare	Comment/Theme/Note/Trend
	TISS			AIS	Each Question	Each Question
IQ1	Question 1	I High	I High	Question 1	--	Similar structure of Integrated Product Teams; Logistics, Engineering, Contracting, Tech Orders; scope difference
	Question 2	I High	I High	Question 2	0	Similar coordinating activities
	Question 3	I High	I Med	Question 3	--	Possible difference in field-user input; contractor involvement
	Question 4	I High	I Med	Question 4	--	TISS: collaborative efforts with IPT, contractor; AIS: independent problem-solving
	Question 5	D, A, I High	D, A, I High	Question 5	--	TISS initially fielded 1992 vice AIS early 1970s
	Question 6	D, A, I High	D, A, I High	Question 6	--	TISS replaced TITE; AIS is first generation
	Question 7	I Med	D, I Med	Question 7	--	AIS suffered more due to obsolescence than TISS
	Question 8	I Low	I Low	Question 8	--	TISS staff focused on complexity of TEWS; AIS staff focused on obsolescence, parts procurement
	Question 9	I Med	I Med	Question 9	++	Similar staff personnel, MAJCOM and contractor involvement
	Question 10	I Low	I Low	Question 10	--	minimal familiarity; general distaste for policy
	Question 11	I Low	I Low	Question 11	++	N/A for current testers (in sustainment); general feelings against policy
	Question 12	I Low	I Low	Question 12	0	N/A
IQ2	Question 1	I Med	I Med	Question 1	++	TISS receipt of 3600/3010 funds
	Question 2	D, A, I High	D, A, I High	Question 2	--	TTIP; impact of ESTS
	Question 3	D, I Med	I Med	Question 3	--	Approval of TTIP in 2004; none for AIS
	Question 4	I High	I High	Question 4	--	TISS: Yes; AIS: No
	Question 5	I Med	I Med	Question 5	--	TISS: Yes; AIS: Not Applicable
	Question 6	I Low	I Low	Question 6	0	N/A
IQ3	Question 1	D, I High	D, I High	Question 1	--	Greater obsolescence for AIS
	Question 2	I Med	I Med	Question 2	0	Internal case studies
	Question 3	I High	I Med	Question 3	--	Optimism contingent upon funding approval
	Question 4	I High	I High	Question 4	--	TISS issues solved by TTIP; ATS & EARTS TBD
	Question 5	I Med	I Med	Question 5	--	AIS issues ongoing for much longer
	Question 6	I Med	D, I High	Question 6	--	Much more pressing concern for AIS
	Question 7	I Low	I Low	Question 7	0	N/A
IQ4	Question 1	I Low	I Low	Question 1	++	Yes
	Question 2	I Low	I Low	Question 2	++	Only impact is unexpected supply or trans issues
	Question 3	I Low	I Low	Question 3	++	Seldom
	Question 4	I Low	I Low	Question 4	++	Yes
	Question 5	I Low	I Low	Question 5	++	Yes, contingent upon coordination early on in process
	Question 6	I Low	I Low	Question 6	++	Support established at SPO, depot and manufacturer(s)
	Question 7	I Low	I Low	Question 7	0	Increased MICAPs due to ops tempo
	Question 8	I Low	I Low	Question 8	0	Varies: less than 30 to 120 days

Appendix H: List of Terms and Commonly Used Acronyms

AFB	Air Force Base
AFCATE	Air Force Common Automatic Test Equipment
AFI	Air Force Instruction
AFMC	Air Force Materiel Command
AFPD	Air Force Policy Directive
AFRL	Air Force Research Laboratory
AIS	Avionics Intermediate Shop
ALC	Air Logistics Center
ARTS	Aircraft Radar Test Station
ASC	Aeronautical Systems Center
ATE	Automated Test Equipment
ATS	Antenna Test Station
ATS	Automated Test Systems
ATS/E	Automated Test Systems/Equipment
AUR	All-up Round
AWC BBS	Air Warfare Center Bulletin Board System
C^3	Commodity Class Consignment
CNI	Communication, Navigation and Identification
COTS	Commercial Off-the-shelf
CTS	Computer Test Station
DMSMS	Diminishing Manufacturing Sources and Material Shortages
DoD	Department of Defense
DoDI	Department of Defense Instruction
DTS	Display Test Station
EA	Executive Agent
EARTS	Enhanced Aircraft Radar Test Station
ED	Executive Directorate
ESTS	Electronic Systems Test Set
FYDP	Future Year Defense Plan
GAO	General Accounting Office
HAF	Headquarters Air Force
HQ	Headquarters
I & C	Indicators and Controls
IPT	Integrated Product Team
IWSM	Integrated Weapon System Management
LRU	Line Replaceable Unit
MAJCOM	Major Command
METS	Mobile Electronic Test Set
MICAP	Mission Capability (Highest Supply Demand Priority)
MOA	Memorandum of Agreement
MSD	Material Support Division

MTS	Microwave Test Station
OI	Operating Instruction
OSD	Office of the Secretary of Defense
PGM	Product Group Manager
PMRT	Program Management Responsibility Transfer
POM	Program Objective Memorandum
PM	Program Manager
SAF	Secretary of the Air Force
SPD	System Program Director
SPO	System Program Office
SRU	Shop Replaceable Unit
TCTO	Time Compliance Technical Order
TEWS	Tactical Electronic Warfare System
TISS	TEWS Intermediate Service Station
TITE	TEWS Intermediate Test Equipment
TO	Technical Order
TPS	Test Program Set
TRU	Tester Replaceable Unit
TTIP	TISS Technology Insertion Program
USAF	United States Air Force
UUT	Unit-under-test
VXI	Versa Module Eurocard Extensions for Industry
WPAFB	Wright-Patterson Air Force Base, OH
WR-ALC	Warner-Robins Air Logistics Center, GA
WR-ALC/LEA	WR-ALC ATS Division; Air Force ATS PGM

Appendix I: Selected SPO Data for IQ 1

Investigative Question #1: What are the differences in how ATE is being managed?

Sources of Data:

SPO and Depot
- Program Managers
- Equipment Specialists

Organizational Charts

Supporting Questions:

(Please type answers directly below each question and use as much space as required)

1. What is your duty title and job description?
- *DUTY TITLE MASKED* o Performs LM & PM functions o Coordinates parts problems (bases & contractor) o Management side – planning, TTIP program, modernization - *DUTY TITLE MASKED* o Interface with DRA15 o Monitor progress on ACC's requirements o "watchdog" for ACC interests - Overall management of the TISS Program to include funding all modifications (software and hardware), T.O.s, Field Engineering support and Configuration Management of the system - *DUTY TITLE MASKED*
2. What activities are part of your daily work that pertain to the management of this equipment?
- coordinate with *MANUFACTURER NAME MASKED*, WR, field sites on parts problems (shortages) and obsolescence issues - run TCMs – bimonthly meetings with all involved parties (essentially an IPT) - TTIP (TISS technology insertion program) upgrade of COTS equipment; GP and RF interfaces - Coordinate base/contractor issues - Working 08-11 POM
3. What activities do you perform that pertain to short-, mid- and long-term planning for this equipment?
- Work closely with *MANUFACTURER NAME MASKED* representatives on all ranges of planning

- Actively involve people from field in planning process
- Emphasize the importance of frequent user input throughout planning *and* development
- Engineering support budgeted for
- Meet every other month; comprehensive program website accessible by all users and members of the program community
- Website components include:
    o TISS General Information
    o TISS Logistics Information
    o TISS Technology Insertion Program
    o TISS Commercial Computer Support
    o AWC BBS Information
    o TISS Software Configuration
    o TISS Deficiency Reports (DR)
    o TISS Field Bulletins
    o TISS Field Problem Reports
    o TISS Technical Coordination Meetings (TCM)
    o TISS SERD List/TISS Allowance Standard
    o TISS T.O. List
    o TISS Workaround Summary
    o TISS Silver Bullets
    o TISS Training
- Users perspective genuinely sought *(multiple respondents re-iterated)*

4. What activities do you perform in support of or in response to issues that arise from field-level users of this equipment?

- IPT/TCM meet to review issues together (every other month)
    o SPO, ACC, LEACC, LSRAC, *MANUFACTURER NAME MASKED*, *MANUFACTURER NAME MASKED*, *MANUFACTURER NAME MASKED*, Schoolhouse
- Have capability to use AWC BBS for classified software updates
    o Total replacement of software as opposed to patches
    o Field users are able to rapidly download all software updates to their test stations
    o This is a classified system used by AWC and WR-ALC/LS (Electronic Warfare Division) to send out classified Aircraft flight programs. All the F-15 shops have access to it. We were able to take advantage of this because most of our TISS Software is classified.
- Coordinate field issues with contractor (getting parts where they are needed, getting help on site)

5. When was this equipment initially fielded?
- 1992, development 90-92

- **NOTE: reference TISS historical timeline on program website**
- TISS remained at SPO vs. LEA PMRT (as well as assoc. TPS)
    - SSS; received formal approval to keep focal point of management as is instead of splitting up TPS/ATS ownership and transferring everything down to LEA **(have a copy of this report)**

6. What did this equipment replace, if applicable?

- TITE was old system
- Originally intended for ECP to support new TEWS ($65M)
- Instead, competed a new system for $200M
- SPO director decision
- Initially had to use MATE computer – costly and not friendly to use *(multiple respondents expressed distaste for MATE)*

7. Have you encountered any obsolescence issues pertaining to this equipment? If so, please explain.

- COTS equipment from the mid ‘80s
- Just now starting to have some real problems, parts shortages
- Performed a case study internally in ’02 predicting projected shortages in ’07 & ’08 (losing capability of stations) – believe case study was a big help to funding approval for TTIP
- SPO has a great deal of flexibility on workarounds
- Formal workaround process signed off by ACC/ *MANUFACTURER NAME MASKED* /SPO; managed at SPO
- Internally managed website that all have access to for posting of workarounds, communication

8. What managerial challenges do you perceive as unique to this equipment?

- TEWS are some of the most complex LRUs
- Didn’t transfer to LEA **(reference copy of approved request)**

9. With whom do you routinely work in support of managing this equipment? (duty titles and job descriptions)

- Reference POC list provided
- Reference internal TISS website

10. Are you familiar with DoD policy regarding the acquisition and development of common test equipment? (AFPD 63-2)

- Yes, doesn’t apply because this piece of equipment is in sustainment phase

11. How does this DoD policy affect this equipment, if at all?
- It would be “overkill” to make this piece of equipment common - TEWS is too complicated to generalize - Common ATS will only be successful if aircraft have common LRUs
12. Please add any additional information you feel would aid in answering Investigative Question #1.

Appendix J: Selected Depot Data for IQ 1

Investigative Question #1: What are the differences in how ATE is being managed?

Sources of Data:

SPO and Depot
- Program Managers
- Equipment Specialists

Organizational Charts

Supporting Questions:

(Please type answers directly below each question and use as much space as required)

1. What is your duty title and job description?
DUTY TITLE MASKED. I am responsible for the F-15 AIS program. *DUTY TITLE MASKED* *DUTY TITLE MASKED*
2. What activities are part of your daily work that pertain to the management of this equipment?
Work with the IPT team (*DUTY TITLES MASKED*) together we manage the AIS program WR-ALC/LEA's responsibility is to sustain the weapon system ATE for the life of the system. The SPO acquires the ATE upfront and all supporting equipment/spares/tech data/engineering drawings/training/etc. required to operate and maintain the ATE. During the acquisition process the SPO, MAJCOMs, ALCs, and contractors form an IPT to ensure the ATE can be supported from cradle to the grave. The driving force behind the functional requirements of this IPT is the mission statement specified in the Operational Requirements Document (ORD) and Mission Needs Statement (MNS) which is prepared by the users/MAJCOM Participation by all members is critical to successful fielding and Sustainment of ATE. The MAJCOMs provide valuable insight into the day to day functional test requirements. Every effort should be made to have them during the initial and all follow-on phases of acquisition and sustainment.
3. What activities do you perform that pertain to short-, mid- and long-term planning for this equipment?

Since this program is over 30 yrs old it is hard to do short term planning, Mid to Long term working with the IMs and ESs we tried to predict what we will need and see if the item is in the warehouse from test station that have been turned in.
4. What activities do you perform in support of or in response to issues that arise from field-level users of this equipment?
When issues arise from the field the ES or IM will work the issue and coordinate with me on the decision
5. When was this equipment initially fielded?
Early 1970s.
6. What did this equipment replace, if applicable?
N/A.
7. Have you encountered any obsolescence issues pertaining to this equipment? If so, please explain.
Due to the age of the system (1960s/1970s) technology, the AIS has numerous obsolescence issues. The CTS, DTS, MTS, CNI, I&C are being replaced by the ESTS, but the ATS and EARTS must be sustained until 2025. We have an ongoing upgrade program with Honeywell to develop prototype replacements for obsolete tester replace units in the AIS. Obsolescence *(Multiple respondents indicated)* ~ 50% of ARTS Test Replaceable Units (TRUs) are obsolete/non-procurable ~ 62% of MSIP and EARTS TRUs are obsolete/non-procurable Diminishing Manufactory Sources Very limited repair sources Repair turnaround time exceeds 120 days on average I-level experiencing throughput issues due to parts non-availability Adversely impacts Weapon System availability TRUs spares levels 50% below authorizations Cannibalization virtually non-existent at the I-level/Depot Station Mission Capable rates rapidly degrading across CAF Reference F-15 ATS Slideshow included – *AUTHOR NAME MASKED.*
8. What managerial challenges do you perceive as unique to this equipment?

Old technology generates major obsolescence issues. New technology insertions lead to incompatibility issues due to timing, signal processing, and theory of operation changes. Lack of a complete engineering data package leads to difficulty in procuring spares as the equipment becomes obsolete or unsupportable. Adequate support equipment, tools, data, and training must be procured upfront, to ensure successful Sustainment of the ATE for the life of the system. All these tools must be acquired to keep the ATE operational and supportable. The ALC must be involved in the acquisition process at the initial stage to ensure all required essential elements are addressed to sustain the equipment for the life of the system. Unfortunately the ALC is not always a major player during the acquisition phase. Also budgetary constraints have sometimes lead to cutting maintenance data such as engineering drawings which later on become essential for procurement of follow-on spares or replacement of the obsolete ATE. This happened with the management of the F-15 AIS and lead to both risky reverse engineering projects and expensive sole source acquisitions. The AIS is an aging system that contains numerous obsolescence issues. To ensure the user's mission capability is not degraded and the ATE can be acquired at the best cost, complete engineering data should always be procured during the acquisition phase.
9. With whom do you routinely work in support of managing this equipment? (duty titles and job descriptions)
Command HQ ACC, Equipment Specialist they work all the D200 comps, test the station and work all the TO issue, Item managers manage different parts for the test station and make sure that we have parts in supply, Contracting Officer makes that the contractor is performing its duty IAW the contract, the Engineer is responsible for the software, drawings and support the ES. Participation by all members is critical to successful fielding and Sustainment of ATE. The MAJCOMs provide valuable insight into the day to day functional test requirements. Every effort should be made to have them during the initial and all follow-on phases of acquisition and sustainment.
10. Are you familiar with DoD policy regarding the acquisition and development of common test equipment? (AFPD 63-2)
No I am not. I do know that we have a requirement to use existing equipment to cut down on proliferation of unique testers.
11. How does this DoD policy affect this equipment, if at all?
Not understanding this policy I am not sure how to answer this question.

12. Please add any additional information you feel would aid in answering Investigative Question #1.

Appendix K: Selected SPO Data for IQ 2

Investigative Question #2: How much funding is budgeted/funded in the Program Objective Memorandum (POM) and Future Year Defense Plan (FYDP) for your ATS program?

Sources of Data:

MAJCOM and SPO/depot financial managers
MAJCOM and SPO/depot subject matter experts
Budget reports
Budget Estimate Submissions (BES)

Supporting Questions:
(Please type answers directly below each question and use as much space as required)

1. Who is responsible for funding your related equipment?

- F-15 SPO: modifications, production, TCTOs, initial spares
- 3600 development and 3010 production money
- LEACC: handles funding for repairs and spares

2. Are there any funded/unfunded requirements for the equipment? Please explain.

- TTIP Wholly funded with 3600/3010 money through 2007
- Planning process for '08 POM
- Depot money:

	583	MSD Eng	MSD UUT	540	545	Repairs	Spares
FY01	$ 600,000.00	$ -	$ -	$ -	$ -	$ 3,120,000.00	$ 350,000.00
FY02	$ 600,000.00	$ -	$ -	$ -	$ -	$ 3,120,000.00	$ 350,000.00
FY03	$ 600,000.00	$ 1,030,000.00	$ -	$ -	$ -	$ 3,120,000.00	$ 350,000.00
FY04	$ 635,000.00	$ 1,030,000.00	$ -	$ -	$ -	$ 3,192,000.00	$ 723,000.00
FY05	$ 635,000.00	$ 3,550,000.00	$ -	$ -	$ -	$ 3,320,000.00	$ 370,000.00

These requirements were funded 100% and executed for all years except the MSD engineering dollars for FY05. Those funds are in limbo because program changes required a change in our original justification. The change generated a lot of questions and second-guessing by the funding command which we are currently addressing.

3. What equipment funding requirements were included in the last 2 POM cycles? Please include the associated BES input.

- TTIP inputs were first POM money received since 1991

- First tried in 2000, not even close - In 2002, didn’t miss the cut by much - Got it in ’04; one of only two F15 inputs to make the cut - TTIP received $41.6M from the 2004 POM; $36M for production and development contract, remaining funds dedicated to engineering support. - The $36M will be evenly distributed between 3010 production funds and 3600 development funds.
4. Do you get the funds needed to adequately support your equipment program? Please explain.
- Yes, right now - Important to plan well in advance - Preparation is key; used a case study with predicted impact to justify
5. Are your equipment POM inputs funded? If not, how far below the Air Staff/MAJCOM funding line did the requirements fall?
- Yes
6. Please add any additional information you feel would aid in answering Investigative Question #2.

Appendix L: Selected Depot Data for IQ 2

Investigative Question #2: How much funding is budgeted/funded in the Program Objective Memorandum (POM) and Future Year Defense Plan (FYDP) for your ATS program?

Sources of Data:

MAJCOM and SPO/depot financial managers
MAJCOM and SPO/depot subject matter experts
Budget reports
Budget Estimate Submissions (BES)

Supporting Questions:
(Please type answers directly below each question and use as much space as required)

1. Who is responsible for funding your related equipment?

540 – AFMC
MSD Engineering – AFMC
583 – ACC/ANG/AFRC

2. Are there any funded/unfunded requirements for the equipment? Please explain.

For MSD Engineering normally funded by approx 30% of actual requirement.
For 540 normally funded by approx 80% of actual requirement.
For 583 normally funded by approx 15% of actual requirement.

	583	MSD Eng	MSD UUT	540	545
FY01	$ -	$ 6,100,000.00	$ 9,400,000.00	$ -	$ -
FY02	$ -	$ 6,100,000.00	$ -	$ 118,000.00	$ -
FY03	$ -	$ 6,600,000.00	$ -	$ 1,600,000.00	$ -
FY04	$ 933,000.00	$ 4,200,000.00	$ -	$ 1,400,000.00	$ 463,000.00
FY05	$ 6,000,000.00	$ 14,000,000.00	$ 7,000,000.00	$ 2,000,000.00	$ 300,000.00

3. What equipment funding requirements were included in the last 2 POM cycles? Please include the associated BES input.

None.

4. Do you get the funds needed to adequately support your equipment program? Please explain.

Inadequate funding to properly support ATS and EARTS. Need funds to completely replace the whole system with state of the art technology to ensure the user's mission capability will not be degraded. Until this happens the operational capability of the AIS is in jeopardy of being compromised and eventual grounding of aircraft will occur.
5. Are your equipment POM inputs funded? If not, how far below the Air Staff/MAJCOM funding line did the requirements fall?
I don't think MSD Engineering has a POM. I think it is just available annually. Put down MSD Engineering $5M/yr is usually issued. I asked for about $18M each year and they approve about $5M. I am not sure if 540 (Software Funds) has a POM. I normally get about $1M and ask for about $1.5M.
6. Please add any additional information you feel would aid in answering Investigative Question #2.

Appendix M: Selected SPO Data for IQ 3

Investigative Question #3: What are ATE SPO, depot, and MAJCOM assessments of ATE/ATS sustainability for the two programs?

Sources of Data:

MAJCOM Staff
SPO/depot program managers
SPO/depot equipment specialists

Supporting Questions:

(Please type answers directly below each question and use as much space as required)

1. What specific sustainability issues (e.g. hardware, components) does this equipment have?
- ELGAR - Freq Synthesizer: COTS with unique mods, limited number, contractor unable to support past '08.
2. Is there an action plan to address these issues? Please explain.
- Yes, TTIP looking for suitable sub/development work - Plan developed by internal IPT - IPT is key to address these issues
3. Are these issues solvable? If not, why? What roadblocks, if any, are hindrances to reaching a solution?
- Yes - No concerns **assuming** expected approval for funding in '08 POM - Optimistic about support from ACC
4. Are there timelines for reaching a solution? Please explain.
- The SPO received funding to procure 18 of the new Elgar P/Ss to use in workaround packages to support the Field until the TTIP upgrade. These WA (-2181) packages became available in Aug 04
5. When did these issues first arise?
6. How urgent of a priority are these issues?
7. Please add any additional information you feel would aid in answering Investigative

Question #3.
- *MANUFACTURER NAME MASKED* has core group of engineers since day 1 of TISS program – continuity very valuable - Perform "maintenance assistance visits" to aid field performance
8. Please e-mail completed questionnaire to jeremy.howe@afit.edu. Thank you for your assistance.

Appendix N: Selected Depot Data for IQ 3

Investigative Question #3: What are ATE SPO, depot, and MAJCOM assessments of ATE/ATS sustainability for the two programs?

Sources of Data:

MAJCOM Staff
SPO/depot program managers
SPO/depot equipment specialists

Supporting Questions:
(Please type answers directly below each question and use as much space as required)

1. What specific sustainability issues (e.g. hardware, components) does this equipment have?

Operational capability approaching 50% level. (*multiple respondents indicated)*

System Health is Poor

Modified once (1985) since initial fielding in the 70s
Over 18 years has transpired without any improvements

Critical TRUs impacting system now

Digital Multimeter (DMM)
RMS VOLTMETER
HF COUNTER
Oscilloscope
Spectrum Analyzer
X/L – Band Signal Generator
Impedance Unit #1 & # 2

TRUs are unique & unsupportable

Limited or no repair sources exist
Component level parts are non-procurable or repairable
Limited or no spares in the inventory
50% below spares authorizations

Reference F-15 ATS Slideshow included – *AUTHOR NAME MASKED.*

2. Is there an action plan to address these issues? Please explain.
Annual requests for funding in the 583, MSD Engineering, and 540 budget cycles. Partial funding is band aiding this system.
3. Are these issues solvable? If not, why? What roadblocks, if any, are hindrances to reaching a solution?
Yes with adequate funding.
4. Are there timelines for reaching a solution? Please explain.
Projected grounding of F-15s in FY07.
5. When did these issues first arise?
Ongoing for last 10-15 years. We have been continually requesting funds to replace the ATS and later on the EARTS since they are not being replaced by ESTS. *(multiple respondents indicated)*
6. How urgent of a priority are these issues?
Critical. Scenario I Grounding will occur through normal Obsolescence in CY07 Scenario II If any critical TRU fails the following will occur Lateral support between I-level will be required A/C start grounding within 7- 9 months (or sooner) once Spares are exhausted or when unit is unable to compete with local/lateral demand Reference F-15 ATS Slideshow included – *AUTHOR NAME MASKED*.
7. Please add any additional information you feel would aid in answering Investigative Question #3.
8. Please e-mail completed questionnaire to jeremy.howe@afit.edu. Thank you for your assistance.

Appendix O: Selected MAJCOM Data for IQ 3

Investigative Question #3: What are ATE SPO, depot, and MAJCOM assessments of ATE/ATS sustainability for the two programs?

Sources of Data:

MAJCOM Staff
SPO/depot program managers
SPO/depot equipment specialists

Supporting Questions:
(Please type answers directly below each question and use as much space as required)

1. What specific sustainability issues (e.g. hardware, components) does this equipment have?
Primarily, the equipment is plagued with obsolescence and diminishing manufacturing sources or DMS.
2. Is there an action plan to address these issues? Please explain.
Yes. The SPO and Warner Robins address obsolescence via sustaining engineering methods whereby they evaluate each Test Replaceable Unit (TRU) on the test stations as well as internal components. After evaluation, the engineers attempt to resolve issues via Form, Fit, and Function replacements and or seek new vendors to supply components.
3. Are these issues solvable? If not, why? What roadblocks, if any, are hindrances to reaching a solution?
These issues are solvable. However, the primary roadblock in a timely resolution is funding.
4. Are there timelines for reaching a solution? Please explain.
Timelines are established, but they are based on several factors: degree of obsolescence; availability of repair sources; logistical impacts.
5. When did these issues first arise?
Obsolescence is a normal occurrence and usually impacts the weapon system (were replacements are necessary) within 7-10 years.
6. How urgent of a priority are these issues?
Depending upon the impact to weapon system availability, the priority can be urgent but

normally, if managed correctly, is routine. *Researcher Follow-up clarification regarding "managed correctly*": From a sustainment perspective, Program Management and Engineer should predict, forecast, and continually monitory the health of their system/program to ensure obsolescence issues can be addressed in a timely manor. Otherwise implementation of fixes becomes more costly and is usually late to need therefore becoming urgent in nature.
7. Please add any additional information you feel would aid in answering Investigative Question #3.

Appendix P: Selected MAJCOM Data for IQ 4

Investigative Question #4: What are MAJCOM assessments of field units' abilities to support assigned equipment with resources provided by SPO/depot?

Sources of Data:

MAJCOM subject matter experts
Memorandums documenting ATE/ATS problems
REMIS data

Supporting Questions:
(Please type answers directly below each question and use as much space as required)

1. Do units get the parts they need to support their assigned equipment? Please explain.
Yes
2. Do units get the replacement parts in a timely fashion? Please explain.
Yes, unless there is unforeseen supply/transportation issues.
3. How often do technicians have to rely on technical procedures (at the direction of the SPO) not provided in established TO procedures? Who proposed the solution (field, MAJCOM, or SPO/depot)? Please explain.
Very seldom does the backshop require TO direction from the SPO. If needed, the SPO, depot, and MAJCOM determine solution based on engineering analysis/direction.
4. Are TOs of good quality? Please explain.
Yes, but that depends on the unit's ability to maintain proper upkeep.
5. Are TCTOs of good quality? Please explain.
Normally, yes. But there needs a high level of coordination between MAJCOM, SPO, and depot to ensure accuracy.
6. Do units receive adequate SPO troubleshooting support when formal technical data is exhausted? Please explain.
Yes. Telephonic support is established for all major systems (TISS, ANT/EARTS, and ESTS). For TISS, the technicians can call *MANUFACTURER NAME MASKED* vfr direct, for ANT they can call depot and for ESTS they can call *MANUFACTURER NAME MASKED.*

7. Are there relatively more, fewer, or about the same number of MICAPs as in the past? Please explain.
They are probably more MICAPs due to increased Ops TEMPO and due to aging weapon systems.
8. Are backorders longer than 30 days common? Give examples of recurring problems.
If you're referring to LRUs, usually we can get replacements well under 30 days. However, for station parts its 120 days for older weapon systems.
9. Please add any additional information you feel would aid in answering Investigative Question #4.

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Vita

Captain Jeremy A. Howe was born in Valparaiso, Indiana. Upon graduating from Chesterton High School in 1995, he entered into undergraduate study at the University of Notre Dame, where he earned a Bachelor of Architecture degree. Upon graduation in May, 2000, he was commissioned into the United States Air Force through the Reserve Officer Training Corps program.

During his first assignment, he served as Maintenance Supervisor for the 2d Support Squadron at Fairchild AFB, Washington. He was named the squadron's company grade officer of the year for 2002, a year which culminated in the squadron successfully completing the short-notice testing, upload and forward deployment of 88 Conventional Air Launched Cruise Missiles for use during Operation Iraqi Freedom.

In August 2003, he entered graduate study under the auspices of the Logistics Management program at the Air Force Institute of Technology. Upon graduation, he will be assigned to the Maintenance and Munitions Analysis Division at the Air Force Logistics Management Agency, Maxwell AFB Gunter Annex, Alabama.

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14. ABSTRACT The management of United States Air Force ATS/E presents a variety of issues that affect the long-term capability and mission readiness of weapon systems. Traditional procurement processes suggest that individual aircraft platform System Program Offices (SPOs) developed, improved and replaced ATE on an "as-required" basis. Increased obsolescence, however, and a concern for maintaining longer-term viability provided the necessary inertia for a movement towards the procurement and development of consolidated, common test equipment that would support multiple weapon systems. In 1998, the Air Force Chief of Staff directed HQ AFMC to establish a Common Support Equipment office to facilitate the combination of similar legacy ATE into common equipment. Today, some ATE continues to be managed by individual SPOs, while other ATE is primarily managed by the Automated Test Systems Division at Warner-Robins Air Logistics Center. This research examines the differences of these two approaches. Specifically, this research focuses on the management of two pieces of ATE for a mature aircraft system – the F-15.

15. SUBJECT TERMS
F-15, Automatic Test Equipment, ATE, Automatic Test Systems, ATS, ATS/E, Tactical Electronic Warfare System Intermediate Service Station, TISS, Avionics Intermediate Shop, AIS, Common Test Equipment

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