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Comparing Management Approaches for Automatic Test Systems: A Strategic Missile Case Study

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COMPARING MANAGEMENT APPROACHES FOR AUTOMATIC TEST SYSTEMS: A STRATEGIC MISSILE CASE STUDY

THESIS

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Abstract

From 1980 to 1992, the DoD spent over $50 billion acquiring Automatic Test Systems (ATS) used to test weapon systems. At that time, procuring unique ATS to support single weapon systems was the norm. In 1994, the DoD made a dramatic change to their ATS acquisition policy; common ATS that supported multiple weapon systems was preferred over ATS tailored to support a single weapon system. Expected benefits of this new policy included: more reliable equipment, increased supportability, decreased cost, smaller logistics footprint, and decreased manning. To date, the common ATS initiative has garnered little support AF-wide due to lack of substantive data supporting the expected benefits in a practical setting. Although this common ATS policy has been in place for more than 10 years, the majority of the ATS procured in the 1980-1992 "bubble" is still in service but is facing severe aging and obsolescence issues.

The purpose of this research was to compare two ATS programs selected because of their numerous similarities, with their singular difference being whether the equipment was managed as common core (Cruise Missile ATS) or managed as part of the weapon system (ICBM ATS). This research seeks to satisfy two goals. The first goal of this case study was to determine if the expected benefits of common ATS are being realized in a practical setting. Second, if the expected benefits are not being met, the common ATS hindrances should be understood so Air Staff and Air Force Materiel Command senior leaders can correct the process of procuring common ATS.

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To the Devoted Maintainers in My Corner of the Air Force

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COMPARING MANAGEMENT APPROACHES FOR AUTOMATIC TEST SYSTEMS: A STRATEGIC MISSILE CASE STUDY

I. Introduction

Overview

The Department of Defense (DoD) and the uniformed services face growing concerns regarding aging and obsolete Automatic Test Systems (ATS) acquired in the 1970s and 1980s. During this period, the US military procured large amounts of ATS to support platforms that remain in service today—well beyond the platforms' expected life-cycles. The Defense Department spent over $50 billion acquiring ATS from 1980 through 1992, and the vast majority of these procurements were testers designed to support specific weapon systems (Ross, 2003:2). Over the years, several sources have criticized the continued proliferation of weapon system specific ATS and highlighted the need to adopt a procurement strategy of acquiring ATS that supports multiple weapon systems, otherwise known as common ATS (US GAO, 2003:1-4; MacAulay Brown Inc., 2002:4; Greening, 1999b:4-6).

In 1994, the DoD announced a new ATS procurement policy requiring the minimization of unique types of ATS in field, depot, and manufacturing operations (PMA-260, 1997:1). The objective of this new DoD ATS policy was to minimize unique types of ATS in DoD, thereby reducing redundant, non-recurring ATS investments and lessening logistics burdens and long-term costs (Greening, 1999b:6). To implement this policy, the DoD selected the US Navy as the Executive Agent for ATS. As Executive

Agent, the Navy is responsible for developing strategic roadmaps to achieve commonality amongst DoD ATS and to ensure conformity with DoD mandates (OSD (AT&L), 2004). In 2003, the United States General Accounting Office investigated DoD compliance with mandates to develop common ATS and found a lack of conformity to requirements DoD-wide, but most egregiously in the Air Force. Their findings uncovered a lack of guidance mandating compliance and a lack of support and funding to enable either the Executive Agent or the Air Force ATS Division to control ATS development. Historically, the Air Force has not had a service-level ATS standardization policy and has continued to procure and manage weapon system unique ATS as part of the parent weapon system (US GAO, 2003:8).

The immediate problem of how to properly address aging ATS issues has two extremes. Each System Program Office could continue to support or procure their weapon system specific ATS, or the Air Force could embrace the common tester philosophy to support multiple platforms (MacAulay Brown Inc., 2002:1). Many sources document the approach of unique ATS as being wasteful because multiple weapon systems will require similar, if not identical, ATS to replace the obsolete equipment (US GAO, 2003:15; MacAulay Brown Inc., 2002:1; Greening, 1999b:6-7). The benefits of economies of scale will be lost and redundant procurements will waste valuable resources. On the other hand, procuring common ATS significantly complicates otherwise independent programs and further complicates schedules and requirements. Past and current procurement policies require funding to flow through individual program offices whose concern is paying more than their fair share to purchase common ATS. Unique ATS is easy to implement but inefficient; in contrast, common ATS is more difficult to implement but offers efficiencies in acquisition, logistics, and sustainment. To better understand the impacts of ATS management strategy, this research is designed to thoroughly compare two similar systems that are managed at the extreme opposites mentioned above—unique versus common ATS.

Problem Statement

To date, the common ATS initiative has garnered little support AF-wide due to lack of substantive data supporting the expected benefits which include: more reliable equipment, increased supportability, decreased cost, smaller logistics footprint, and decreased manning. Decision makers at AF/ILM need to know specific costs, benefits, and potential pitfalls to fully understand the implications of allowing System Program Offices to continue entire weapon system ownership vice consolidating similar legacy ATS into a common core tester. The purpose of this research was to compare two similar ATS systems, one currently managed as common core ATS (cruise missile ATS, managed at Warner Robins-Air Logistics Center) and the other managed as part of the weapon system (Minuteman III ATS, Ogden-Air Logistics Center), to better understand the influential factors impacting currently fielded ATS.

Research Question

Is strategic missile ATS more sustainable/supportable and efficient when managed as common core ATS or when managed as part of the supported weapon system?

Investigative Questions

1. What are the ATS management differences between common core and weapon system unique System Program Office approaches?

    This investigative question focused on ATS program management and how or if their decisions impact the sustainability and supportability plans for the ATS they manage.

2. How much funding is budgeted/funded in the Program Objective Memorandum and Future Year Defense Plan for both ATS programs being studied?

    This investigative question sought to better understand the efficiency component of the research question and to facilitate financial requirement comparisons between the two ATS programs.

3. What are ATS System Program Office, Depot, and Major Command assessments of long-term ATS sustainability for both programs being studied?

    The goal of this investigative question was to clarify current and future sustainability issues facing each ATS program so they could be compared.

4. For both ATS programs being studied, what are Major Command assessments of their field units' ability to support their assigned support equipment with the available ATS resources and System Program Office support?

    This investigative question sought the users' perspective on how well their System Program Office/Depot supported field unit needs regarding their assigned ATS. These assessments enabled supportability comparisons between the two programs.

Scope and Limitations of Research

With a focus on ATS program management, this research was designed to thoroughly analyze two sets of similar ATS supporting mature Air Force weapon systems, ICBM and Cruise Missile ATS. Because this research was limited to the Air Force, the results may not be applicable to other military service branches that are not required to follow AF guidance and instructions. In addition, mature weapon systems were selected for this research. Over the last 10 years, Congressional, DoD, and Air Force guidance have evolved pertaining to ATS, particularly for new procurements of weapon systems. For this reason, results of this research may have limited applicability to new system procurements. A final limitation of this research is that only two sets of ATS were included in this study. Consequently, generalizing all facets of this research to the rest of the ATS in the Air Force inventory may be premature. Future research following this research's methodology would strengthen applicability and any generalizations made by this study. A mitigating factor for this research is a parallel study conducted by Captain Jeremy Howe, entitled *Evaluating Management Strategies for Automated Test Equipment (ATE): An F-15 Case Study*. Both case studies compare two similar ATS systems with the major programmatic difference being management approach (common vs. weapon system specific).

The purpose of limiting this research to Cruise Missile and ICBM ATS is that they are both very similar but with one significant difference, program management approach. Similarities include: nuclear certification requirements, operational requirements, operating environment, maintenance concept, the same career field of personnel maintains both sets of ATS, and both support high readiness rate weapon systems. The uncommon similarity of these two sets of ATS, paired with their opposite management approaches (unique vs. common core ATS), allowed an opportunity to thoroughly examine how the independent variable (management approach) impacted the dependent variable (supportability/efficiency of ATS). Correlations discovered in this research can provide future researchers with a solid baseline to study less similar ATS. Also, practitioners will undoubtedly relate to portions of this research and can apply the efforts of this research to improve future Air Force ATS initiatives.

Methodology

The researcher selected a case study strategy for the research design. The research was completed in two phases. The goal of the first phase was to build a foundation for the research comparing Cruise Missile and ICBM ATS management approaches. Unstructured interviews were used to collect archival data pertaining to programmatic decisions and to identify potential interviewees for the second phase. In the second phase, the researcher conducted formal telephone interviews. Results from unstructured interviews, documents, archival records, and questionnaire responses were reviewed to identify patterns and to uncover underlying themes. Conclusions regarding the impact of opposite management approaches on sustainment/supportability and efficiency were then drawn.

Summary

The purpose of this chapter was to introduce the research contained in this case study. It began by providing an overview of the aging ATS problem facing the DoD and the two management approaches used within the defense acquisition community to address this problem. Next, the chapter presented a problem statement whereby the fundamental research and supporting investigative questions were derived to guide the study. In addition, the scope of the research was delimited and research subject characteristics were compared to illustrate unique commonality. Lastly, the methodology and the specific strategy used to guide the data collection and analysis were described.

II. Literature Review

Overview

The purpose of this chapter is to identify the literature reviewed while preparing to conduct this study. First, Automatic Test Systems are rigidly defined in the military environment so its meaning will be developed, and a basic description of Cruise Missile and ICBM ATS will follow. Because Cruise Missile ATS is managed as common ATS and ICBM ATS is managed as part of the supported weapon system, basic understandings of both approaches are covered. The evolution of DoD ATS policy is then followed by the current military ATS guidance which implements the policy. Next, a recent US General Accounting Office report is summarized which evaluates the DoD's adherence to its own ATS policy. Last, differences between commercial and DoD ATS and two endemic problems facing military ATS will be briefly discussed.

Automatic Test System Defined

Automatic Test Systems have evolved considerably over the years but their function remains the same. ATS is used to identify and isolate failed components, to facilitate component adjustments back into specifications, and to assure a system or component is ready for use (Greening, 1999a:9; OSD (AT&L), 2004a; Fletcher, 1998:7). In the early days of electronics maintenance, technicians routinely troubleshot and repaired electronic systems with analog volt-ohm meters to measure circuit outputs, oscilloscopes to compare frequency parameters, and soldering irons to replace components (OSD (AT&L), 2004a). Today, electronics are very complex and have many different failure modes than earlier systems. Single-layer circuit boards with solid state components like transistors, resistors, capacitors and diodes have been replaced by multi-layer boards which are densely packed with high-speed digital components and minimal solid state components (OSD (AT&L), 2004a). In short, automatic testing is required due to the complexity of modern electronics; manually testing all components and circuit paths in typical modern systems is virtually impossible.

The DoD defines an Automatic Test System as a "fully-integrated, computer-controlled suite of electronic test equipment hardware, software, documentation, and ancillary items designed to verify the functionality of Unit-Under-Test assemblies (PMA-260, 1997:2)." Air Force guidance further describes ATS as "equipment designed to conduct analysis of functional or static parameters automatically and to evaluate the degree of Unit-Under-Test performance degradation (SAF/AQK, 1994a:1)." They may also be used to isolate Unit-Under-Test faults. The decision making, control, or evaluative functions are usually done under computer control with minimum reliance on human intervention (SAF/AQK, 1994a:1).

Several DoD and Air Force sources indicate Automatic Test Systems are comprised of three major components: automatic test equipment, test program sets, and test program set software development tools (Fletcher, 1998:7; PMA-260, 1997:2; OSD (AT&L), 2004a; Greening, 1999a:9; SAF/AQK, 1994a:1). Figure 1 provides a visual understanding of these ATS components.

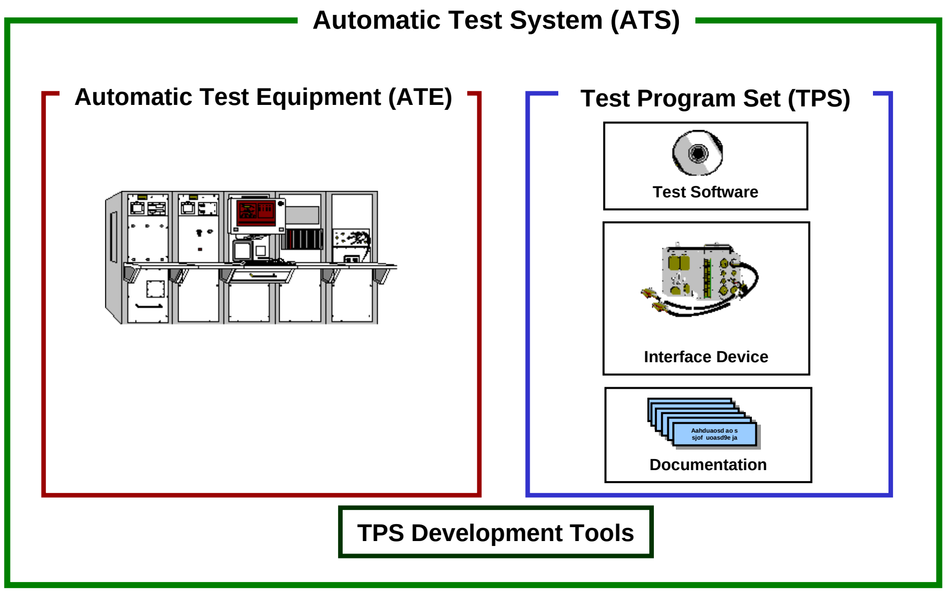


Figure 1. Major ATS Components (Fletcher, 1998:7)

Automatic Test Equipment.

Automatic Test Equipment (ATE) primarily consists of the test hardware and the operating software used to perform self-tests, calibrations, and other ancillary tasks associated with the test hardware (OSD (AT&L), 2004a). The hardware can be as small as a laptop computer or as large as multiple electronic racks weighing thousands of pounds. It can also be designed for ease of mobility to operate in austere conditions or can operate at fixed locations in a rigid lab environment (Fletcher, 1998:7-8). The computer is the heart of the Automatic Test Equipment which controls test instruments like digital voltmeters, signal generators, and switching assemblies (OSD (AT&L), 2004a). Automatic Test Equipment is very flexible in its ability to test various system levels; typically, Automatic Test Equipment can be configured to test an entire system, a system's Line Replaceable Units, or the Shop Replaceable Units (Fletcher, 1998:8-9). For example, an electronic box that can be removed as a single component from a system is a Line Replaceable Unit, and each circuit card or subcomponent that is removable and replaceable within that electronic box is considered a Shop Replaceable Unit.

Test Program Set.

The Test Program Set (TPS) includes testing software, interface devices, cables, and documentation (Fletcher, 1998:8). The Automatic Test Equipment operates under the control of test software, not to be confused with operating software, to provide stimulus to the Unit-Under-Test and to also provide a means of measuring the numerous outputs of the Unit-Under-Test (OSD (AT&L), 2004a). When signals are measured outside of allowable tolerances, the test software analyzes the results and recommends the probable cause to the technician for repair or replacement. Test software is usually written in standard languages like ATLAS, C, or Ada (Fletcher, 1998:8).

Units-Under-Test can be designed and built with countless configurations of connections and input/output ports. Automatic Test Equipment is physically connected to a Unit-Under-Test via Interface Devices which routes input/output signals from the Unit-Under-Test to the appropriate input/output connections on the Automatic Test Equipment (OSD (AT&L), 2004a). Interface Devices are typically holding fixtures and test cables designed for use with specific test software (Fletcher, 1998:8). Test equipment designers attempt to maximize the capability inherent in the Automatic Test Equipment itself so that Interface Devices remain passive and only serve to route signals to and from the Unit-Under-Test (Fletcher, 1998:8-9).

Test Program Set Development Tools.

The Test Program Set development tools are required to develop the test software and Interface Devices. These include Automatic Test Equipment and Unit-Under-Test simulators, Automatic Test Equipment and Unit-Under-Test description languages, and programming tools such as compilers (OSD (AT&L), 2004a).

Cruise Missile ATS

Purpose.

Cruise Missile ATS is designed to test and diagnose missiles and their associated Carrier Aircraft Equipment used to launch missiles (532 TRS, 1997a). The AGM-86B Air Launched Cruise Missile, AGM-86C/D Conventional Air Launched Cruise Missile, and AGM-129 Advanced Cruise Missile systems are all tested with this ATS. The AGM-69A Short Range Attack Missile was also tested with this ATS until it was removed from Air Force inventory in the early 1990s (AES and UDRI, 2004:5.1-1). This same ATS is used to test and troubleshoot B-52 Common Strategic Rotary Launchers, B-52 Pylons, and B-2 Rotary Launcher Assemblies (532 TRS, 1997a). This equipment was also used to support B-1B 180-inch Launchers until the B-1 transitioned from a nuclear bomber to a conventional bomber in the 1990s (AES and UDRI, 2004:5.1-1). A large portion of these systems' Line Replaceable and Shop Replaceable Units are supported by this equipment as well (AES and UDRI, 2004:5.1-1 thru 4; 532 TRS, 1997a).

System Description.

The major portion of Cruise Missile ATS consists of several pieces of Automatic Test Equipment to include: the Electronic Systems Test Set, the Remote Switching Control Assembly, the Air Data Test Set, and the Missile Radar Altimeter Test Assembly (AES and UDRI, 2004:5.1-3; Smith, 2004). This test equipment was designed and built primarily by Boeing in the mid-1970s and delivery was completed in the mid-1980s

(AES and UDRI, 2004:5.1-3). Although the Automatic Test Equipment is managed by Warner Robins' ATS Division, the dozens of Unit-Under-Test test adapters, cable sets, and test software are managed by their respective weapon system program office and are not considered common because they only support one weapon system or a small portion of a weapon system.

Electronic Systems Test Set.

The components that make up the GSM-263 Electronic Systems Test Set (ESTS) include: a 3-bay main rack, a Unit-Under-Test power control rack, a Cathode Ray Tube display station, and a line printer (WR-ALC/LEA, 2002:4-1). See Figure 2 below.

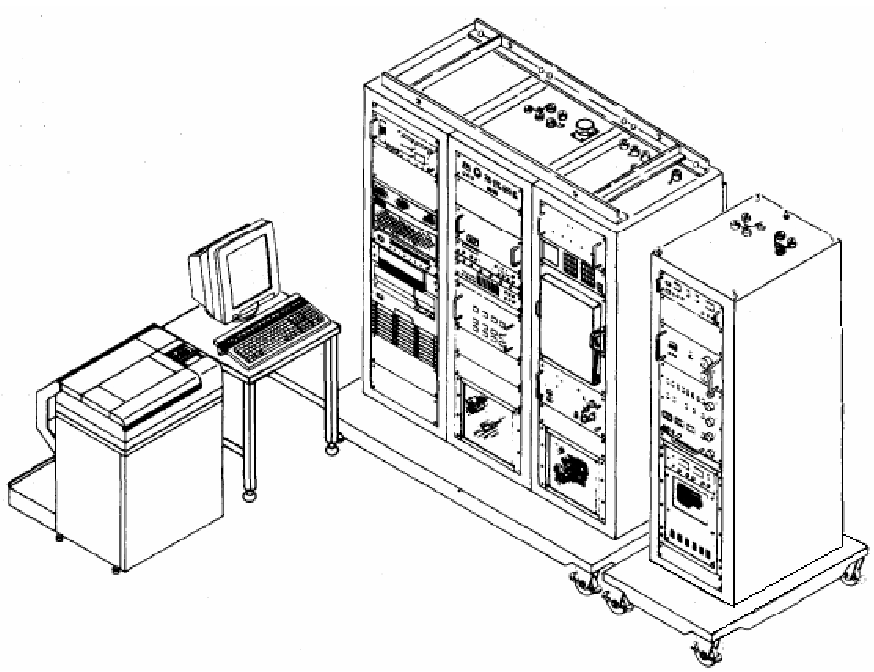


Figure 2. Electronic Systems Test Set (AES and UDRI, 2004:5.1-1)

The Electronic Systems Test Set operates under automated computer control to provide power, stimulus, switching, monitoring, and measuring of test signal flow to the Unit-Under-Test. The main Electronic Systems Test Set rack is a 3-bay configuration that contains equipment drawers providing most of these functions (WR-ALC/LEA, 2002:4-1). The Unit-Under-Test Power Control Rack provides power to the Unit-Under-Test (WR-ALC/LEA, 2002:4-1). The line printer and display terminal provide the means for operators to communicate with the system (WR-ALC/LEA, 2002:4-1). The Electronic Systems Test Set is a self-contained system which provides its own cooling, control, and power distribution (WR-ALC/LEA, 2002:4-1). The testing of a Unit-Under-Test is accomplished by using patch boards and test software provided by the specific Unit-Under-Test Test Program Set. The patch boards attach to the Electronic Systems Test Set main rack patch board receiver located in the third bay. The software is in the form of removable disks which are inserted into the main rack's disk drive located in the first bay (WR-ALC/LEA, 2002:4-1).

Five different Electronic Systems Test Set models exist (532 TRS, 1997b). The first version was the Model GSM-263 and was designed to support the AGM-69A, AGM-86B, and B-52 pylons. Most of these early models were modified into Model GSM-263A which added the capability to support B-1 180-inch Launcher testing (AES and UDRI, 2004:5.1-1). Model GSM-263Gs allow communication between the Electronic Systems Test Set and Remote Switching Control Assembly required to test the AGM-129. They are also used to test B-52 Common Strategic Rotary Launchers (AES and UDRI, 2004:5.1-1). Model GSM-263Fs has the modification required for AGM-129 testing but not B-52 Common Strategic Rotary Launcher testing (AES and UDRI, 2004:5.1-1). Model GSM-263C was developed with more advanced computer and data storage hardware and is used to test the B-2A Rotary Launcher Assembly and its associated Line Replaceable Units (532 TRS, 1997b). There are 54 Electronic Systems

Test Sets in operation (this number does not include the approximately 30 in depot storage) (Smith, 2004). See Tables 1 and 2 below.

Table 1. Location/Quantity/Model of Electronic System Test Set Field Test Locations

Base	Quantity/Model
Andersen AFB	3A
Barksdale AFB	10G
Fairchild AFB	1 (263), 1A, 3G
Minot AFB	4G
Whiteman AFB	5C
Hill AFB	1A, 2G
Total	**30**

(AES and UDRI, 2004:5.1-8)

Table 2. Location/Quantity/Model of Electronic System Test Set Training, Test, Repair, and System Integration Lab Test Stations

Base	Quantity/Model
Vandenberg AFB	2 (263), 1A, 2G, 1C
Tinker AFB	1 (263), 2C, 3G, 1F
Boeing	3A
Raytheon	3G
Edwards	2A, 2C
Robins	1A
Total	**24**

(AES and UDRI, 2004:5.1-8)

Remote Switching Control Assembly.

The Remote Switching Control Assembly (RSCA) operates under software control from the Electronic System Test Set, F or G model, and is needed for guidance and pyrotechnic testing on the AGM-129 (AES and UDRI, 2004:5.1-3). Limited numbers of Remote Switching Control Assemblies exist and are only located at AGM-129 sites and a few test locations (Smith, 2004). See Figure 3 below.

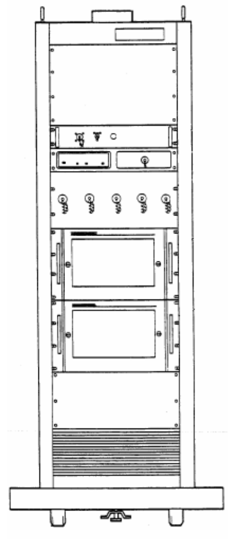


Figure 3. Remote Switching Control Assembly (AES and UDRI, 2004:5.1-3)

Air Data Test Set.

The Air Data Test Set (ADTS) simulates pitot and static pressures associated with AGM-129, AGM-86B, and AGM-86 C/D missiles in flight (532 TRS, 1997b). The major component within the Air Data Test Set is the Air Data Test Controller, ADT-222B, which allows remote operation from the Electronic System Test Set (AES and UDRI, 2004:5.3-13). 18 Air Data Test Sets are located at field units (Smith, 2004). See Figure 4 below.

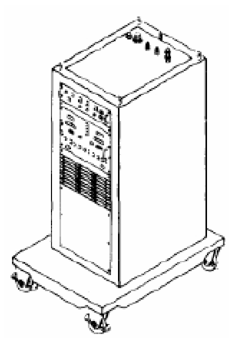


Figure 4. Air Data Test Set (AES and UDRI, 2004:5.1-1)

Missile Radar Altimeter Test Assembly.

The Missile Radar Altimeter Test Assembly (MRATA) is used in conjunction with the Electronic Systems Test Set to test the radar altimeters in AGM-86 C/D and AGM-129 missiles (AES and UDRI, 2004:5.2-1). Three Missile Radar Altimeter Test Assembly models exist, but 2 are virtually identical; the third model is slightly different and is used exclusively with the AGM-129 (AES and UDRI, 2004:5.2-6). 76 Missile Radar Altimeter Test Assemblies of differing versions are located at nine locations (AES and UDRI, 2004:5.2-8). See Figure 5 below.

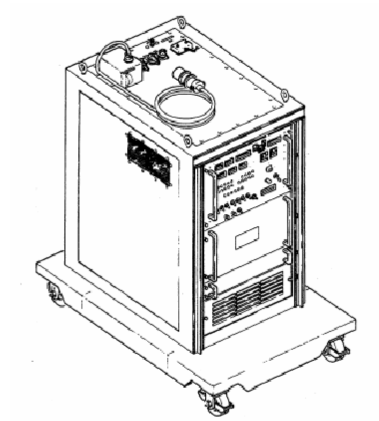


Figure 5. Missile Radar Altimeter Test Assembly (AES and UDRI, 2004:5.2-1)

ICBM ATS

Purpose.

ICBM ATS was designed to be operated by Electronics Lab (E-Lab) technicians located at operational missile wings and test locations. Electronics Lab technicians use this equipment to test and troubleshoot components of the Minuteman and Peacekeeper weapon systems (532 TRS, 2004:420). Units-Under-Test include individual missile components as well as a number of drawers installed in the Lower Equipment Room of Launch Facilities (missile locations) and in the capsules of Missile Alert Facilities (alert crew locations). Faulty components and drawers are removed from Launch Facilities and Missile Alert Facilities, returned to base, and Electronic Lab technicians test, isolate, and repair the faults. Only three operational wings, one test/training location, and the depot have this ATS: Malmstrom AFB, F.E. Warren AFB, Minot AFB, Vandenberg AFB, and Hill AFB, respectively.

System Description.

This ATS consists of: the Electronic Equipment Test Station, AN/GSM–315, commonly called the E-35; the Electronic Equipment Bench Test Group, QQ–364/GSM–315, commonly called the Mobile Work Surface; a Video Display Subsystem; three Interface Test Adapters; and a line printer (532 TRS, 2004:420). A fixed disk installed in the Electronic Equipment Test Station, as well as removable tape cartridges, contains each Unit-Under-Test's operating program. The fixed disc contains instructions for the computer to configure each test instrument in the ATS for testing components of the Unit-Under-Test (532 TRS, 1994).

Electronic Equipment Test Station.

The Electronic Equipment Test Station (E-35) has eight bays of equipment with three functional groups: computer group, power and switching group, and the instrumentation group (OO-ALC/LMES, 2004:1-4). Parallel bi-directional busses are used to route data to and from the three functional groups. The computer receives stored data from the peripherals, processes the stored data and outputs control data to the power and switching group and instrumentation group (532 TRS, 2004:420).

The instrumentation group receives the data needed to generate stimuli for testing a Unit-Under-Test (532 TRS, 2004:420). Once the stimuli signals are generated, selected paths in the power and switching group send the signals to the Unit-Under-Test via the Interface Test Adapter. Simultaneously, data transfers from the computer group on the bus to the power and switching group. In turn, the power and switching group uses this data to provide power to the Unit-Under-Test via the Interface Test Adapter (532 TRS, 2004:420).

When the power and stimuli signals energize and exercise the Unit-Under-Test, response signals return from the Unit-Under-Test through selected paths of the power and switching group or via direct connections to the instrumentation group (532 TRS, 2004:420). The instrumentation group interprets the response and performs measurements which are routed to the computer group via the address and data bus for display or printout. See Electronic Equipment Test Station in Figure 6 below.

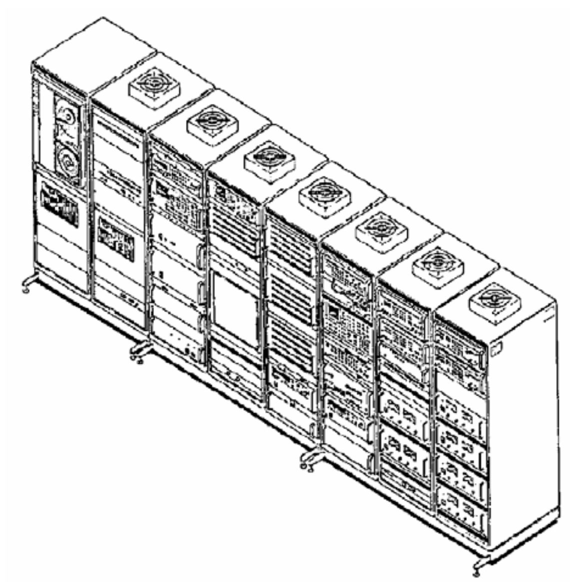


Figure 6. Electronic Equipment Test Station (OO-ALC/LMES, 2004:1-18)

Mobile Work Surface.

The Mobile Work Surface (MWS), formally named the Electronic Equipment Bench, provides a working platform for Units-Under-Test as well as storage space for test equipment not in the original design of the Electronic Equipment Test Station (532 TRS, 1994:5-6). See Figure 7 below.

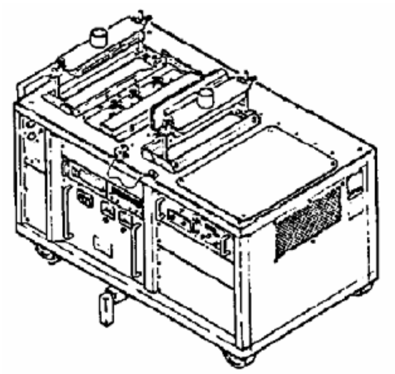


Figure 7. Mobile Work Station (OO-ALC/LMES, 2004:1-18)

Associated Equipment.

Three Interface Test Adapters, two for self test and one for calibration, are included in the ATS because they're not associated with Units-Under-Test. The Video Display Subsystem consists of a video display unit, keyboard, processor, and dual 3.5-inch floppy disc drives (OO-ALC/LMES, 2004:1-16). See Figure 8 below.

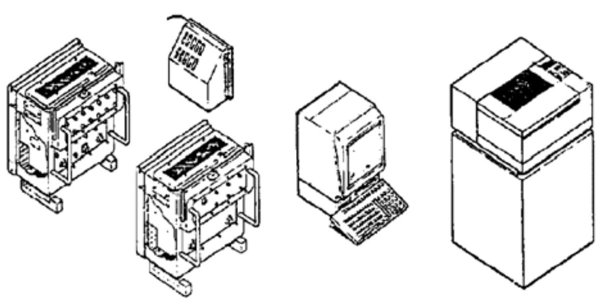


Figure 8. Interface Test Adapters, Video Display Unit, and Printer (OO-ALC/LMES, 2004:1-18)

ATS Program Management Approaches

As early as the 1960s and through the early 1990s, System Program Offices only had one option for ATS development, to develop stovepipe ATS that supported a specific weapon system (Wynne, 2004b:1). The weapon system program manager also had the responsibility to develop, in parallel, the ATS necessary to support their systems. Over the last 10 years, the DoD and their ATS Executive Agent have written considerable guidance to consolidate ATS development and limit unique ATS development (DoD, 1996; Fletcher, 1998; Greening, 1999a, 1999b, 1999c; Wynne, 2004a; VandenBerg, 2004). The DoD's objective is to pull ATS development away from the weapon system program manager and allow a separate program manager, outside the weapon system program office, to integrate the new weapon system into an existing family of ATS (Wynne, 2004a).

Weapon System Specific ATS Management.

Under the weapons system specific approach, each System Program Office supports, improves, and replaces the ATS for its system independently of other programs (Wynne, 2004b). This management ideology is easy to implement but may be inefficient. This approach appears to be wasteful of resources, since multiple weapon systems will confront similar challenges, and the resulting upgrade, sustainment, and replacement programs will thereby inevitably end up funding similar, if not identical technologies (MacAulay Brown, 2002:1-2). Multiple ATS types also complicate logistics and sustainment for deployed forces because of the increased footprint size. The ICBM ATS in this study is categorized as weapon system specific.

Common ATS Management.

Under the common ATS management approach, program management is consolidated and the service components pursue common ATS to support multiple platforms (Wynne, 2004b). Common ATS is very difficult to implement since individual System Program Offices must adjust their schedules and requirements to accommodate the needs of several users; in turn, it significantly complicates the contractor's responsibilities and effort to satisfy multiple user system requirements. Within the Air Force, common ATS is still funded by weapon system program offices that pay the common ATS program a proportional amount of funding required to procure the amount of ATS their weapon system program requires. This funding strategy is further complicated because weapon system program managers are concerned about paying more than their fair share for the sake of commonality (MacAulay Brown, 2002:1-2). The weapon system programs are also held at greater risk if other programs responsible for paying their proportional share suffer funding cuts; support equipment is often times the first requirement that is cut. With these drawbacks in mind, there are benefits to common ATS. If designed and built correctly, common ATS offers efficiencies in acquisition, logistics, and sustainment (MacAulay Brown, 2002:1-2). The AF has attempted to enforce commonality in ATS through initiatives such as the Modular Automatic Test Equipment (MATE) program of the late 1970s and early 1980s; however, these programs failed to achieve success every time (MacAulay Brown, 2002:E2-E3). The Cruise Missile ATS in this study is categorized as common ATS.

DoD ATS Policy

DoD spent $50 billion on ATS acquisition and support between 1980 and 1992, peaking the interest of Congress (USGAO, 2003:4). Congressional language in the Fiscal Year 1993 Conference Report directed that "Comprehensive and uniform DoD-wide policy and guidance to the Acquisition and Management of Maintenance and Diagnostic ATE be developed and implemented and OSD oversight responsibility be established (Wynne, 2004b:1)." Also, the Fiscal Year 1994 Appropriations Bill contained a recommendation for the Secretary of Defense to create an ATS acquisition policy (Wynne, 2004b:1).

Evolution of Policy.

0n 29 Apr 1994, the Office of the Undersecretary of Defense (Acquisition and Technology) published a memorandum which stated "DoD Components shall satisfy all acquisition needs for Automatic Test Equipment hardware and software by using designated ATS families (Greening, 1999b:5)." This memorandum also appointed the Navy as the DoD Executive Agent for ATS and requested a coordinated Executive Agent Charter. Lastly, it recommended organizational and funding adjustments to implement this policy and proposed acquisition changes to be incorporated in DoD Directive 5000.2 (Greening, 1999b:5, Wynne, 2004b:2).

On 10 June 1994, the Assistant Secretary of the Navy for Research, Development and Acquisition issued a memo entitled "DOD Policy for Automated Test Systems (ATS)" in which they accepted the assignment as DoD's ATS Executive Agent (Wynne, 2004b:2). The memo also specified six Executive Agent responsibilities: 1) definition and management of DoD ATS standards, 2) guiding ATS family product engineering, 3) establishment of ATS research and development requirements, 4) review of ATS specifications and procurements, 5) maintenance of a waiver process, and 6) service as ATS Lead Standardization Activity. The Navy designated Naval Air Systems Command, Aviation Support Equipment Program Office (PMA-260) as Director of the ATS Executive Agent Office (Greening, 1999b:5, Wynne, 2004b:2).

On 15 Mar 1996, DoD Regulation 5000.2-R replaced the 1994 memorandum and formally published the DoD ATS policy (DoD, 1996). Five new requirements were established:

> 1) ATS families or Commercial-Off-The-Shelf components that meet defined ATS capabilities shall be used to meet all acquisition needs for automatic test equipment hardware and software.
>
> 2) ATS capabilities shall be defined through critical hardware and software elements.
>
> 3) The introduction of unique types of ATS into the DoD field, depot and manufacturing operations shall be minimized.
>
> 4) Selection of ATS shall be based upon a cost benefit analysis which shall ensure that the ATS chosen is the most cost beneficial to the DoD over the life-cycle."
>
> 5) An open systems approach shall be followed for all system elements (mechanical, electrical, software, etc.) in developing systems. (PMA-260, 1997)

On 10 January 1997, the ATS Executive Agent sent the first copies of the DoD ATS Selection Process Guide throughout the DoD acquisitions community (Greening, 1999b:6). This guide presented the processes and procedures program managers were to use when selecting the appropriate ATS solution to meet the testing requirements for their weapon systems. The guide includes cost benefit analyses tools and describes the policy deviation process to be followed when use of a DoD designated ATS family is not appropriate (Greening, 1999b:6). See Appendix A and B for DoD ATS organizational chart and their responsibilities.

On 6 February 1997, the Service Acquisition Executives signed a Joint Memorandum of Agreement to document processes and procedures that would be followed to implement the DoD ATS policy (Wynne, 2004b:3).

In 1998 and 1999, the ATS Executive Agent wrote the DoD ATS Master Plan, the DoD ATS Handbook, the DoD Architecture Guide, and updated the DoD ATS Selection Process Guide.

On 5 April 2002, DoD released a revised version of DoD Instruction 5000.2-R which contained the ATS policy originally included in the 1996 version (DoD, 2002). It stated:

> The program manager shall use DoD ATS families or Commercial-off-the-Shelf components that meet defined ATS capabilities to meet all acquisition needs for automatic test equipment hardware and software. Critical hardware and software elements shall define ATS capabilities. The program manager shall consider diagnostic, prognostic, system health management, and automatic identification technologies. The program manager shall base ATS selection on a cost and benefit analysis over the complete system life cycle. Consistent with the above policy, the program manager shall minimize the introduction of unique types of ATS into the DoD field, depot, and manufacturing operations. (Wynne, 2004b:3)

In May of 2003, the Secretary of Defense downsized Instruction 5000.2-R from more than 200 pages to 36 pages, and in the process, removed all ATS policy references (OSD (AT&L), 2004). Until the issue could be addressed, all service components followed the ATS guidance in DoD Instruction 5000.2-R, Change 4 (Johnson, 2004).

On 28 July 2004, the Office of the Undersecretary of Defense (Acquisition and Technology) reissued the latest DoD ATS policy via a memorandum which stated the policy would be included in the next issuance of DoD Instruction 5000.2-R (Wynne, 2004a). The memorandum also cancelled the Navy's role as the DoD Executive Agent. It also stipulated that ATS Service matters would be coordinated by the ATS Management Board comprised of each Service's lead ATS office and chaired by the Navy.

In September of 2004, the ATS Management Board drafted a Joint Memorandum of Agreement, which was signed by each Service Acquisition Executive, detailing the processes and procedures that each Service will follow in satisfying ATS requirements (VandenBerg, 2004). This Memorandum of Agreement replaced the 1997 Memorandum of Agreement.

Current DoD ATS Policy.

As of 28 July 2004, the DoD ATS policy is as follows:

> To minimize the life cycle cost of providing Automatic Test Systems for weapon systems support at DoD field, depot, and manufacturing operations, and to promote joint service Automatic Test Systems interoperability, program managers shall use approved DoD ATS Families as the preferred choice to satisfy automatic testing support requirements. Commercial-off-the-Shelf solutions that comply with the DoD ATS Technical Architecture should only be used if the Milestone Decision Authority concurs that an approved DoD ATS Family will not satisfy the requirement. Automatic Test System selection shall be based on a cost and benefit analysis over the system life cycle. (Wynne, 2004a)

This latest policy varies slightly from the previous 2002 guidance; Commercial-off-the-Shelf is no longer a preferred option and there is no specific mention of minimizing unique ATS development. Although implied, the overall objective of this new DoD ATS policy is to minimize unique types of ATS in DoD; in turn, reducing redundant ATS investments, lessening logistics burdens and long-term costs. The policy's near- and long-term objectives are stated in the ATS Master Plan.

Near-term objectives.

> 1) Eliminate redundant investments in weapon system unique ATS developments which duplicate capabilities already existing in the DoD inventory.
>
> 2) Lower ATS acquisition costs.
>
> 3) Increase ATS commonality to decrease weapon system Operations and Support costs.
>
> 4) Develop a flexible management approach for acquisition of commercial ATS.
>
> 5) Increase commercial component use in ATS for product improvements in DoD ATS families. (Greening, 1999a:6)

Long-term Objectives.

> 1) Substantially reduce test software program development time and costs.
>
> 2) Facilitate economical re-hosting of DoD's large investments in ATS software programs.
>
> 3) Provide methods to maximize use of commercial components and software in ATS.
>
> 4) Reduce the burden and cost of logistics support for the DoD ATS inventory through commonality. (Greening, 1999a:7)

ATS Families.

Four ATS families are designated under the current ATS policy. An ATS family consists of interoperable ATS that has the capability to support a variety of weapon system test requirements through flexible architecture (Greening, 1999a:16-17). The Army's Integrated Family of Test Equipment and the Navy's Consolidated Automated

Support System were the initial DoD ATS families. Since then, the Marine Corps' Third Echelon Test System and the Joint Service Electronic Combat Test System Tester have been added to the list of approved DoD Family Testers (Wynne, 2004a).

The Army's Integrated Family of Test Equipment (IFTE) has evolved as their standard Automatic Test Equipment for support of all weapon systems. IFTE provides a vertically integrated test equipment capability for all levels of maintenance (OSD (AT&L), 2004c).

Designed for ashore and afloat intermediate maintenance locations (to include Navy repair depots), the Consolidated Automated Support System (CASS) was developed by the Naval Air Systems Command (NAVAIR) as the Navy standard Automatic Test Equipment for support of electronic systems. CASS was designed to be modular and currently consists of four configurations. The various mainframe configurations of CASS contain five or six racks of test instruments fully integrated into a complete test system (OSD (AT&L), 2004d).

The Marine Corps' Third Echelon Test System (TETS) provides capability to test, diagnose, and screen a wide variety of their ground forces' electronic and electro-mechanical units. TETS supports testing of analog, hybrid, and digital technologies and includes both a basic and Radio Frequency configuration and has been designed to function from the tailgate of a High Mobility Multipurpose Wheeled Vehicle (Greening, 1999b:22).

Joint Service Electronic Combat Test System Tester (JSECST) is a joint USAF-USN procurement program featuring a flight line electronic warfare systems tester providing end-to-end functional testing of electronic combat systems installed in or on operational aircraft. Capabilities include threat representative simulations and technique/signal response analysis (OSD (AT&L), 2004f).

Current Military ATS Guidance

This section provides a brief description of all the existing guidance that currently applies to Air Force ATS. Although the DoD ATS policy has been recently reissued, much of the guidance over the last 10 years is still current.

DoD.

A memorandum entitled *DoD Policy for Automatic Test Systems,* dated 28 Jul 2004, is the only document containing the current DoD ATS Policy. The acting Under Secretary of Defense (Acquisition, Test, and Logistics) stated this policy will be included in the next revision of DoD Instruction 5000.2 (Wynne, 2004a).

DoD ATS Executive Director.

On 28 Jul 2004, the Under Secretary of Defense (Acquisition, Test, and Logistics) cancelled the Navy's ATS Executive Authority responsibilities and made them the DoD ATS Executive Director. This seemingly slight name alteration made one significant change. It was the opinion of the US General Accounting Office in 2003 that the Executive Agent never had any real authority over DoD ATS matters (US GAO, 2003). The new title is more commensurate with the duties PMA-260 (the office within the Navy assigned Executive Agent responsibilities) performed in the past and is expected to perform in the future. The previous referential guides published by PMA-260 (described below) are still in effect, two of which are in the process of being rewritten.

2004 Joint Memorandum of Agreement.

This Memorandum of Agreement among Service Acquisition Executives, dated Sep 2004, replaced the 1997 Memorandum of Agreement of the same subject. In essence, the content of the document remains the same, but shifts responsibilities. The 1997 memorandum did not specify responsibilities for the Service Acquisition Executives--the 2004 memorandum does. Oversight and guidance responsibilities were transferred to the Service Acquisition Executives from PMA-260 who retained the other responsibilities. Under the 1997 memorandum, PMA-260 appeared to have all the responsibilities, but no authority. This revised 2004 memorandum appears to correct this problem by shifting some of the responsibilities upward to the Service Acquisition Executives (PMA-260, 1997 and VandenBerg, 2004).

DoD ATS Master Plan.

This publication provides a consolidated plan for the implementation of the DoD ATS acquisition policy and investment strategy to include near and long-term objectives. The ATS organizational structure is thoroughly detailed and each participant and Integrated Product Team responsibility is covered. Each Service Components' ATS management organization, to include their ATS acquisition strategy, is identified. The four ATS families are described, and it covers the process for adding testers to current designated families; the ATS Master Plan also presents established criteria for designating future DoD ATS families. Covered more comprehensively in other publications, the ATS selection and policy deviation processes are abbreviated. The Master Plan also identifies the major participants in the DoD ATS management structure, identifies ongoing DoD ATS Research and Development planning efforts, and defines the evolving DoD ATS modernization strategy (Greening, 1999b:6-8).

DoD ATS Handbook.

The DoD ATS Handbook provides, in a frequently asked questions format, program managers who are unfamiliar with ATS the basic information they need before making decisions regarding automatic testing. It also presents definitions and discusses various aspects of ATS acquisition, including authority of the program manager, acquisition strategy, contracting, test and evaluation, controlling costs, and lessons learned (Fletcher, 1998).

DoD ATS Selection Process Guide.

As the title implies, this guide provides the procedures and tools needed by the program manager to select military ATS according to the DoD ATS Policy. Although the policy recently changed, the large majority of the content in this guide still applies. The selection process provides a structured approach consisting of four steps: 1) definition of weapon system support/test requirements; 2) definition of ATS alternatives; 3) alternative analysis; and 4) alternative selection. See Figure 9 below.

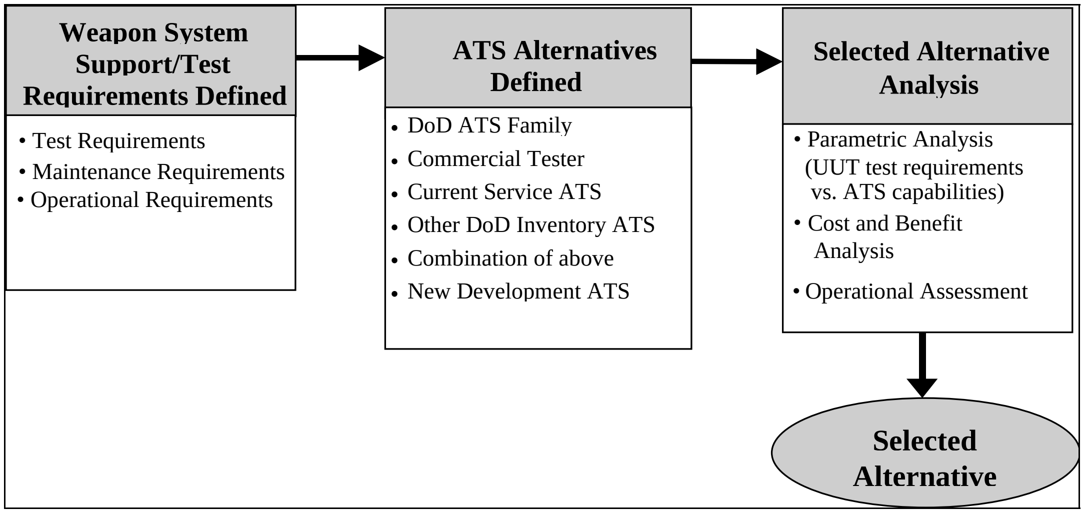


Figure 9. ATS Selection Process (Greening, 1999c:3)

DoD ATS Architecture Guide.

Consistent with the DoD ATS policy, this guide focuses on an open system architecture; meaning, it focuses on using accepted industry standards rather than designing one-of-a-kind systems. The four functional groups in the ATS architecture (models, components, interfaces, and rules) are thoroughly defined and further categorized into 22 key elements. The specifics of the 22 elements go beyond the scope of this research, but it should be noted that they exist. The ATS architecture has 3 objectives: 1) to reuse information rather than recreate it; 2) to reduce the recurring engineering costs normally associated with rehosting Test Program Sets from one tester to another; and 3) to allow economical insertion of technology or capability into an existing ATS (Greening, 1999a:11). This guide is also related to the DoD Joint Technical Architecture which requires more supportable, open architecture for numerous other systems outside the realm of ATS. The lessons learned from Operation DESERT

STORM led to the development of the DoD Joint Technical Architecture which later evolved into Joint Vision 2010 (Greening, 1999a:9).

Air Force.

The Air Force's ATS Leadership Office is the Automated Test Systems Division located at Warner Robins AFB. They are the Air Force lead for coordinating Joint Service projects, and they have representatives on various Integrated Product Teams and working groups within the ATS organizational structure (See Appendix F). They also ensure the DoD ATS policy is promulgated throughout the Air Force and monitor acquisition and modernization planning for policy compliance (Wynne, 2004a).

Air Force Policy Directive 63-2.

Air Force Policy Directive 63-2 was formalized in July 1994 shortly after the original DoD policy. The directive emphasizes efficiencies and reduced costs can be achieved by standardizing ATS while still meeting maintenance and deployment requirements. Because the basic ATS policy has changed very little, this 2-page directive remains in effect, even though it was written before the DoD released their latest ATS policy in 2004 (SAF/AQK, 1994a).

Air Force Instruction 63-201.

Air Force Instruction 63-201 implements the policy contained within Air Force Policy Directive 63-2. The Air Force ATS policy is as follows: the first alternative is ATS standard families; the second alternative is procurement of existing test equipment in the DoD inventory; the third alternative is a modification to existing DoD inventory ATS; the fourth alternative is Commercial-off-the-Shelf equipment; and last, if none of the above alternatives satisfy the requirements, new development must be approved by a waiver to the policy (SAF/AQK, 1994b).

US General Accounting Office Assessment

At the request of Senator Christopher Shays in January 2002, the General Accounting Office studied how the military departments manage ATS and reported their findings in GAO-03-451 entitled, *Military Readiness, DoD Needs to Better Manage Automatic Test Equipment Modernization*. The theme of the report was that military departments are not adequately following DoD guidance regarding common ATS development. Because the Navy and Air Force have the majority of military ATS, the General Accounting Office focused their attention on these two military departments. The Air Force appeared to be the most flagrant violator of the common ATS policy set forth by DoD in 1994. General Accounting Office found little evidence suggesting that consideration is being given to develop equipment with a common utility for more than one weapon system (USGAO, 2003:1). Examples of unique ATS being developed as recently as the Joint Strike Fighter are cited (USGAO, 2003:12). The General Accounting Office made six recommendations to the Department of Defense regarding military ATS. The recommendations are as follows:

> 1) Reemphasize the policy that common automatic test equipment be developed to the maximum extent possible.
>
> 2) Reconsider whether placing the ATS Executive Agent in the Navy (or any single service) is the most effective way to implement DoD policy.
>
> 3) Give the Executive Agent the authority and resources to include representatives from all of the services, with a scope to include the oversight of Automatic Test Equipment acquisition and modifications for all weapon systems.

> 4) Give the Executive Agent the authority and resources to establish a mechanism to ensure that all Automatic Test Equipment acquisitions and modernizations are identified early enough to provide a comprehensive look at commonality and interoperability.
>
> 5) Give the Executive Agent the authority and resources to direct the Services to draw up modernization plans for its review so it can identify opportunities to maximize commonality and technology sharing between and within the Services.
>
> 6) Give the Executive Agent the authority and resources to continue efforts to research technical issues dealing with tester commonality such as the development of open system architecture and other join applications (USGAO, 2003:15-16).

DoD Reaction to the Recommendations.

The DoD concurred with all six recommendations, mostly without comment. DoD stated they would propose an Automatic Test Equipment acquisition policy statement for the next issuance of DoD Instruction 5000.2. They also commented on how authority would be granted to the Executive Agent and the plan to incorporate ATS into the Planning, Programming, Budgeting and Execution process to give visibility to ATS within the DoD budget. (USGAO, 2003:21-22)

Differences Between Commercial and DoD ATS

Although ATS is physically similar in both the military and commercial sectors and serves the same purpose, there are two significant external differences: ATS environment and funding. These two factors could potentially impact ATS obsolescence, efficient program execution, and the program manager's ability to field sustainable ATS in a timely manner.

Environment.

There are several considerations, as seen in Table 3, which distinguish the commercial from the military environment which contribute to ATS obsolescence issues.

Table 3. Commercial versus Military Environment

Consideration	Commercial (typical)	Military (typical)
Number of Sites/ATE?	Small	Large
Sites Co-located?	Usually	Almost Never
Unit Under Test (UUT) Life?	1-5 Years	15-30 Years
UUT Diversity?	Low	Extremely High
ATE Life?	10-30 Years	30 Years or more

(Marion, 2001:746)

A limited number of ATS sites decreases the recurring cost of replacing obsolete equipment. In the case of multiple ATS sites, either a higher recurring replacement cost is incurred or the organization mitigates this cost by maintaining several different equipment configurations further complicating ATS obsolescence (Marion, 2001:747).

As locations increase, the odds of an obsolescence replacement requirement go up exponentially (Marion, 2001:747). Understandably, co-locating sites helps mitigate this effect because ATS support infrastructure is pooled and document changes, training, and travel are all decreased (Marion, 2001:747).

Long Unit-Under-Test life dramatically increases the probability of encountering ATS obsolescence problems. In the commercial environment, a manufacturer's limited product line becomes the Unit-Under-Test pool which generally has a short life. In the military environment, weapon systems are designed for long life, requiring associated

Units-Under-Test to have long lives which usually outlast the test equipment (Marion, 2001:748).

ATS diversity also increases the impact of Commercial-off-the-Shelf obsolescence. Commercial manufacturers typically have only a handful of products. In the military environment, there are literally hundreds of models requiring testing (Marion, 2001:748).

Of the five considerations in Table 3, the decision process of determining ATS life is the most similar between commercial and military applications. In both environments, ATS is kept until the cost of replacing it is less than the cost of maintaining it (Marion, 2001:747). Although the cost equation is similar, the actual ATS life is driven by the life of the product being supported. Typically, Commercial-off-the-Shelf equipment life cycles mirror the commercial product lines they support, not the military applications of the same test equipment. For this reason, the military faces Commercial-off-the-Shelf ATS obsolescence issues earlier than the Units-Under-Test (Marion, 2001:748).

In short, commercial manufacturers face ATS obsolescence issues, but the obsolescence problem is much larger in the military environment. The problem is so widespread in the military that it spawned a whole new market sector dedicated to replicating obsolete equipment to support military needs.

Funding.

Private and publicly owned companies are accountable to themselves or their shareholders. Their goals vary, but they generally try to maximize profitability according to their business strategy. One could argue that the federal government has a similar constituency in the taxpayer and a similar goal to maximize the investment of tax dollars; however, company size is considerably different. The federal budget is almost 4 times larger than the world's largest retailer's total sales. In 2004, Wal-Mart's total net sales were $256B (Wal-Mart, 2004:2). The US Federal Government's budget for Fiscal Year 2005 is expected to be approximately $818B, and the proposed DoD budget for 2005 is $402B—49% of the entire federal budget (OMB, 2004). Governmental spending receives considerable oversight, particularly the DoD, partly because of the large amount of money involved. This oversight and control is understandable, but executing programs in a timely manner is difficult because of the layers of funding reviews and the limitations Congress puts on the appropriations.

DoD's Planning, Programming, and Budgeting System.

The purpose of the Planning, Programming, and Budgeting System (PPBS) is to systematically build a DoD budget for the President's approval, who in turn, forwards the budget to the Congress for authorization and appropriation (DoD, 1984:2). The ultimate objective of the system is to provide the best mix of forces, equipment, and support attainable within fiscal constraints (AF/XPPE, 2003:7). The system is the DoD's foundation of fiscal accountability to the Congress and to the President (DoD, 1984:2). Each military department has their own specific guidance; within the Air Force, Air Force Policy Directive 16-5 implements DoD Directive 7045.14 which outlines *Planning, Programming, and Budgeting* (AF/PEI, 1994).

Because the specifics of each phase goes beyond the scope of this research, only a broad description of each is covered to provide a sense of how the DoD builds their budget proposal. In *Planning*, the Secretary of Defense establishes a fiscal vision for the

DoD based on the National Policy set forth by the President. Forces, manpower, and equipment are apportioned during *Programming* to achieve the DoD vision. Within this phase, the Program Objective Memorandum is built. In the *Budgeting* phase, cost details are projected and executed to support the requirements identified in the previous phase (AF/PEI, 1994:1). The DoD's budget submission then competes with the other 26 federal agencies for Congressional and Presidential approval (OMB, 2004). Figure 10 provides a sense of the 2-year process.

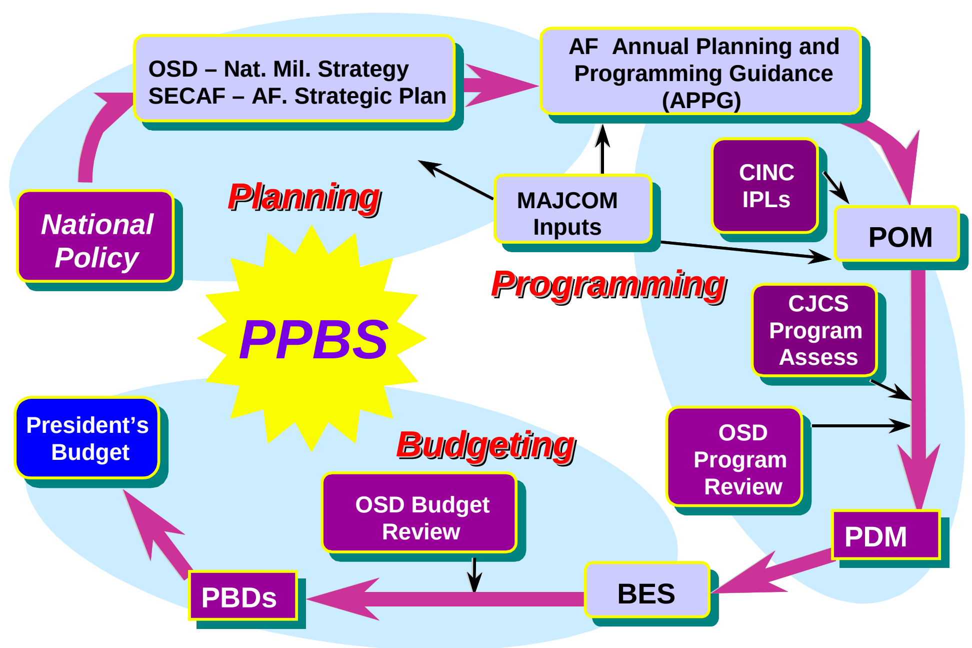


Figure 10. Planning, Programming, and Budgeting System Cycle (Faldowski, 2003)

Air Force Corporate Structure.

Residing within the Air Staff, the Air Force Corporate Process is the means by which the Air Force implements its Planning, Programming, Budgeting, Execution System (AF/XPPE, 2003:21). The subtle name change highlights the importance of *Execution*. The Air Force uses their Corporate Process to integrate all their program needs and resources, to enable open assessments, and to provide recommendations to the Air Force Secretary and Chief of Staff (AF/XPPE, 2003:21). Each level of the Air Force Corporate Process is responsible for recommending resource and budgetary requirements. Appendix C illustrates the overall Air Force Corporate Process business approach with its layers of oversight.

Fourteen mission panels form the foundation of the Air Force Corporate Process and integrate the Program Element Monitors to the Planning, Programming, Budgeting, and Execution System (AF/XPPE, 2003:19). Program Element Monitors are assigned to Program Elements as the Air Force "expert" and are responsible for proposing all future resource and budgetary needs (AF/XPPL, 1999:4). Program Elements are five and six digit numbers assigned to major weapon systems or programs (Faldowski, 2003). The 14 Panels review and develop options for the Air Force Group (AF/XPPE, 2003:25). The Air Force Group is the first level of the corporate structure that integrates the mission areas into a single Air Force program. The Air Force Group is also the entry point to bring issues into the Air Force Corporate Process for review. They also oversee all programming activities before the Air Force Board review (AF/XPPE, 2003:24-25). Topics brought to the Air Force Board should be limited to important matters requiring resolution. The Air Force Board refines integrated programs before submitting them to the Air Force Council (AF/XPPE, 2003:23-24). The Air Force Council is the final Air Force Corporate Process body and makes recommendations to the Chief of Staff of the Air Force and the Secretary of the Air Force (AF/XPPE, 2003:23).

Further compounding the funding bureaucracy, each Major Command staff has their own vetting system before program requirements enter the formal Air Force

Corporate Process. The Major Command Plans and Programs staffs flow their requirements to the respective Air Staff Program Element Monitor, providing yet more opportunities for funding problems. The success of any program starts with the due diligence of a Program Element Monitor. If any link in the chain (from a Major Command process through the top of the Air Force Corporate Process) fails to articulate a program need, that requirement will be lost for at least 2 years, because of the biennial cycle of the Planning, Programming, Budgeting, and Execution System (AF/XPPE, 2003:12).

Problems Facing Military ATS

The military services are currently fielding weapon systems faster than the ATS required to sustain them (VandenBerg, 2004:10). As ATS is at times an afterthought, it is not surprising that obsolescence problems and limited sources of replacement parts quickly impact military ATS. A recent study conducted by Major Paul Griffith, entitled *Decision Criteria for Common Air Force Automated Test Equipment*, compared a number of available practices to mitigate obsolescence and diminishing manufacturing sources. His research categorized twenty three factors that are useful when determining ATS requirements into eight general categories. The ATS categories are as follows: design, availability, performance, concept of operations, characteristics, time, workload, and cost criteria (Griffith, 2004:67-83).

Obsolescence.

ATS obsolescence can come from many sources, but are generally categorized in three forms: increasing ATS age, rapid technological changes that potentially makes

ATS obsolete even before fielding, and the scarcity of replacement parts due to Diminishing Manufacturing Sources and Material Shortages (Griffith, 2004:22). To highlight the potential impact of obsolescence, the Air Force agency responsible for ATS development estimates an increase of 14%, 31%, and 55% ATS obsolescence rates over a projected two-, five-, and ten-year time frame (Johnson, 2004).

Diminishing Manufacturing Sources and Material Shortages.

Diminishing Manufacturing Sources and Material Shortages (DMSMS) is the loss or impending loss of manufacturers or suppliers of critical items or the shortage of raw materials (DMEA, 2004). "Although increased reliability has lengthened system life cycles, decreased demand, fewer manufacturers, and rapid advances in technology have shortened component life cycles from between 10 and 20 years to between 3 and 5 years (McDermott, Shearer, and Tomczykowski, 1999:1-1)." The cost of resolving these shortage problems is of primary concern to DoD program managers. This problem particularly impacts microelectronics but affects nonelectronic systems as well. To minimize the impact, System Program Offices must be able to incorporate the most timely and cost-effective resolutions to avoid costly redesign (McDermott, Shearer, and Tomczykowski, 1999:1-1).

The Defense Microelectronics Activity operates under the authority, direction, and control of the Deputy Under Secretary of Defense for Logistics and is located in Sacramento, California (DMEA, 2004). Defense Microelectronics Activity was founded because of the core importance of technological superiority regarding the US military strategy and national security. "Two factors make it difficult, if not impossible to provide reliable, long-term support for the military's fielded systems: 1) the rapid pace of technological development; and, 2) the commercial microelectronics technology business climate surrounding microelectronics technology (DMEA, 2004)." Defense Microelectronics Activity leverages the capabilities and advantages of advanced technology to solve operational problems in existing weapon systems, to increase operational capabilities, to reduce operating and support costs, and to reduce the effects of DMSMS (McDermott, Shearer, and Tomczykowski, 1999:1-1). Defense Microelectronics Activity presents program managers with appropriate solution options to keep systems operational for the long-term (DMEA, 2004). Defense Microelectronics Activity is also the DoD Executive Agent for microelectronics DMSMS, and in this role, it helps to identify microelectronics obsolescence problems and their solutions (McDermott, Shearer, and Tomczykowski, 1999:1-1).

The Air Force works closely with Defense Microelectronics Activity to mitigate DMSMS and obsolescence issues. Air Force Research Laboratory's Materials and Manufacturing Directorate, Manufacturing Technology Division manages the Air Force's DMSMS Program (ManTech, 2005a). The Headquarters Air Force Materiel Command's DMSMS mission is to:

> Reduce the impact of DMSMS situations by distribution of notices, and providing tools to single managers for identification and resolution of DMSMS situations to ensure the continued availability of items and essential materials needed to support current and, when possible, planned defense requirements. (ManTech, 2005b)

To meet this mission, a "hub" operation was implemented whereby a clearinghouse of information on DMSMS issues relevant to the Air Force is available at Air Force Materiel Command's DMSMS System Program Office located at Wright-Patterson AFB, Ohio (ManTech, 2005c).

Summary

The generally accepted ATS definition is shared by military and commercial sectors and both are plagued with obsolescence and diminishing parts sources. However, their environments and the appropriation of funding differ considerably and accelerate the military's ATS obsolescence and DMSMS problem. The DoD ATS policy has significantly changed over the last 10-11 years. Program managers are supposed to seek common ATS solutions instead of weapon system specific solutions (which was the policy until 1994). In the US General Accounting Office's opinion, the DoD has not made sufficient progress towards embracing this new policy. Because this research seeks to compare two similar ATS systems (Cruise Missile and ICBM ATS), both systems were described.

III. Methodology

Overview

The purpose of this chapter is to describe the methodology chosen to guide this research. The researcher selected a qualitative methodology with a case study strategy as the research design based primarily on the literature reviewed from Creswell (1994, 1998, 2003) and Yin (1994, 2003). Yin's case study protocol formed the basis for the questionnaire design used to collect the research data.

This research complements a parallel study conducted by Captain Jeremy Howe, entitled *Evaluating Management Strategies for Automated Test Equipment (ATE): An F-15 Case Study*. Both studies compare two similar ATS systems with the major programmatic difference being management approach (common vs. weapon system specific). Both researchers studied unrelated ATS systems but worked closely together to build a common methodology for two primary reasons. First, a common methodology with identical data collection and analysis tools would enable a protocol that could be duplicated by future researchers seeking to strengthen generalizations or to further build upon theories that emerged from the current research. Second, it afforded us the opportunity to compare our findings and to possibly refine our own theories.

Three Research Designs

The foundation of any research begins with a topic selection. The interest within the topic under study aimed the researcher towards an appropriate research paradigm—a logical system that encompasses theories, concepts, and procedures to help understand phenomena (Dane, 1990:336). Creswell identified two widely accepted paradigms that could be used in research design and also a third that combines the two main paradigms. The three research paradigms are quantitative, qualitative, and a mixed method combining quantitative and qualitative (Creswell, 1994:4, 173).

Quantitative Research.

Sometimes called the traditional, experimental, or positivist approach, quantitative research seeks to explain or predict phenomena from a controlled, unbiased position (Leedy and Ormrod, 2001:101). Creswell defined 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)

Given these perspectives from Leedy, Ormrod, and Creswell, one can recognize the presence of scientific method, finitely measurable data, and the concept of testing. More specifically, research following this paradigm builds on previously understood information and produces a hypothesis that can be tested by collecting and analyzing some form of numerical data. The study is concluded upon confirming or disproving the hypothesis under test. The purpose of quantitative research is to explain or predict phenomena that generalize a given population (Creswell, 1994:116). Concepts, variables, hypotheses, and methods are generally defined before the study and remain the same throughout; also, researchers strive to not interfere with research subjects to remain unbiased (Leedy and Ormrod, 2001:102). Experimental and survey methods are a couple of quantitative research forms commonly conducted by the scientific and academic community to test theories stemming from previously performed qualitative research (Creswell 1994:10).

Qualitative Research.

Referred to as the interpretive or constructivist approach, qualitative research answers questions about complex events or new areas of study with the purpose of describing or understanding phenomena (Leedy and Ormrod, 2001:101). Creswell 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)

Rather than testing a specific hypothesis, qualitative research usually begins with wide areas of research, collects large amounts of verbal and written data, and synthesizes the data into a cogent disquisition accurately describing the topic of study; it also forms the basis for more focused quantitative research in the future (Creswell, 1994:145). Qualitative research is often exploratory and builds theory from the ground up, and is commonly conducted following five methods: ethnography, grounded theory, case study, phenomenological study, and biography (Creswell, 1998:27). Table 4 reflects the continuum of both widely accepted paradigms and their distinctive characteristics.

Table 4. Research Evolutionary Model

Objective/Phase		Logic/ Theory		Hypothesis	Data/Model	Paradigm	Method	Analysis	Causality
"Levels of Knowing" Observation - Establish Facts	Inductive	Inductive - Conclusion supported by premisese - Assign sample attributes to a whole class (make inferences based on sample data) - Necessity = Prerequisities (if fire, then oxygen is present, - Validity of inferrence is unproveable - Extrapolate	Theory Building	Examples: - Presence of "a"	Field or natural setting - Descriptive Models - Phenomenon observed as they occur	Qualitative	*(...of Data Collection)* Ethnography Phenomenology	Descriptive	Construct Validity
Categorization - Determining "Characteristics" - Group Facts				- Presence of "a" distinct from "b"			Content Analysis Case Study Grounded Theory Historical Observational Developmental		Rationality - apriori - falsifiability - parsimony
Correlation - "Association" - Realize some relationship exists between facts	Deductive	Deductive - A collusion follows from the premisese - Process of reasoning from which conclusion is true based on premise if premise is true - Sufficiency (i.e. if fire, then heat) - If "a", then "b" must exist	Theory Validating	- Covariance between amount of "a" and "b"	Lab or designed experiment - Prescriptive Models	Quantitative	Correlation Surveys	Inferential	Correlation Statistically significant - Practically significant
Causality - "Relationships" (i.e. $E=MC^2$) "Determinism" - Can now make predictions - Thorough knowledge - May control environment				- "a" causes "b"			Designed Experiments		Temporal precedence Exclusivity

(Swartz, 2004)

Mixed Research.

A mixed method combines quantitative and qualitative methodologies. The original intent of mixing the two methods was to triangulate findings and to demonstrate convergence in results (Creswell, 1994:189). In recent years, researchers found other purposes of mixing methods to include examining overlap, finding contradictions and new perspectives, and to add scope and breadth to a study (Creswell, 1994:175). Creswell proposed three mixed design models. The *two-phase design* separates the qualitative and quantitative studies into two distinct phases. In the *dominant-less dominant design,* the researcher presents the study within a single paradigm with a small piece of the research conducted with the alternative design. Lastly, the *mixed-methodology design* represents the most complex method because both paradigms are combined throughout the design (Creswell, 1994:179-180).

Assumptions of the Traditional Paradigms.

The assumptions of both classic paradigms should be well understood because they will help guide the research design. Creswell synthesized research from numerous sources (Firestone, 1987; Guba and Lincoln, 1988; McCracken, 1988) to better understand the assumptions of each paradigm on several dimensions (Creswell, 1994:4). Table 5 indicates the characteristics of each paradigm for the five main assumptions.

Table 5. Quantitative and Qualitative Paradigm Assumptions

Assumptions	Question	Quantitative	Qualitative
Ontological	What is the nature of reality?	Objective and singular	Subjective and multiple
Epistemological	What is the relationship of the researcher to that being researched?	Independent	Interacts
Axiological	What is the role of values?	Value-free and unbiased	Value-laden and biased
Rhetorical	What is the language of the research?	Formal	Informal
Methodological	What is the process of the research?	Deductive, cause and effect	Inductive, shaping of factors

(Creswell, 1994:5)

Basis for Selecting the Qualitative Method

The nature of the problem required a more thorough examination than currently existed in the literature. The existing literature related to this research topic only considered the advantages of common ATS and disadvantages of weapon system specific ATS in a theoretical environment. Very little literature was found that considered supportability or efficiency in a practical environment. Although there was a significant amount of guidance and directives to adopt the common ATS movement under the auspice of cost savings, sources citing the possible impact of this initiative on weapon system supportability were not found. In theory, the potential benefits of common ATS were obvious but assumed decentralized management would not impact supportability of the ATS and ultimately the supported weapon system. Despite the expected benefits of the common ATS initiative, sources discussed in Chapter 2 revealed a broad program management reluctance to embrace common ATS. Qualitative research lends itself to this topic because of the lack of evidence that substantiates the benefits of common ATS in a practical setting.

More specifically, the goal of this research was to thoroughly compare two ATS programs selected because of their numerous similarities, with their singular difference being whether the equipment was managed as common or weapon system unique. My intention was to hold equipment-caused program impacts constant, so the opposing management approaches could be thoroughly examined. This purposeful selection was made to help increase the likelihood of providing a meaningful, traceable explanation for any significant differences between the programs. By carefully examining two similar programs, possible dependencies between the investigative questions could be proposed. If the problems associated with both programs could be explained and dependencies understood, then logically, my chances of proposing theory were increased. Therefore, the nature of this research and the data required to answer the research question is best addressed with qualitative research.

Five Traditions of Qualitative Research

After deciding to follow a qualitative methodology, the appropriate tradition of inquiry to guide the research needed to be determined. Although there are many other accepted traditions, Creswell identified five popularly accepted traditions frequently used (Creswell, 1998:5). The five traditions are biography, phenomenological study, grounded theory study, ethnography, and case study.

> Biography: the study of an individual and her or his experiences as told to the researcher or found in documents and archival material. Biographical writings include individual biographies, autobiographies, life histories, and oral histories. (Creswell, 1998:47)
>
> Phenomenological Study: a study that describes the meaning of the lived experiences for several individuals about a concept of phenomenon. A phenomenologist explores the structures of consciousness in human experience. (Creswell, 1998:51)
>
> Grounded Theory Study: a study to generate or to discover a theory, an abstract analytical schema of a phenomenon that relates to a particular situation. This situation is one in which individuals interact, take action, or engage in a process in response to a phenomenon. (Creswell, 1998:56)
>
> Ethnography: a description or interpretation of a cultural or social group or system. The researcher examines the group's observable and learned patterns of behavior, customs and ways of life. (Creswell, 1998:58)
>
> Case Study: an exploration of a "bounded system" or a case (or multiple case) over time through detailed, in-depth data collection involving multiple sources of information rich text. This bounded system is bounded by time and place, and it is the case being studied—a program, an event, an activity or individual. (Creswell, 1998:61)

Five Traditions Compared.

By reviewing the definitions, each tradition is distinguishable from the others because of their objectives. These differing objectives also require varying data collection techniques, but the widest differences are noted during analysis (Creswell, 1998:64). Creswell further points out two areas of overlap that require clarification before selecting a tradition. The first overlap is between ethnography and a case study. An ethnography examines a cultural system while a case study examines a bounded system. The perceived overlap lies in the scope of each study. An ethnography examines the entire culture while a case study would be reserved to examine a specific facet of the studied culture (Creswell, 1998:66). The second overlap appears when a researcher studies an individual. A biography is commonly used to study an individual, but a case study could also be used. To clarify this overlap, Creswell recommends a biography for an individual and a case study when studying several individuals (Creswell, 1998:66).

Theory Use and the Five Traditions of Inquiry.

Creswell recommended for anyone designing a study to consider how theory is used within each of the five traditions (Creswell, 1998:84). He conceptualized these traditions along a continuum, Figure 11, according to whether they are used before the study or after the study.

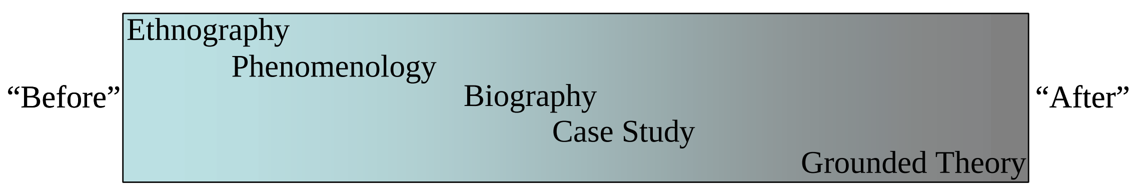


Figure 11. Extent of Theory Use in the Five Traditions (Creswell, 1998:85)

On his continuum, Creswell shifts an ethnography to the extreme left because researchers usually bring a strong cultural lens to the study that has previously shaped their theory and initial questions (Creswell, 1998:86). Next on the continuum is phenomenology, also at the “Before” end. Phenomenologists begin their studies with a strong philosophical perspective instead of a distinct social theory (Creswell, 1998:86). Biographies are positioned towards the middle because theory use varies widely as a result of the research objective. Thus, theory or even a theoretical perspective may or may not guide the study (Creswell, 1998:85). Case studies are also positioned in the middle for the same reasons as biographies. However, case studies lean slightly further toward the “After” side because a theoretical perspective is often times offered after the analysis is concluded (Creswell, 1998:87). Grounded theory is shifted to the far right of the theory "After" side of the continuum. With grounded theory research, theories should emerge through the data collection and analysis and be posed at the end of a study (Creswell, 1998:86).

Reasoning for Selecting the Case Study Method

The case study selection was based primarily on Creswell's comparisons of the five traditions. Secondarily, the three conditions outlined by Yin (2003) in determining an appropriate research strategy were also considered in the selection.

The case study strategy is an exploration of a "bounded system" by time and place, specifically focusing on a program, event, activity or individuals (Creswell, 1998:61). The focus of the other four strategies did not lend themselves to the research of comparing programs. Also, the case study method properly addressed the needs of this research's data collection and data analysis. Documents, archival records, and interviews enabled a collection of information from multiple sources. As will be discussed at the end of this chapter, the analysis sought to use these multiple sources to triangulate on central themes interpreted by the researcher.

Yin provided three conditions to consider when selecting a strategy. The three conditions are: types of research questions, extent of control an investigator has over actual behavioral events, and degree of focus on contemporary as opposed to historical events (Yin, 2003:5). First, research or investigative questions that ask "how" or "why" are more explanatory and likely to lead to the use of case study. Although the investigative questions in this research ask "what" and "how much," Yin points out that “what” type questions can also be used (Yin, 2003:5 to 6); furthermore, the investigative questions were carefully worded to facilitate comparisons with the goal of explaining, which is another attribute of case research. Second, the researcher does not require control of behavioral events as suggested by Yin. Third, this study was considered contemporary because it focused on two ongoing strategic missile ATS programs. Adding further credibility to the strategy selection, the case study is preferred to examine contemporary events when the relevant behaviors cannot be manipulated (Yin, 2003:7). Regarding this research, there was little any one person could do to mask their ATS programs’ sustainability or efficiency within the government environment.

Case Study Design

Once the case study strategy was selected, five components were considered important when setting up the research design. The five components are: a study’s questions, its propositions, its units of analysis, the logic linking the data to the propositions, and the criteria for interpreting the findings (Yin, 2003:21).

Outlined in Chapter 1, the research and investigative questions address the first component regarding the study’s question. Regarding propositions, the second component is used to help direct the researcher to areas of the study that need examined as part of the overall study (Yin, 2003:22). To the extent of deriving investigative questions, differences between the programs under study were expected because of wide program management refusal to adopt the common ATS initiative. In a broader context, this research sought to thoroughly examine two programs, and then, offer specific propositions consistent with Creswell’s Theory Use Continuum (Creswell, 1998:85). The unit of analysis, the third component, relates to the fundamental problem of defining the case. The unit of analysis can be difficult to identify, but this research clearly distinguished the unit of analysis as a single program. This research consisted of two programs (the Cruise Missile ATS program compared to the ICBM ATS program). The fourth and fifth components, linking data to propositions and criteria for interpreting the findings, are the least well developed in case studies (Yin, 2003:26). Because this research sought to ultimately develop theory, two similar programs with identical questionnaires were linked to facilitate data comparison. Linking data to propositions before data collection was not possible because of the absence of well defined theory. Pattern matching, convergence, and triangulation were used once data was collected from multiple sources to validate the answers to the investigative questions. Validating the investigative questions' answers increased the reliability of proposed data dependencies during the analysis phase.

After considering the five components of setting up a research design, four types of case study design were reviewed. The four types of designs are single-case (holistic), single-case (embedded), multiple-case (holistic), and multiple-case (embedded); they are depicted in a 2 X 2 matrix in Figure 12 (Yin, 2003:39).

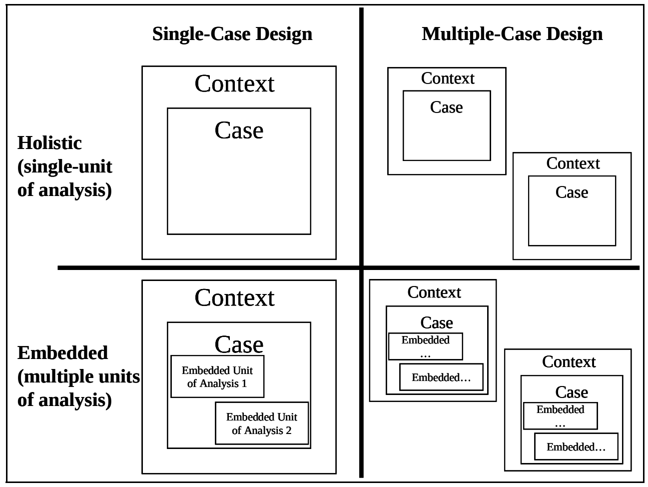


Figure 12. Basic Types of Designs for Case Studies (Yin, 2003:40)

A multiple-case (holistic) design proved most appropriate for comparing two similar programs. The uncommon similarity of Cruise Missile ATS (managed as common ATS) and ICBM ATS (managed as weapon system-specific ATS) provided a unique opportunity to understand how dramatically different program management approaches impacted sustainability and efficiency.

Operational Protocol Design for this Case Study

A well-defined protocol increases the reliability of case study research and guides the researcher through data collection of a case study (Yin, 2003:67). The protocol contains more than just the instrument; it also contains the procedures and general rules to be followed when using the instrument (Yin, 2003:67). A case study protocol should generally cover four sections: an overview of the case study, field procedures, case study questions, and a guide for the case study report (Yin, 2003:69). In the context of this Strategic Missile ATS Case Study, these four considerations are fully addressed.

Case Study Overview.

From 1980 to 1992, the DoD spent over $50 billion acquiring ATS. At that time, procuring unique ATS to support single weapon systems was the norm. In 1994, the DoD made a dramatic change to their ATS acquisition policy; common ATS that supports multiple weapon systems was preferred over ATS tailored to support a single weapon system. Expected benefits of this new policy included: more reliable equipment, increased supportability, decreased cost, smaller logistics footprint, and decreased manning. Although this common ATS policy has been in place for more than 10 years, the majority of the ATS procured in the 1980-1992 “bubble” is still in service, but is facing severe aging and obsolescence issues.

This research examines two ATS systems procured during the “bubble.” They have numerous similarities and a single, stark difference; one is managed as common ATS (Cruise Missile ATS) and the other is managed as part of the weapon system (ICBM ATS). This research seeks to satisfy two goals. The first goal of this case study is to see if the expected benefits of common ATS are being realized in a practical setting. Second, if the expected benefits were not met, it is important to develop an explanation so senior leaders at the Air Staff and Air Force Materiel Command can correct the process of procuring common ATS.

Field Procedures.

Field procedures are important to case study protocol because they interface the researcher with sources of information for data collection. Because of the dynamic aspects of gaining access to interviewees and gathering data, Yin recommends making the procedures as operational as possible (Yin, 2003:73).

The topic of this case study dictated the offices required to participate in this case study. Without good participation from the Cruise Missile and ICBM communities, this research would not be possible. For this reason, good rapport/trust was critical with the key points of contact and potential interviewees. Initial contact with key individuals was made from both communities well in advance of conducting interviews in order to open lines of communication; the researcher was candid about the purpose and importance of the research. While building rapport, these initial contacts allowed the identification of experts who were knowledgeable when it came time to conduct interviews. These individuals were also contacted before performing the interviews to discuss the goal of the research and to gain their trust.

After receiving permission from the Wright Site Institutional Review Board to use volunteers in this research, the consent form and a copy of the interview discussion points were forwarded to the interviewees so they would be less apprehensive and more prepared to discuss their program's fine points. Telephone interviews were also scheduled at their convenience, so it was important to begin interviews well in advance because of the potential need to reschedule telephone interviews. Protection of interviewee confidentiality was a major stipulation of the Wright Site Institutional Review Board's approval. For this reason, only the offices (not the individuals) involved with the interviews are provided below, and all completed questionnaires in Appendix N through AJ have been redacted. Those invited to participate included:

1) *Cruise Missile subject matter experts from Headquarters Air Combat Command, Langley AFB, VA.*

They were useful to this research because they are responsible for ensuring their subordinate units are properly equipped with Cruise Missile ATS to perform their missions. They are uniquely positioned to evaluate the Cruise Missile ATS program from the user's perspective.

2) *ICBM subject matter experts from Headquarters Air Force Space Command, Peterson AFB, CO.*

They were useful to this research because they are responsible for ensuring their subordinate units are properly equipped with ICBM ATS to perform their missions. They are uniquely positioned to evaluate the ICBM ATS program from the user's perspective.

3) *ICBM ATS subject matter experts from Twentieth Air Force, F.E. Warren AFB, WY.*

Air Force Space Command relies heavily on Twentieth Air Force to provide system-level expertise to keep their Major Command's staffing lean. For this reason, much of their ICBM ATS experience is at Twentieth Air Force. They are also positioned to evaluate the ICBM ATS program from the user's perspective.

4) *Program personnel from the Automatic Test Systems Division at Warner Robins-Air Logistics Center, GA.*

These system experts are involved in the daily tasks of running the Cruise Missile ATS program. Their perspective was critical to understanding how they are organized, how they plan, the level of resources they are provided, and how they support the fielded Cruise Missile ATS.

5) *Program personnel from the ICBM System Program Office at Ogden-Air Logistics Center, Hill AFB, UT.*

These system experts are involved in the daily tasks of running the ICBM ATS program. Their perspective was critical to understanding how they are organized, how they plan, the level of resources they are provided, and how they support the fielded ICBM ATS.

Numerous issues were expected to arise while working with the above information sources to include: building trust, defending positions, rescheduling interviews, locating the correct person to talk to, getting people to voluntarily participate, getting people to respond to requests, etc. As with most problems, tact, perseverance, and starting to collect data early aided greatly in navigating through these difficulties.

Case Study Questions and Data Collection.

The heart of this case study protocol is the substantive questions that form the research and the data collected. The research question was designed to address the Problem Statement introduced in Chapter I. Logically, the four investigative questions address the research question. If all four investigative questions were answered, then the research question could be fully answered. See Figure 13 below.

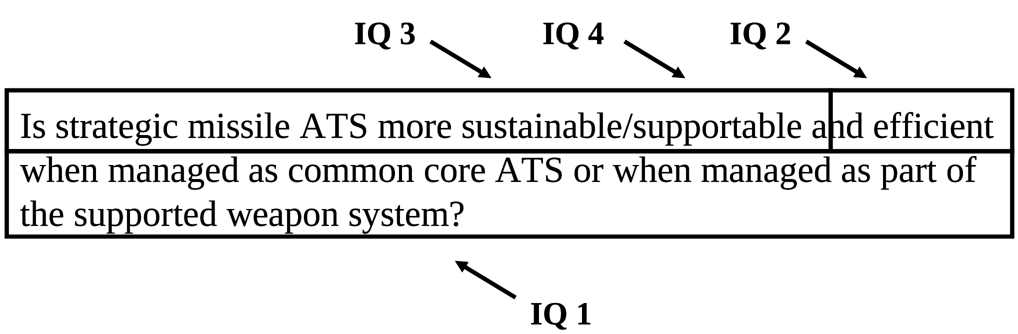


Figure 13. Dissection of the Research Question

Investigative Questions.

1. What are the ATS management differences between common core and weapon system unique System Program Office approaches?

> This investigative question focused on ATS program management and how or if their decisions impact the sustainability and supportability plans for the ATS they manage.

2. How much funding is budgeted/funded in the Program Objective Memorandum and Future Year Defense Plan for both ATS programs being studied?

> This investigative question sought to better understand the efficiency component of the research question. Efficiency was examined to facilitate financial requirement comparisons between the two ATS programs.

3. What are ATS System Program Office, Depot, and Major Command assessments of long-term ATS sustainability for both programs being studied?

> The goal of this investigative question was to clarify current and future sustainability issues facing each ATS program so they could be compared.

4. For both ATS programs being studied, what are Major Command assessments of their field units' ability to support their assigned support equipment with the available ATS resources and System Program Office support?

> This investigative question sought the users' perspective on how well their System Program Office/Depot supported field unit needs regarding their

assigned ATS. These assessments enabled supportability comparisons between the two programs.

Data collected to answer Investigative Questions 1, 3, and 4 was expected to be purely qualitative, while data collected for Investigative Question 2 was expected to be both qualitative and quantitative.

Data Collection.

To maximize the benefits of data collection, Yin recommended following three principles. First, using multiple sources of evidence will assist convergence and triangulation on facts (Yin, 2003:97). Second, Yin recommended assembling the data separately from the final report to help readers better understand any conclusions (Yin, 2003:101). Third, a clear chain of evidence that links the question asked, the data collected, and the conclusions drawn further assists the reader in following the research's logic (Yin, 2003:97-105). A Data Categorization Matrix (See Appendix H) was developed to provide a means to categorize/characterize data before beginning the analysis. Any conclusions made by this research should be traceable back to the matrix.

This research primarily focused on data collection through interviews and secondarily on documents and archival records. The distinction between documents and archival records is slight, but notable. Documents usually take the form of letters, memorandums, published guidance, etc. Archival records can take these forms as well but usually contain a majority of quantitative data (Yin, 2003: 85-86).

To facilitate data collection during interviews, questionnaires were developed for each investigative question (See Appendix D – G). These questionnaires were developed with the assistance of Captain Howe to guide his data collection as well. In determining the interview questions, each investigative question was broke down to its basic elements and then addressed individually. The goal was to build a repeatable methodology that future researchers could follow; therefore, standardized questionnaires that anyone could use while collecting interview data for ATS programs were built. Because these are standardized questionnaires, the questions were used to guide interviews and were not intended be rigidly followed. Interviewees that stray away from the topic of discussion were allowed to continue so as to not stifle their thoughts. Questionnaires were sent to interviewees well in advance of the scheduled interview to help them prepare. To ensure the data was captured during the interview, notes were transcribed directly into the electronic questionnaire. Immediately after the interview, the notes were developed into full narrative answers and forwarded to the interviewee for their review. They were encouraged to clarify or expound on their responses and send the finalized questionnaire back to the researcher.

Documents and archival records were collected as well. These were particularly useful because they were less biased than a person's telephone response to a questionnaire. During the interviews, the interviewee was asked for any documents or archival records that helped address the interview questions. Because multiple sources were sought, contradictory answers were expected. When this happened, interviewees were contacted to clarify their original answers or to explain the documents. When there were still contradictory answers, both answers were provided in the findings.

Guide for the Case Study Report.

Yin points out case study reports do not have a uniformly accepted outline as seen in traditional scientific experiments (Yin, 2003:77). For this reason, it is important to give thought to the presentation of findings and the analysis before collecting the data so the researcher can logically guide their research. The following three subsections briefly describe how the findings and analysis are presented in Chapter IV.

Describing the Data Collected.

Types and quantity of data from each ATS program is presented before answering the investigative questions.

Answering the Investigative Questions.

Each investigative question is answered for the two ATS programs under study. Differences and similarities between the two ATS programs are discussed. Completed Questionnaires are located at Appendix N – AJ and have been redacted to protect interviewee confidentiality.

Data Analysis.

To assist with data analysis, a tool was designed that provides a way to visually categorize and characterize all the research data on a single page. The Data Categorization Matrix (See Appendix H) satisfied several other research needs as well: it ensured a thorough data review; it provided a way to discern the most meaningful data; it assisted program comparisons; it facilitated general theory building; and it provided a logical path others can follow.

After thoroughly reviewing and categorizing/characterizing the data with the matrix, the results of each investigative question were compared between the Cruise Missile and ICBM ATS programs to subjectively determine the degree of difference. Next, the four investigative questions were prioritized from most different to least different. This prioritization was the basis for theorizing dependencies between program management approach (common or weapon system specific), sustainment, supportability, and funding. Based on research results and analysis, lessons learned and proposed implications are presented in Chapter V.

Summary

This chapter described the research designs, methodologies, and strategies considered to conduct this research. The researcher selected a multiple-case study design to guide the comparison of both strategic missile ATS programs. Specific protocol and data collection procedures were designed to facilitate a comprehensive comparison with the goal of explaining and building theory. A brief overview of the findings and analysis report format was also provided.

IV. Results and Analysis

Overview

The purpose of this chapter is to explain the results and analysis from the case study. This chapter starts by describing the data collected to conduct this research. Next, the answers to the investigative questions cited in Chapters I and III are provided. Last, a structured data analysis is described which formed the basis for theorizing dependencies between the topics of the four investigative questions.

Data Collected

The specificity of this research topic dictated the organizations required to provide data to conduct this study. System Program Offices responsible for ATS program management and MAJCOM staffs responsible for providing their units with the ATS they need to perform their missions were the focus of this research. These offices are specified within the Field Procedures Section in the previous chapter. Confidentiality had to be protected for each person that participated in this research's interviews as a prerequisite for the Wright Site Institutional Review Board granting permission to conduct interviews. For this reason, their names are not provided, and the completed questionnaires at Appendix N through AJ have been redacted.

Interviews.

In all, 12 interviews were conducted, resulting in 23 completed questionnaires (See Appendix N through AJ). The quantity and quality of interview data were considered equal from both groups involved in this case study. Those interviewed seemed candid, and there were very few disparities in the interview data. Countering views are provided while answering the four investigative questions in the Results Section.

Cruise Missile ATS Interviews.

Three Cruise Missile ATS subject matter experts from Headquarters Air Combat Command (HQ ACC) participated in telephone interviews. Questionnaires pertaining to long-term ATS sustainment and supportability of currently fielded ATS were administered to HQ ACC personnel. From the System Program Office within the Automatic Test Systems Division at Warner Robins AFB, three functional experts participated in telephone interviews. Questionnaires regarding Cruise Missile ATS program management, long-term sustainment, and program funding were administered to System Program Office personnel.

Intercontinental Ballistic Missile ATS Interviews.

Three ICBM ATS subject matter experts from Headquarters Air Force Space Command (HQ AFSPC) and Twentieth Air Force participated in telephone interviews. Questionnaires pertaining to long-term ATS sustainment and supportability of currently fielded ATS were administered to HQ AFSPC personnel. From the Minuteman III System Program Office at Hill AFB, three functional experts participated in telephone interviews. Questionnaires regarding ICBM ATS program management, long-term sustainment, and program funding were administered to System Program Office personnel.

Documents and Archival Data.

Supporting documents and archival records were solicited during the interviews. A considerable number of documents were collected from the Cruise Missile group; however, very little documentation was obtained from the ICBM group. Several avenues were pursued to collect documentation from the ICBM group, but it appeared documentation similar to that collected from the Cruise Missile group did not exist. The difference in the quantity of documentation was attributed to the level of senior leadership concern with Cruise Missile ATS sustainment and funding matters. This difference in amount of documentation is further discussed while answering the four investigative questions in the Results Section.

Results

Investigative Question 1.

What are the ATS management differences between common core and weapon system unique System Program Office approaches?

Both offices responsible for managing the ATS under study are organized similarly and perform the same functions. Cruise Missile ATS and ICBM ATS program offices are both organized as Integrated Product Teams; that is, functional expertise (contracting, equipment specialists, engineering, logistics, etc.) is matrixed to a central team responsible for managing a specific program. Both program offices have similar functional expertise within their Integrated Products Teams, and both conduct monthly meetings to discuss program updates. Their daily activities are very similar; they both plan, manage, coordinate, track metrics, etc. Also, both program offices routinely interface with field units to address their ATS issues on a similar basis. Although the team structure and administrative responsibilities are similar, there are stark differences in systems knowledge and the way they address obsolescence/diminishing manufacturing sources issues.

The amount of systems knowledge was higher within the ICBM group than it was in the Cruise Missile group. Cruise Missile ATS is managed by Warner Robins Air Logistics Center's ATS Division, responsible for over 70% of the Air Force's ATS, but they do not manage any of the weapon systems the ATS supports (Johnson, 2004). The Cruise Missile programs are managed by the Cruise Missile Product Group at Oklahoma City Air Logistics Center. Interviewees within the Cruise Missile Group believe their systems knowledge of their assigned ATS suffers from this split responsibility (See Appendix N, P, W, X). Cruise Missile ATS Integrated Product Team members (at WR-ALC) are in routine contact with the Cruise Missile Product Group (at OC-ALC) to discuss ATS technical issues and to provide technical assistance with testing possible ATS upgrades (Appendix P). This split responsibility limits their ability to adequately "care and feed" for their program also.

At the program level, Cruise Missile ATS requirements are strongly linked to supporting the Cruise Missile fleet and articulated up their leadership chain. As support initiatives are pushed up the leadership chain, the impacts of Cruise Missile ATS sustainment on the supported weapon system are less understood and supported because their time and resources are devoted to ATS in imminent "crisis" (Appendix P, Q). Interviewees believed ATS does not get the due attention of senior leadership unless it is immediately in danger of impacting a weapon system because of severe under-funding of common ATS (Appendix P, Q). The farther away these requirements get from the System Program Office, the less the requirement is linked to an actual weapon system (in this case, Cruise Missiles) and supported. Management of Minuteman III ATS and the Minuteman III weapon system reside together. Because the ICBM core expertise is located within the same division at Hill AFB, splitting of expertise and requirements does not exist in their program. This allows ICBM ATS requirements to be more directly tied to the weapon system requirements and advocated with a single voice.

The deepest difference between the management of these two ATS programs stems from the way in which they chose to address obsolescence and diminishing manufacturing sources problems. Cruise Missile ATS was fielded throughout the early to mid 1980s, and ICBM ATS was fielded in the mid 1980s (Appendix P, Q, AD, AF). Given the age of both systems, it is understandable they are both facing considerable obsolescence and diminishing manufacturing sources problems. Although both ATS systems under study are projected to be unsupportable in the 2008-2010 timeframe, both have far different plans to address the problem. Interestingly, both of these systems have many of the same obsolete components, but these problems are being addressed entirely differently.

Addressing ICBM ATS Obsolescence.

The majority of the ICBM ATS obsolescence problems stemmed from the government's management of Commercial-off-the-Shelf components installed in the E-35 Electronic Equipment Test Station (Appendix AD, AF). Item Managers responsible for these components relied on larger users (typically aircraft program offices) to integrate "suitable substitutes" with their systems, and then, the component Item Manager would induct these new substitutes into the Air Force supply system to replace the previously fielded parts through attrition. ICBM field units frequently order a part and receive a “suitable substitute” that will not fit/work within the E-35 Electronic Equipment Test Station.

Addressing this problem, the ICBM ATS group has been focused on acquiring a new test set named Ground Minuteman Automatic Test System (GMATS) since the late 1990s. A system overview for Ground Minuteman Automatic Test System is located at Appendix J. While acquiring this new ATS, ICBM ATS program management decided to partner with industry to provide configuration control and parts replenishment rather than rely on the government Item Managers as before (Appendix AD, AF). By adopting Integrated Contractor and Integrated Logistics Support (ICS/ILS), the program office hopes to avoid the seemingly random replacement of components and subcomponents they require to maintain the Ground Minuteman Automatic Test System. Ground Minuteman Automatic Test System was designed to support the Minuteman III weapon system through 2020.

Because the first deliveries of this ATS are being made to field units in spring 2005, they are currently focused on successfully bedding down the new ATS and ensuring the field units receive training.

Addressing Cruise Missile ATS Obsolescence.

Since 2000, the Cruise Missile ATS group attempted to fund a service life extension study to investigate their obsolescence issues. In 2003, they received sufficient fall out money (583 Sustaining Engineering) from the Global War on Terrorism to charter the study. The study provided three options: 1) procure a custom Commercial-off-the-Shelf tester, 2) procure a common Commercial-off-the-Shelf tester (a good example is GMATS), and 3) create a form, fit, function replacement plan that addresses each obsolete component on a priority basis (AES and UDRI, 2004). The Cruise Missile program management team opted for the form, fit, function option because they did not think they would receive the funding required to procure a new tester. They also felt they could adequately address the component-level problem (assuming the components are not disposed of), extending the sustainability of the Cruise Missile ATS out to 2030—the life of the Cruise Missile fleet. The design life of the current Cruise Missile ATS was for 15 years—it is currently 23 years old (Appendix P, Q).

The Cruise Missile ATS program expects to experience an increased amount/rate of unsupportable components due to Item Managers disposing of parts deemed obsolete by other weapon systems. They recognize their form, fit, function plan relies heavily on the Air Force supply system to provide the parts required to keep the ATS operating. This problem has occurred several times in the past. In several cases, depot technicians have had to remove parts from warehoused Cruise Missile ATS to fill orders because component-level Item Managers no longer stock the required parts—the same problem the ICBM ATS group experienced. Interviewees cited numerous reasons Item Managers dispose of components to include: infrequent orders, deemed obsolete, replaced by newer model, etc.

In short, daily administrative tasks are similar between the two ATS programs, but there are considerable differences in system expertise and plans for addressing obsolescence.

Investigative Question 2.

How much funding is budgeted/funded in the Program Objective Memorandum and Future Year Defense Plan for both ATS programs being studied?

The largest difference between these two programs is funding. For the last seven years, little progress has been made to secure the funding required for Cruise Missile ATS; no one is quite sure whose responsibility it is to *program* (POM) for Cruise Missile ATS (Appendix R, V). Appendix K indicates the Cruise Missile ATS Operations and Maintenance funding levels over the past 5 years. Conversely, ICBM ATS has received considerable funding for a major ATS replacement program totaling more than $100M as a result of Air Force Space Command POM submissions. The detailed funding for the replacement ICBM ATS effort is in Appendix L.

In theory, the Air Force's Planning, Programming, Budgeting, and Execution System treats all programs the same way. That is, each program is given a Program Element Code (PEC) and Major Command/Air Staff Program Element Monitors (PEMs) articulate their program requirements at their level to secure necessary funding.

Cruise Missile ATS falls under the Common Systems Program Element Code, 78070, with hundreds of other Air Force common testers, ranging from small multi-meters to large integrated test sets. Air Force Materiel Command's Directorate of Requirements has management responsibility of Program Element Code 78070 but has never included any Cruise Missile ATS requirements in their POM submissions to the Air Staff. There appears to be two reasons for their failure to fund Cruise Missile ATS requirements: 1) Program Element Code 78070 has historically provided only procurement funding more inline with replacing small test equipment like multi-meters and oscilloscopes; and 2) Program Element Code 78070 has historically been significantly under funded.

Directly answering the investigative question, there has been zero dollars budgeted in the POM for Cruise Missile ATS over the last seven years (Appendix R, V). Cruise Missile ATS has only received small amounts of Operations and Maintenance funds for software and exchangeable upkeep and limited amounts of Material Support Division funds used to solve component-level problems, not tester-level problems. Tester-level problems require Element of Expense Investment Code 583 funds, which Cruise Missile ATS has only received once (fallout money from Global War on Terrorism), over the past 7 years. These funds were used to contract out the *Cruise Missile, Bomber Suspense/Release ATS/ATE Roadmap* that assessed the obsolescence options for the ATS (AES and UDRI, 2004). Headquarters Air Combat Command has linked the Cruise Missile ATS funding issue to the inability to properly sustain Cruise Missile ATS beyond the 2008-2010 timeframe. The topic of Cruise Missile ATS funding has received considerable attention from Air Force senior leadership, but no funding has resulted.

Falling under Program Element Code 11213 with the Minuteman III weapon system, ICBM ATS has received procurement funding to replace the obsolete equipment with the Ground Minuteman Automatic Test System (Appendix AI).   The procurement of Ground Minuteman Automatic Test System was over $100M and was managed at a relatively low level compared to the senior leadership involvement with Cruise Missile ATS. Appendix J provides an overview of GMATS.

Investigative Question 3.

What are ATS System Program Office, Depot, and Major Command assessments of long-term ATS sustainability for both programs being studied?

For the purpose of this research, sustainability was defined as the degree to which depots and System Program Offices provide reliable and maintainable equipment over the long-term. The Cruise Missile ATS program is frustrated with the progress they have made to address their sustainability issues. In their opinion, funding remains their largest hurdle to properly address sustainability (Appendix S, T, W). Headquarters Air Combat Command, the user of Cruise Missile ATS, is also concerned and has spent considerable effort over the past 5 years to articulate the importance of adequately addressing the Cruise Missile ATS sustainment issues to Warner Robins Air Logistics Center and HQ Air Force Materiel Command's Directorate of Requirements. As indicated while answering Investigative Question 2, Program Element Code 78070 only provides procurement funds for small test equipment and has been historically under funded. The ICBM ATS program has not suffered in a similar manner. The ICBM ATS program has procured new ATS for their weapon system which promises to remain sustainable through 2020 (J, Z, AB, AE). ICBM ATS program management and Headquarters Air Force Space Command, the user of ICBM ATS, are satisfied with their sustainment effort.

Cruise missile sustainability issues started to arise in the late 1990s. The expected drop dead date for the system is between 2008 and 2010. The Cruise Missile ATS sustainment plan lists 9 prioritized projects that, if adequately addressed, will extend the system out to 2030, which is the projected life span of the Cruise Missile fleet (see Appendix M for the Cruise Missile Sustainment Plan). However, these priorities are contingent on adequate funding given at finite intervals over the next 25 years. Cruise Missile ATS interviewees view funding as the largest hindrance to long-term sustainment based on their inability to secure funding in the past (Appendix P, R). They have assumed they will not receive any procurement dollars for the life of the program and have been forced to build a long-term sustainment plan that addresses one priority at a time and is dependent on Materiel Support Division funds (Appendix R, V). All Air Force programs compete annually for Materiel Support Division funds to conduct component-level studies. Because these funds are competitive and only available one year at a time, Cruise Missile ATS program management can only plan short-term sustainment projects. When unplanned problems arise, spare Cruise Missile ATS in the depot warehouse are cannibalized to provide replacement parts to field units.

Further exacerbating the sustainability problems associated with Cruise Missile ATS is the fact that program management was transferred from San Antonio-Air Logistics Center to Warner Robins-Air Logistics Center in 2000, shortly after obsolescence issues started to dramatically increase. From 1995 through 1999, San Antonio failed to address any sustainability issues, leaving Warner Robins behind the sustainment curve (Appendix P, T, V).

Cruise Missile ATS sustainability has received considerable attention from HQ Air Combat Command, Air Force Materiel Command, and the Air Staff. Headquarters Air Combat Command’s Logistics’ Directorate cited Cruise Missile ATS as their #1 sustainment concern for WR-ALC in 2003. Brigadier General Collings, HQ/ACC LG, sent a memo of concern to Major General Wetekam, WR-ALC/CC, specifically addressing the concern over Cruise Missile ATS sustainment. In turn, Major General Wetekam replied supporting Brigadier General Collings' position and stated his "Center" would search for solutions and asked Brigadier General Collings' to also send a memo to Air Force Materiel Command's Director of Requirements (AFMC/DR) with the same concerns. AFMC/DR agreed they had responsibility to *program* for the sustainment effort, but when they were informed the effort would be in excess of $100M, they changed their position regarding sustainment funding. The Air Force's General Officer Nuclear Surety Steering Group routinely discusses the Cruise Missile ATS issue in their bi-monthly teleconferences. Lieutenant General Reynolds, a member of the steering group and the Vice Commander for Air Force Materiel Command, is involved in the issue as well. The cruise missile ATS sustainability funding issue is being prepared for presentation to the Air Force Board (Appendix V). The Air Force Board resides within the Air Staff and is chaired by a 2-star general. The Board is responsible for resolving issues, particularly funding, within integrated programs. If resolution is not reached at this level, it will be elevated to the Air Force Council chaired by the Air Force's Vice Chief of Staff. In short, the Cruise Missile ATS program has been plagued with sustainability issues and has received considerable general officer attention but continues to make little progress regarding funding responsibility.

Although the ICBM System Program Office faced the same sustainability issues with the same drop dead date of 2008-2010, they were able to field a long-term sustainability solution by replacing the E-35 Electronic Equipment Test Station. The Ground Minuteman Automatic Test System (GMATS) is the new ICBM ATS and was designed to last through 2020. Appendix J provides an overview of Ground Minuteman Automatic Test System. ICBM ATS program management hopes the new ATS will last even beyond 2020 based on their integrated contractor support. Ground Minuteman Automatic Test System stations will be installed at operational locations from the spring 2005 through fall 2006 (Appendix Z, AE). To date, they have had only a few problems regarding software and Test Program Set development. These problems were overcome with additional funding, and the program stayed on schedule. This researcher could not find any memos of concern or general officer involvement regarding ICBM ATS. The issue appears to have never gotten above the colonel-level and continues to be worked at Headquarters Air Force Space Command by one master sergeant and at Headquarters Twentieth Air Force by two technical sergeants. The long-term sustainment plan does not rely on organic Air Force supply that requires lifetime buys of all replacement parts. Instead, program management established a partnership with Boeing to provide integrated contractor/logistics support to ensure their system receives the attention it did not get under Air Force Item Manager control (Appendix Z, AJ).

Investigative Question 4.

For both ATS programs being studied, what are Major Command assessments of their field units' ability to support their assigned support equipment with the available ATS resources and System Program Office support?

For the purpose of this research, supportability was defined as the degree to which field level technicians can repair the equipment in the short-term. Both the Cruise Missile and ICBM ATS suffer almost equally regarding supportability because of their equal age and design. There are a few differences worth noting.

Supportability issues for Cruise Missile ATS were of such high concern at Headquarters Air Combat Command that they permanently assigned their functional staff expert to WR-ALC as a "liaison" to help address supportability issues (Appendix U). Until the ACC liaison arrived at WR-ALC, many operational units called the Cruise Missile Product Group (formal name of the Cruise Missile Systems Program Office) for ATS support rather than the Cruise Missile ATS Systems Program Office (Appendix N, O). The Cruise Missile ATS office also relies on the Cruise Missile program office for ATS supportability questions. Out of necessity, Cruise Missile ATS program management has relied heavily on addressing component level solutions so they have worked very closely with the component-level Item Managers to ensure the parts are not dumped out of the supply system (Appendix U). From the operational unit's perspective, they appear to get replacement parts in a timely fashion. However, parts are either coming from the supply system through the depot requiring modification or from cannibalizing spare equipment in the depot warehouse. It is unknown how long cannibalizing will sufficiently last. Occasionally, replacement parts remain on back order for up to a year until a source is found by the Item Manager or the equipment specialist. There appears to be a strong relationship between the Cruise Missile ATS program and the component-level Item Managers.

The ICBM program office has more heavily relied on the Air Force supply system and did not invest as heavily in a relationship with the component-level Item Managers. According to those interviewed, the ICBM ATS group appears to receive incorrectly configured parts more frequently than the Cruise Missile ATS group (Appendix Y, Z). Also, more replacement parts remain on back order longer. To mitigate this problem, they developed a defensive component-level repair plan where the ICBM ATS depot's Precision Measurement Equipment Laboratory (PMEL) repairs their faulty ATS components. This plan seems sound and reasonable, but masks repairs from the Air Force supply system. To remedy this problem in the future, they have established a contractor support plan for all spare parts. ICBM ATS program management and Air Force Space Command subject matter experts have been very pleased with PMEL's support and credit them for the current ICBM ATS lasting this long. Also, the ICBM community has an effective process to quickly dispatch depot technicians to field locations if needed (Appendix Y, Z).

In short, both System Program Offices and depots provide approximately the same level of parts availability and technical assistance, but they have different means. The Cruise Missile ATS group works closely with component Item Managers, cannibalizes spare parts from warehoused spares when parts are not available in the Air Force supply system, and are rarely required to dispatch depot technicians to repair ATS in the field. The ICBM ATS group depends heavily on their ATS depot to repair faulty parts instead of relying on component Item Managers, and they more readily dispatch depot technicians to repair ATS in at field units.

Analysis of Data

Because of the large amount of data collected, it was important to develop a systematic way to convert the data into meaningful information. To do so, the results of each investigative question were reviewed, and the source data was categorized/characterized with the matrix located at Appendix H. The matrix satisfied three primary purposes: 1) *thoroughness,* it required a line-by-line data review before any correlations were made; 2) *ease of use,* it provided the means to organize the data in a summarized single-page; and 3) *traceability,* it provided a means for others to understand the logical steps of any theory that emerged. The completed matrix is located at Appendix I.

Categorizing Data.

To categorize, the *data type* and *quantity of data* were identified for each ATS group and each interview question. Data type was simple to assign, but quantity required a degree of subjectivity. Generally, one or two sources resulted in a quantity assessment of low. Three or four sources resulted in a quantity assessment of medium. A greater number of sources or what seemed to be irrefutable data resulted in a quantity assessment of high. Again, these were subjectively assessed.

Characterizing Data.

After thoroughly reviewing and categorizing the data for a given line on the matrix, the data between the two ATS programs was compared. If the data from both programs seemed *contradictory*, the “Compare” block was marked with a --. If the data from both programs seemed *marginal,* the “Compare” block was marked with a 0. If the data from both programs seemed *equivalent*, the “Compare” block was marked with a ++. If the data from both programs seemed *similar but with 1 notable difference,* the “Compare” block was marked with a +-. The most relevant comments were annotated as well. After repeating this process for each interview question in the matrix, the overall investigative question was characterized based on the aggregate of the line-by-line comparisons. Investigative questions were not quantitatively characterized; that is, the majority of -- or ++ assessments did not rule. Many of the individual questions could be classified as minor or major and had to be factored in the assessment. The comment block was helpful in discerning the relevance of any given line. Again, these were subjectively assessed.

Findings for Cruise Missile ATS and ICBM ATS regarding Investigative Questions 2 (funding) and 3 (sustainment) were the most different, while Investigative Questions 1 (program management) and 4 (supportability) were the most similar. Stratifying the four investigative questions from most different to most similar was as follows:

1) Investigative Question 2 (funding): While Cruise Missile ATS severely lacks funding, ICBM ATS has received over $100M to replace their obsolete ATS. See results in Table 6.

Table 6. Categorized and Characterized Data for Investigative Question 2

	Type and Quantity of Data				**Compare**	**Comment/Theme/Note/Trend**
	Cruise Missile ATS		ICBM ATS		Each Question	Each Question
IQ 2	Question 1	I, D High	I Medium	Question 1	**--**	CM = unknown. ICBM = AFSPC.
	Question 2	I, D High	I Medium	Question 2	**+-**	Both have unfundeds. CM group addresses them one at a time. ICBM group buying new system.
	Question 3	I, D, A High	I, A Medium	Question 3	**--**	CM group never has POMed, ICBM group secured $107M for new tester.
	Question 4	I, D High	I Low	Question 4	**--**	CM group = No. ICBM group = Yes.
	Question 5	I, D, A High	I, A Medium	Question 5	**--**	CM group never has POMed, ICBM group secured $107M for new tester.
	Question 6	I Medium	I Low	Question 6	**N/A**	CM group, replacement bill was far too high→FFF plan. ACC, would like ATS to go to CMPG with CMs.

2) Investigative Question 3 (sustainment): The Cruise Missile ATS sustainment plan is to address 9 prioritized projects (Appendix M) over the next 25 years

requiring near-guaranteed funding before each project start. The ICBM ATS sustainment plan is to procure new ATS and to shift the replacement parts responsibility from organic Air Force support to Integrated Contractor/Logistics Support. See results in Table 7.

Table 7. Categorized and Characterized Data for Investigative Question 3

	Type and Quantity of Data				**Compare**	**Comment/Theme/Note/Trend**
	Cruise Missile ATS		ICBM ATS		Each Question	Each Question
IQ 3	Question 1	I, D High	I High	Question 1	++	Very similar sustainment issues apply to the E-35 and ESTS.
	Question 2	I, D High	I High	Question 2	--	CM Plan = FFF, risky considering MSD funds. ICBM Plan = enitre ATS replacement.
	Question 3	I, D High	I High	Question 3	+-	Yes for both, approaches significantly differ. CM , FFF plan. ICBM, GMATS solved problem.
	Question 4	I, D, A High	I High	Question 4	--	CM, drop dead = 2010 if FFF projects not funded. ICBM, drop dead = 2020 with GMATS (maybe longer).
	Question 5	I, D High	I Medium	Question 5	++	CM and ICBM ATS sustainment issues arose 1997 timeframe.
	Question 6	I, D High	I Medium	Question 6	++	Both groups viewed sustainment issues as a high priority. CM group has had difficulty getting traction.
	Question 7	I Medium	I Medium	Question 7	N/A	Both groups commented on units band-ading problems to prevent spending O&M dollars--masks issues.

3) Investigative Question 1 (program management): Both programs are organized and support the user similarly, but are currently devoted to dissimilar projects. Cruise Missile ATS program management has been focused on addressing obsolescence with component-level solutions for the past 5 years. ICBM ATS program management is focused on bedding down the Ground Minuteman Automatic Test System at field operating locations. See results in Table 8.

Table 8. Categorized and Characterized Data for Investigative Question 1

	Type and Quantity of Data				Compare	Comment/Theme/Note/Trend
	Cruise Missile ATS		ICBM ATS		Each Question	Each Question
IQ1	Question 1	I Medium	I Medium	Question 1	++	Same Responsibilities.
	Question 2	I Medium	I Medium	Question 2	--	Both work sustainment/support daily, but ICBM ATS mainly works on fielding new GMATS.
	Question 3	I Medium	I Low	Question 3	--	CM ATS plan for component level solutions, ICBM ATS plan for system level solutions.
	Question 4	I Medium	I Medium	Question 4	++	Both treat field user issues similarly.
	Question 5	I, D Medium	I Low	Question 5	++	Both systems are relatively same age, CM ATS is slightly older.
	Question 6	I Low	I Low	Question 6	++	Both current ATS replaced previously obsolete equipment.
	Question 7	I, D High	I, A Medium	Question 7	++	Both suffer from 90+% COTS equipment obsolescence.
	Question 8	I, D High	I Medium	Question 8	--	CM = money. ICBM = supporting the E-35 with COTS equipment managed outside of OO-ALC and ICBMs.
	Question 9	I Medium	I Medium	Question 9	+-	Both routinely work with similar government POCs, but ICBM group works more with prime contractor.
	Question 10	I Low	I Low	Question 10	++	Both groups were mixed on being aware of DoD Common ATS policy.
	Question 11	I Low	I Low	Question 11	++	Mixed replies. Interesting note: GMATS is within an approved family eventhough considered unique.
	Question 12	I Low	I Low	Question 12	N/A	Not much to add. ICBM group is addressing their unique challenge by going with ICS.

4) Investigative Question 4 (supportability): Generally, both ATS program offices provide good support to the field units, and replacement parts availability is similar as well. It is assumed that once the new ICBM ATS is fielded, parts availability will significantly improve, given the severe obsolescence of the ICBM ATS currently fielded. Technical ATS issues were addressed better in the ICBM community than in the Cruise Missile community by their respective System Program Offices because of the advantages of centralized management and more robust resources. See results in Table 9.

Table 9. Categorized and Characterized Data for Investigative Question 4

	Type and Quantity of Data				Compare	Comment/Theme/Note/Trend
	Cruise Missile ATS		ICBM ATS		Each Question	Each Question
IQ4	Question 1	I Medium	I Medium	Question 1	0	Both groups get parts, but rates widely vary. Back orders seem to impact ICBM group more heavily.
	Question 2	I Medium	I Medium	Question 2	0	Fullfillment time appears to be longer and more variable for the ICBM group.
	Question 3	I Medium	I Medium	Question 3	++	Doesn't happen often for either group. Tech data is mature for both systems.
	Question 4	I Medium	I Medium	Question 4	++	TOs for both groups are generally good.
	Question 5	I Medium	I Medium	Question 5	++	TCTOs are rare, but have been historically good.
	Question 6	I Medium	I Medium	Question 6	--	CM units rely heavily on CMPG for ATS assistance, vice LEA. ICBM units receive good SPO support.
	Question 7	I Medium	I Medium	Question 7	0	Anecdotal evidence suggests slight increase for CM ATS and slightly higher for ICBM ATS.
	Question 8	I Medium	I Medium	Question 8	+-	Common for both. However, ICBM ATS appears to have longer fullfillment time of backorders.
	Question 9	I Medium	I Medium	Question 9	N/A	Both program offices generally provide good support, but LEA appears to be on constant learning curve.

Picking a Starting Point for Building the Dependency Model.

Invariably, interviewees within the Cruise Missile ATS group strongly linked funding to the ability to sustain the ATS over the long-term. The Cruise Missile interviewees were very aware of how funding worked, and because they had very little funding, they were focused on addressing each component-level problem one at a time. Within the ICBM ATS group, funding was not their main concern and their sustainment plan was very solid. They were just about to begin installations of the new Ground Minuteman Automatic Test System at field units, extending ATS sustainability out to 2020. The relationship between Investigative Questions 2 (funding) and 3 (sustainment) served as the starting point of a dependency model. Table 10 is the aggregate result for each investigative question comparison.

Table 10. Summary Results for All Investigative Questions

	Program Similarity or Difference	Comment/Theme/ Note/Trend
IQ1	+-	Similar age/problem, different level of management control
IQ2	--	CM ATS can't get into POM, ICBM ATS fairs well in POM.
IQ3	--	CM, FFF sustainment plan. ICBM, entire ATS replacement.
IQ4	++	Generally, good support from both program offices to field

Because the findings of Investigative Questions 2 (funding) and 3 (sustainment) are near opposite extremes between the two ATS groups and interviewees asserted the presence of strong linkages, I logically correlated funding with sustainment. This strong correlation seems obvious, but I felt it was important to establish a firm starting point before proposing theoretical relationships between the investigative questions. Given this starting point, dependencies were posited between all four investigative questions as indicated in Figure 14.

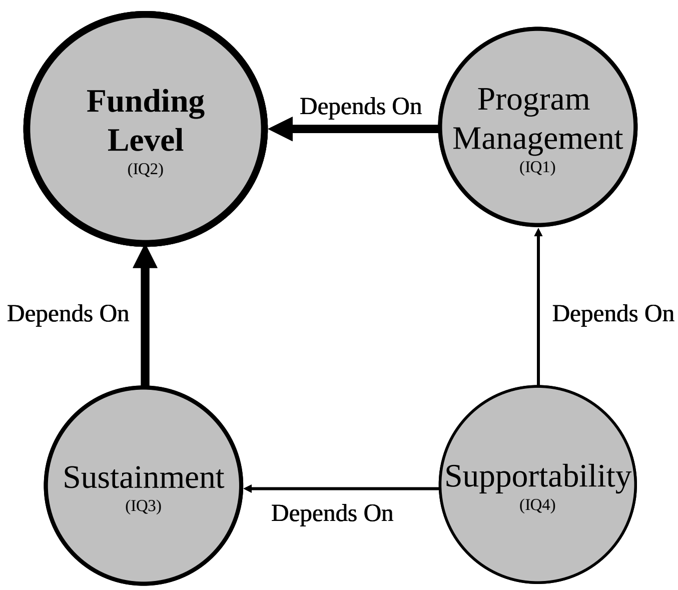


Figure 14. Theoretical Dependency Model

Relationships between Investigative Questions.

Correlating funding with sustainment is a logical inference, but which one is dependent on the other? There are two alternatives: 1) funding level dictates the sustainment plan, or 2) the sustainment plan dictates the funding level. Both of these propositions seem logical, but the first alternative appears to match the realities of the Air Force's fiscally constrained environment. The second alternative assumes a program office will receive all the funds required to execute an ideal program—not a realistic expectation.

The findings of this research indicated that both program offices for Cruise Missile ATS and ICBM ATS built their sustainment plans based on the funding they secured, not the other way around. The ICBM ATS program received all the funds they required to replace all the obsolete ATS—an ideal situation. The Cruise Missile ATS program received limited operations and maintenance funds and a limited amount of funds from the Material Support Division to address component-level solutions over a protracted period—a risky plan with serious implications. Assuming this research's findings are accurate, the sustainment plan is understandably dependent on the funding level. Given this dependency, it would follow that program management's other routine tasks of planning, controlling monitoring, and evaluating also depend on the funding level. Lastly, is supportability more directly dependent on funding, the sustainment plan, or the design of program management? In this case study, supportability was more directly associated with the ATS sustainment plans built in the mid-1980s and with the priorities of program management. One could argue that supportability could be linked with funding as well, but this researcher postulates that the link to funding is indirect based on the data collected from both ATS programs.

Summary

Using the case study methodology identified in Chapter III, data from numerous sources were collected, and then used to answer this research's four investigative questions. The process of categorizing and characterizing the data revealed substantial differences between Cruise Missile ATS and ICBM ATS funding and their sustainment plans which appeared to be linked. These differences were the starting point for proposing a theoretical model that linked dependencies between the four investigative questions.

V. Conclusions and Recommendations

Overview

The purpose of this chapter is to address the research question based on the findings and analysis from Chapter IV, to examine implications of this research for the US Air Force, and to recommend areas for future research that were beyond the scope of this study.

Addressing the Research Question

Is strategic missile ATS more sustainable/supportable and efficient when managed as common core ATS or when managed as part of the supported weapon system?

Sustainability/Supportability.

In short, strategic missile ATS is more sustainable/supportable when managed as part of the supported weapon system. It was expected that the research might lead to this conclusion, but the reason is quite different than originally thought. The research question was originally framed based on the assumption there was a dominating link between program management approach (common or weapon system specific) and a given program's success that was stronger than all other factors. By breaking the research into four components, the researcher was able to study this proposition. The dependencies proposed in Figure 14 are far different than originally expected. Surprisingly, program management (common or weapon system specific) was the third most significant factor. ATS funding was the dominant factor for both programs involved in this case study and their long-term sustainment plans appeared to correlate with funding. Little could be discerned between the two ATS programs' supportability component, adding further credibility to the conclusion that program management was less influential than originally thought.

Efficiency.

It is difficult to determine which approach is more efficient. On the surface, Cruise Missile ATS spends far less funds but only because the program has not historically received adequate funding from its inception. Funding is only one portion of the efficiency equation. The efficiency equation should consider funding spent along with the other resources consumed to maintain the same level of sustainability/supportability.

When the research question was originally framed, the efficiency component purely had to do with efficient use of program funding. As the research progressed, efficiency began to take on a second meaning (and possibly more dominate than funding) that had to do with the efficient use of all resources, not just money. For this reason, it was difficult to determine which program management approach was more efficient.

By only inspecting the dollars spent on both programs, the ICBM group spent a significantly higher amount of money on their program up front. Their $107M investment will provide sustainable ATS through the year 2020 for the Minuteman III program. The Cruise Missile ATS program is planning to spend $11M (in 2004 dollars) over the next 25 years for single-component upgrades on an ATS system that had a design life that expired 7 years ago. Compared to the Cruise Missile ATS program, The ICBM ATS program consumed less senior leadership resources and far less time to provide more sustainable/supportable ATS. Because no one agrees (to date) on who is responsible for Cruise Missile ATS funding, considerable amounts of human resources and time will more than likely continue to be devoted to the Cruise Missile ATS problem.

Implications of Research

There are direct implications for other common ATS programs that support weapon systems within the Air Force. There are also possibly similar implications for other common programs that rely on pooled funding. Regardless of the program, a successful funding strategy for common programs needs to be established to ensure the supported weapon system is adequately sustained. There appears to be three options that could solve the common funding problem: 1) common programs are fully funded by the responsible agency; 2) weapon systems proportionally pay for their required support; and 3) Air Force Corporate Structure is modified to better “care and feed” for common programs.

Air Force-Wide ATS Implications.

The ATS implications are profound when one considers the estimates made by Warner-Robins-Air Logistics Center’s Automatic Test Systems Division regarding ATS obsolescence. In April 2004, they estimated an increase of ATS obsolescence of 14% in two years, an increase of 31% in five years, and a 55% increase in 10 years (Johnson, 2004). If not properly addressed, ATS obsolescence can impact weapon system mission capability rates, increase maintenance time, and increase support costs. Given these concerns and pending need, how can the Air Force meet its ATS funding requirements?

As referenced above, there are three ways. For illustration purposes, each corrective option is proposed below in the context of Cruise Missile ATS.

1) *Air Force Materiel Command's Directorate of Requirements agrees that Cruise Missile ATS requirements belong in the Common Systems Program Element Code, 78070.* This researcher could not find a historical example where this approach was successful.

2) *Air Combat Command's Directorate of Operations use one or more of the Program Element Codes for the Cruise Missiles themselves.* ACC and AF/XOS-N do not support this option because they feel it would jeopardize the on-going and expensive Cruise Missile service life extension programs currently underway. They fear that if Program Element Codes 11120 (Advanced Cruise Missile), 11122 (Air Launched Cruise Missile), and 27323 (Conventional Air Launched Cruise Missile) were used to fund the ATS sustainment effort, one of the service life extension programs would be cut. Also, it would be difficult to determine how much each program should pay. What happens when one program is severely cut? Do the other programs have to make up the difference?

3) *Change the way the Air Force funds common ATS entirely.* To make this approach possible, the Air Force Corporate Structure would have to be modified and would require the establishment of a new funding stream tailored for common ATS.

Broader Implications of Common versus Specific Program Management.

The Air Force Corporate Structure was designed to aid Air Force senior leaders to make good programmatic decisions. Program Element Monitors are a program's spokesperson, and they are supposed to articulate their program's requirements. However, the playing field is not even for Program Element Monitors. Program Element Monitors assigned to common programs have a greater difficulty garnering senior leadership support for three reasons: 1) they usually have significantly more projects to manage than Program Element Monitors assigned to weapon system specific programs; 2) generally, they are less informed about system impacts because they are further removed from the weapon system program; and 3) procurement funding cuts have created an environment where senior leadership focuses on buying as much weapon systems as possible at the expense of common support systems. Program Element Monitors for weapon system specific programs have a clear advantage of being able to focus on a program's entire financial profile and can better plan and manage the movement of funds within their program.

Recommendations for Future Research

Warner Robins-Air Logistics Center's ATS Division openly recognizes a significant funding problem exists for all their integrated ATS. First, future researchers could focus their efforts on determining how many ATS systems the ATS Division is responsible for managing that directly support a weapon system managed by another Weapon System Program Office. Once these systems are identified, the methodology designed to guide this research could be applied to those programs and similarly compared. Research conducted in this manner would help determine the scope of the common ATS problem facing the Air Force.

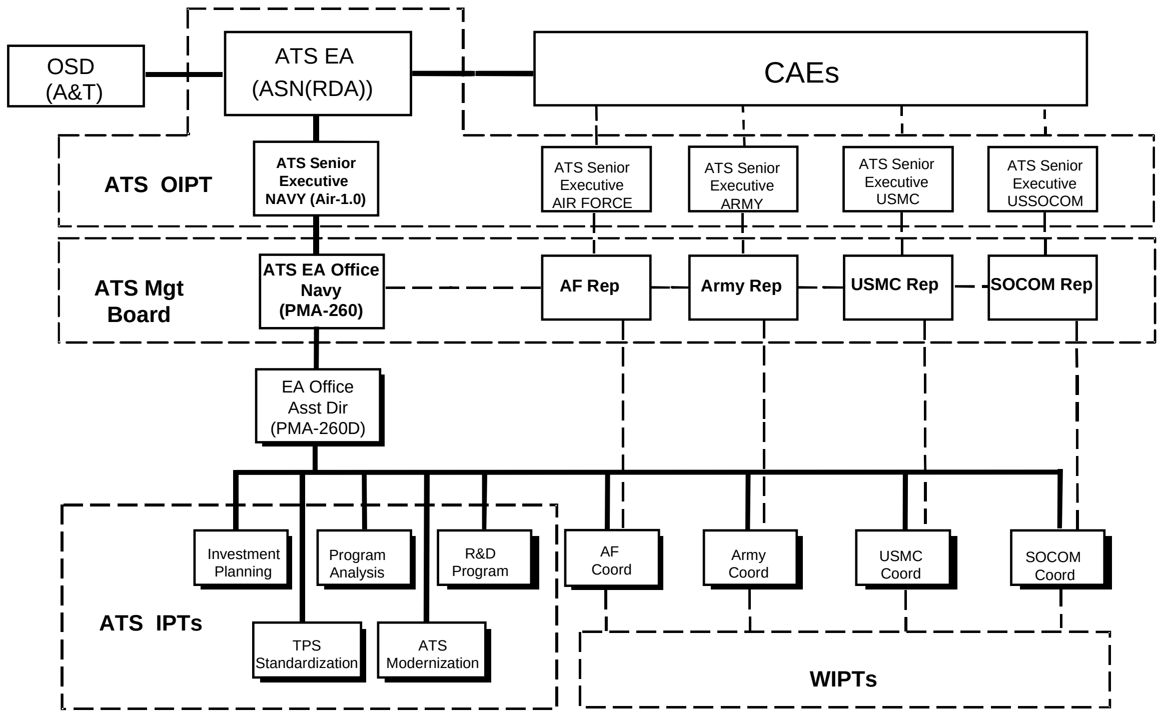
Second, future research could narrowly focus on the common ATS funding process within the Air Force, and then, carefully examine the common ATS funding strategies of the Navy, Army, and Marines. Perhaps one of the sister services has a best practice to benchmark for the Air Force, or possibly, lessons could be learned from all four uniformed services and a common ATS funding strategy could be proposed for DoD-wide implementation.

Last, common Air Force programs should be identified and examined to determine how well they compete in the POM process compared to weapon system specific programs. Is common ATS a single example of an under funded common program? Do all common programs generally suffer the same under funding as found in common ATS? How can common program funding requirements be more clearly articulated and supported? Are there modifications to the Air Force Corporate Process that would correct the problem?

Summary

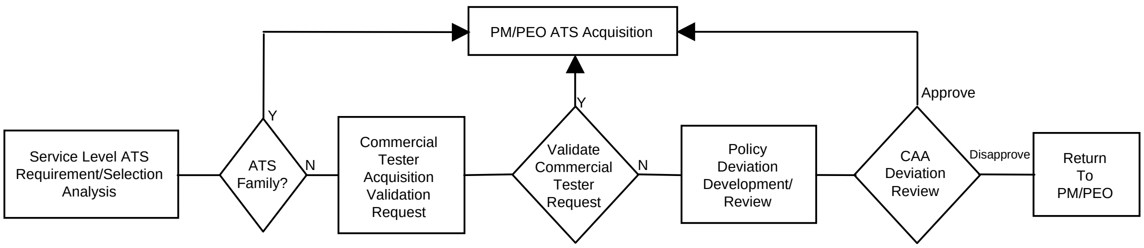
In this chapter, the overarching research question that guided this research was addressed based on the findings and analysis from Chapter IV. According to Warner-Robins-Air Logistics Center's Automatic Test Systems Division, the funding problems for all common ATS is similar to those seen in the Cruise Missile ATS program. The implications of not building a sound common ATS funding strategy were asserted, as well as broader common program management implications. Lastly, future research topics were proposed that would build on this research and help identify the magnitude of common program funding problems.

Appendix A: DoD ATS Organization



(Greening, 1999c:2)

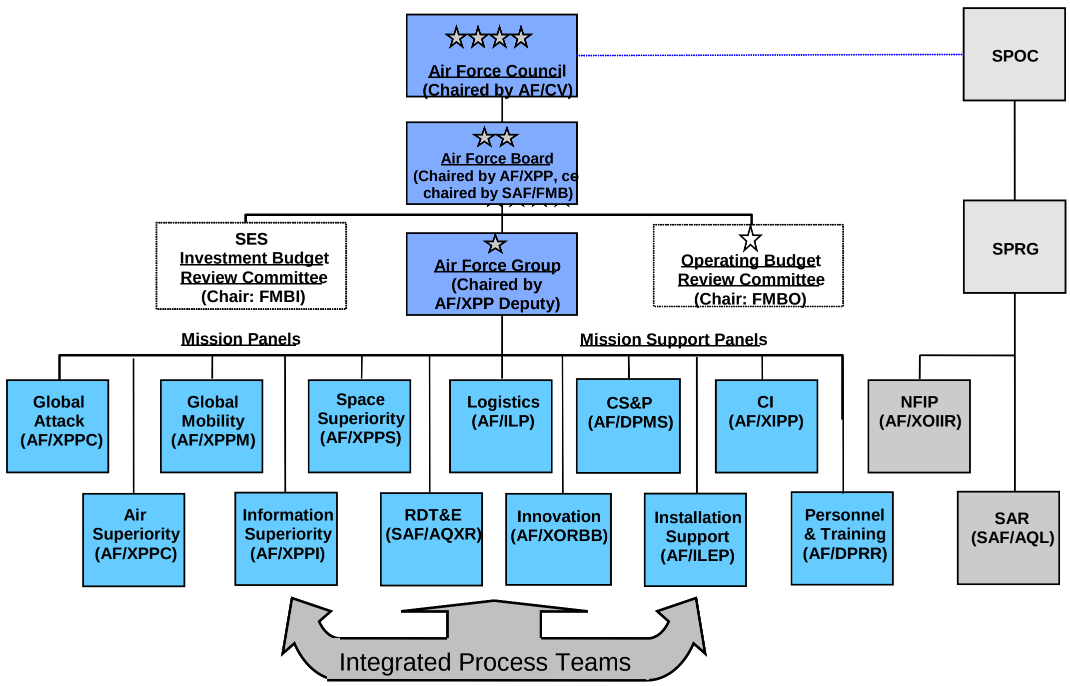
Appendix B: Roles and Responsibilities in the ATS Selection Process

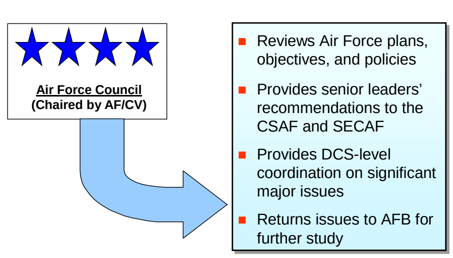


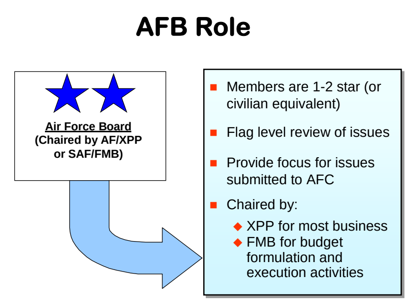
DOD ATS SELECTION PROCESS ROLES & RESPONSIBILITIES						
	PM/PEO	- Parametric analysis of UUT Requirements vs ATS - Operational Assessment - Maintenance Rqmts	-Prepare Commercial Tester Acquisition Validation Request	- Support Commercial Tester Acquisition Validation Request -Implement Service ATS Senior Exec Decision	- Develop Cost Benefit Analysis - Document Parametric Analysis, Operational Assessment, and Maintenance Rqmts - Support Deviation Request	- Support Deviation Request - Implement CAE Decision
	Service AMB Rep	- Determine if rqmt meets policy criteria - Provide input to ATS Master Plan - Conduit for ATS EAO data	-Review Commercial Tester Acquisition Validation Request - Provide guidance to PM/PEO	-Make preliminary recommendation to AMB	-Review deviation request	
	AMB	-Provide guidance to Service AMB Rep -Coordinate tech support of ATS Family	-Provide guidance to Service AMB Rep	-Review Commercial Tester Acquisition Validation Request -Review ATS Master Plan for opportunities to leverage investments	- Provide guidance to Service AMB Rep - Provide recommendation to Service ATS Senior Executive - Review ATS Master Plan for opportunities to leverage investments	- Track deviation through the review cycle
	Service ATS Senior Executive	-Provide guidance to AMB	-Provide guidance to AMB	-Review CTAVR and AMB recommendation -Approve/disapprove request -Info ATS EAO of decision	-Provide issue resolution to AMB - Provide guidance to AMB	-Support recommendation to CAE
	ATS EAO	- Assist Service AMB Rep -Provide additional technical expertise - Update ATS Master Plan	- Assist Service AMB Rep - Provide additional technical expertise	- Update ATS Master Plan if required	- Track deviation request - Assist Service AMB Rep	- Track deviation through the review cycle - Update ATS Master Plan if required
		Monitor and improve ATS selection process				

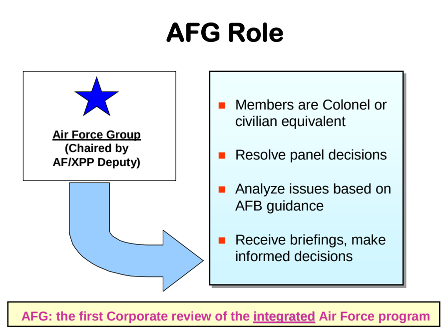
(Greening, 1999c:9)

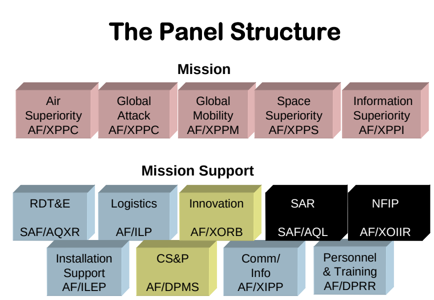
Appendix C: Air Force Corporate Structure











(AF/XPPE, 2003:9, 23-26)

Appendix D: Questionnaire for IQ1

Investigative Question #1: What are the ATS management differences between common core and weapon system unique System Program Office approaches?

Sources of Data:

SPO and Depot

Program Managers, Equipment Specialists, Engineering, Technicians

Documents

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.
13. Please e-mail completed questionnaire to william.ford@afit.edu. Thank you for your assistance.

Appendix E: Questionnaire for IQ2

Investigative Question #2: How much funding is budgeted/funded in the Program Objective Memorandum and Future Year Defense Plan for both ATS programs being studied?

Sources of Data:

MAJCOM and SPO/depot Financial Managers
MAJCOM and SPO/depot Subject Matter Experts
Documents
Archival Records
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.
7. Please e-mail completed questionnaire to william.ford@afit.edu. Thank you for your assistance.

Appendix F: Questionnaire for IQ3

Investigative Question #3: What are ATS System Program Office, Depot, and Major Command assessments of long-term ATS sustainability for both programs being studied?

Sources of Data:

MAJCOM Staffs
SPO/depot Program Managers and Equipment Specialists
Documents

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.
8. Please e-mail completed questionnaire to william.ford@afit.edu. Thank you for your assistance.

Appendix G: Questionnaire for IQ4

Investigative Question #4: For both ATS programs being studied, what are Major Command assessments of their field units' ability to support their assigned support equipment with the available ATS resources and System Program Office support?

Sources of Data:

MAJCOM Subject Matter Experts
Documents

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.

10. Please e-mail completed questionnaire to william.ford@afit.edu. Thank you for your assistance.

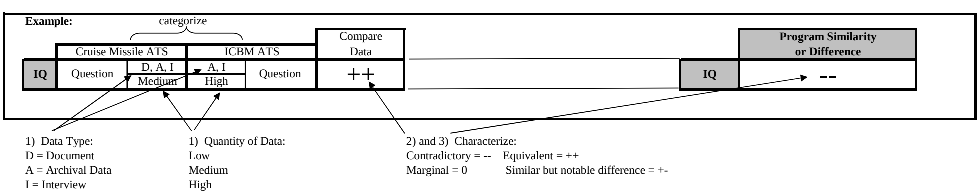
Appendix H: Data Categorization Matrix (Blank)

	Type and Quantity of Data				Compare	Comment/Theme/Note/Trend
	ATS System A			ATS System B	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		

	Program Similarity or Difference	Comment/Theme/ Note/Trend
IQ1		
IQ2		
IQ3		
IQ4		

How to Use:

1) Categorize data for both systems
2) For each line, compare data for each system and characterize if it is contradictory, marginal, or equivalent
3) Considering all data and comparisons for each question, characterize each IQ as contradictory, marginal, or equivalent
4) Use these comparisons and in-depth answers to the IQ to assist in theory building



Appendix I: Data Categorization Matrix (Filled In)

IQ	Cruise Missile ATS		ICBM ATS		Compare (Each Question)	Comment/Theme/Note/Trend (Each Question)
IQ1	Question 1	I / Medium	I / Medium	Question 1	++	Same Responsibilities.
IQ1	Question 2	I / Medium	I / Medium	Question 2	--	Both work sustainment/support daily, but ICBM ATS mainly works on fielding new GMATS.
IQ1	Question 3	I / Medium	I / Low	Question 3	--	CM ATS plan for component level solutions, ICBM ATS plan for system level solutions.
IQ1	Question 4	I / Medium	I / Medium	Question 4	++	Both treat field user issues similarly.
IQ1	Question 5	I, D / Medium	I / Low	Question 5	++	Both systems are relatively same age, CM ATS is slightly older.
IQ1	Question 6	I / Low	I / Low	Question 6	++	Both current ATS replaced previously obsolete equipment.
IQ1	Question 7	I, D / High	I, A / Medium	Question 7	++	Both suffer from 90+% COTS equipment obsolescence.
IQ1	Question 8	I, D / High	I / Medium	Question 8	--	CM = money. ICBM = supporting the E-35 with COTS equipment managed outside of OO-ALC and ICBMs.
IQ1	Question 9	I / Medium	I / Medium	Question 9	+-	Both routinely work with similar government POCs, but ICBM group works more with prime contractor.
IQ1	Question 10	I / Low	I / Low	Question 10	++	Both groups were mixed on being aware of DoD Common ATS policy.
IQ1	Question 11	I / Low	I / Low	Question 11	++	Mixed replies. Interesting note: GMATS is within an approved family eventhough considered unique.
IQ1	Question 12	I / Low	I / Low	Question 12	N/A	Not much to add. ICBM group is addressing their unique challenge by going with ICS.
IQ2	Question 1	I, D / High	I / Medium	Question 1	--	CM = unknown. ICBM = AFSPC.
IQ2	Question 2	I, D / High	I / Medium	Question 2	+-	Both have unfundeds. CM group addresses them one at a time. ICBM group buying new system.
IQ2	Question 3	I, D, A / High	I, A / Medium	Question 3	--	CM group never has POMed, ICBM group secured $107M for new tester.
IQ2	Question 4	I, D / High	I / Low	Question 4	--	CM group = No. ICBM group = Yes.
IQ2	Question 5	I, D, A / High	I, A / Medium	Question 5	--	CM group never has POMed, ICBM group secured $107M for new tester.
IQ2	Question 6	I / Medium	I / Low	Question 6	N/A	CM group, replacement bill was far too high→FFF plan. ACC, would like ATS to go to CMPG with CMs.
IQ3	Question 1	I, D / High	I / High	Question 1	++	Very similar sustainment issues apply to the E-35 and ESTS.
IQ3	Question 2	I, D / High	I / High	Question 2	--	CM Plan = FFF, risky considering MSD funds. ICBM Plan = enitre ATS replacement.
IQ3	Question 3	I, D / High	I / High	Question 3	+-	Yes for both, approaches significantly differ. CM , FFF plan. ICBM, GMATS solved problem.
IQ3	Question 4	I, D, A / High	I / High	Question 4	--	CM, drop dead = 2010 if FFF projects not funded. ICBM, drop dead = 2020 with GMATS (maybe longer).
IQ3	Question 5	I, D / High	I / Medium	Question 5	++	CM and ICBM ATS sustainment issues arose 1997 timeframe.
IQ3	Question 6	I, D / High	I / Medium	Question 6	++	Both groups viewed sustainment issues as a high priority. CM group has had difficulty getting traction.
IQ3	Question 7	I / Medium	I / Medium	Question 7	N/A	Both groups commented on units band-ading problems to prevent spending O&M dollars--masks issues.
IQ4	Question 1	I / Medium	I / Medium	Question 1	0	Both groups get parts, but rates widely vary. Back orders seem to impact ICBM group more heavily.
IQ4	Question 2	I / Medium	I / Medium	Question 2	0	Fullfillment time appears to be longer and more variable for the ICBM group.
IQ4	Question 3	I / Medium	I / Medium	Question 3	++	Doesn't happen often for either group. Tech data is mature for both systems.
IQ4	Question 4	I / Medium	I / Medium	Question 4	++	TOs for both groups are generally good.
IQ4	Question 5	I / Medium	I / Medium	Question 5	++	TCTOs are rare, but have been historically good.
IQ4	Question 6	I / Medium	I / Medium	Question 6	--	CM units rely heavily on CMPG for ATS assistance, vice LEA. ICBM units receive good SPO support.
IQ4	Question 7	I / Medium	I / Medium	Question 7	0	Anecdotal evidence suggests slight increase for CM ATS and slightly higher for ICBM ATS.
IQ4	Question 8	I / Medium	I / Medium	Question 8	+-	Common for both. However, ICBM ATS appears to have longer fullfillment time of backorders.
IQ4	Question 9	I / Medium	I / Medium	Question 9	N/A	Both program offices generally provide good support, but LEA appears to be on a constant learning curve.

	Program Similarity or Difference	Comment/Theme/Note/Trend
IQ1	+-	Similar age/problem, different level of management control
IQ2	--	CM ATS can't get into POM, ICBM ATS fairs well in POM.
IQ3	--	CM, FFF sustainment plan. ICBM, entire ATS replacement.
IQ4	++	Generally, good support from both program offices to field

How to Use:

1) Categorize data for both systems
2) For each line, compare data for each system and characterize if it is contradictory, marginal, or equivalent
3) Considering all data and comparisons for each question, characterize each IQ as contradictory, marginal, or equivalent
4) Use these comparisons and in-depth answers to the IQ to assist in theory building

Example:

categorize

	Cruise Missile ATS		ICBM ATS		Compare Data		Program Similarity or Difference
IQ	Question	D, A, I / Medium	A, I / High	Question	++	IQ	--

1) Data Type:
D = Document
A = Archival Data
I = Interview

1) Quantity of Data:
Low
Medium
High

2) and 3) Characterize:
Contradictory = --   Equivalent = ++
Marginal = 0   Similar but notable difference = +-

Appendix J: Ground Minuteman Automatic Test System Overview

GMATS is a Teradyne S-9160 Automatic Test Station that utilizes current open architecture technology. It was designed to provide the same functionality as the obsolete AN/GSM-315 Automatic Test Station (E-35 Test Station) and the Mobile Work Surface which tests Minuteman III weapon system components located at launch facilities (missile locations) and missile alert facilities (alert crew locations). As can be seen in pictures to the right, GMATS is approximately a quarter of the E-35's size.

Teradyne S-9160 Automatic Test Station

Other aspects of the program requires rehosting 254 Test Program Sets to operate with the new test station, replacing existing specifications and test requirement documents, developing new operations and maintenance manuals, and providing operations and maintenance training to field units.

AN/GSM-315 Automatic Test Station

The system was designed to support Minuteman III ground testing through 2020--a 15 year design life. Each test station has an approximate cost of $850K; a total of 18 stations were purchased.

18 Teradyne S9160 Test Systems
2 Malmstrom AFB, MT
2 Minot AFB, ND
2 FE Warren, WY
4 Vandenberg AFB, CA
2 FLTS (576th)
2 AETC (532nd)
8 Hill AFB, UT
1 SMIC
2 Maintenance Support
3 Depot
2 Software Support Center

Appendix K: Cruise Missile ATS Operations and Maintenance Funding

Appropriation 3400 (Operations and Maintenance)
Cruise Missile ATS

Figures in $ millions

Budget Program	FY01	FY02	FY03	FY04	FY05
583 Sustaining Engineering	0	0	0	0	0
540 (System Software)	0	0	0.099	0.039	0.036
545 (DPEM Exchangeables)	0.100	0.100	0.108	0.327	0.322
MSD Engineering	0.150	0.260	0	0.244	0.510
MSD UUT	0.118	0.042	0.992	1.253	0.500
Total O&M	0.368	0.402	1.199	1.863	1.368

Appendix L: GMATS Procurement Funding

Appropriation 3020 (Missile Procurement)
ICBM ATS (GMATS Replacement)

Figures in $ millions

WEAPON SYSTEM COST ELEMENTS	FY02			FY03			FY04			FY05			FY06		
	QTY	UNIT COST	TOTAL COST	QTY	UNIT COST	TOTAL COST	QTY	UNIT COST	TOTAL COST	QTY	UNIT COST	TOTAL COST	QTY	UNIT COST	TOTAL COST
ATS-E353 BUYS	4	0.984	3.936	2	0.984	1.968	4	2.0745	8.298	4	0.647	2.59	4	0.664	2.656
PRODUCTION ENGINEERING			2.436			6.776			5.262			6.294			10.564
SOFTWARE			6.42			6.775			7.503			13.278			15.789
DATA			1.28			1.276			1.207			1.182			1.764
TYPE 1 TRAINING									0.062			0.062			0.062
Sub Total BP 2200			14.072			16.795			22.332			23.404			30.835
												Total BP 2200			107.438

Appendix M: Cruise Missile ATS Sustainment Plan

Background: The ATS used to support the Air Force's nuclear and conventional Cruise Missile fleet (ALCM/CALCM/ACM) and associated launch gear was operationally fielded in 1981. This ATS includes the Electronics Systems Test Set (ESTS), Missile Radar Altimeter Test Assembly (MRATA), Air Data Test Set (ADTS) and associated Test Program Sets (TPS). The Cruise Missile fleet life span has been extended to the year 2030 to match the B-52 through a Service life extension (SLEP) study and program modification plan. The possibility of a Cruise Missile extension to 2040 to match the B-52 life extension is possible. Service life extension of the ATS was ignored. The Cruise Missile ATS has a design life of 15 years. We are currently at 23 years of operation.

Solved Obsolescence Issues: To date, we have successfully replaced several ESTS power supplies with COTS units. These are the 1A7 (+/-15v), 1A8 (+/- 22 v) and 1A13(5v / 25v) power supplies. A replacement for the RUSKA (PATEC-ADTS) has also been identified and tested. The RUSKA is currently being replaced through attrition with the King Nutronics 3719. Additionally, we have also completed testing and received Nuclear Certification for the ARRAID AEM-6C/ESTS disk drive. This drive replaces the HP 7906 disk drive. This obsolete HP 7906 disk drive was the driver for the 2008 ATS drop dead date. FY05 Demand Reduction Initiative Funding in the amount of $1.2M was received and Installation of the new ARRAID drive is anticipated to begin in mid 2005.

Repair Capability: We have repair capability for several ATS CCAs and are currently developing more TPS for the remaining ATS CCAs. It is critical that replacement parts remain available. We are developing repair capability for the 60V power supply and plan to develop repair capability for the 36V supply. Limited contract repair is currently available.

Depot repair procedures have also been developed for the MRATA RF attenuators (previously DLA items) and the ESTS monitors.

Plan to determine accurate current and projected spares inventory.

Identify what we have in the <u>supply system</u> and the condition of these spares.
Make corrections as required to supply system data bases.
Add new NSNs as required.
Delete unnecessary early versions of CCAs from supply system data bases.
Make revision level corrections if possible to early model CCAs and modules.
Perform check and test on remaining CCAs and modules.
Code all spares as non-disposable. Have ACC provide a non-disposal memo.

Scrap excess ESTS and MRATAs located in warehouse.
Prepare a save list of saved components.
Dispose of items that are beyond economical repair, noncorrectable and obsolete CCAs and modules.
Perform check and test on remaining CCAs and modules.

The time required to accomplish this task will require at least 1 year. In the interim an estimate of current spares will have to suffice.

There are 33 MRATAs in warehouse in multiple configurations. The estimate is that about half of these will be scrapped and useful parts will be inducted into the supply system. The number of configurations will be reduced to two, the -1019 and the -1017.

There are 29 ESTS in warehouse in multiple configurations. Four fully complete ESTS spares will be retained. The twenty five remaining ESTS will be scrapped and all useful parts will be inducted into the supply system.

ESTS and MRATA Components: The supply system configuration for components was not maintained properly in the past. A count of each component can be provided. However, this does not provide an accurate count due to the fact that multiple dash numbers are listed under a single stock number. Correcting this configuration will begin in 2005.

Priorities of Components to be replaced:

Priority 1. MRATA VCO. The original MRATA VCO is no longer supportable. It is no longer manufactured or repairable. Some spares will become available as some MRATAs are scrapped. The replacement VCO is currently in testing at OC-ALC and should be complete in FY05. Although the new VCO is functionally equivalent to the old VCO it is smaller and requires a minor modification (new holes drilled in mounting bracket) to the MRATA chassis to mount it. This is not a true FFF replacement and replacement through attrition is not possible. This will require BP21 modification funding to accomplish.
It is anticipated that procurement of the new VCOs can begin in FY06 and should be completely fielded by FY08 provided funding is available. Total funding needed is $500K to complete modification.

Priority 2. MRATA Programmable RF Attenuators. These Weinschel 140 series attenuators are no longer manufactured. Repair parts are not available. There are few spares in the supply system. Currently repairs are accomplished through cannibalization. The Programmable attenuators have an explosion proof requirement. There are currently no COTS units available that meet this requirement. A modified COTS unit would be the only practical solution. It is anticipated that the OEM (Weinschel) for the 140 series attenuators will agree to develop a replacement based on their current 150 series. Once new attenuators are qualified all attenuators will be replaced. Replacement through attrition is not possible. The replacement attenuators although functionally equivalent will not be exactly the same size as the old ones. This is not a true FFF replacement and will require BP21 modification funding to accomplish.

This item has been identified as an FY05 MSD Engineering Project ($510K). Provided funding for this project is available, we anticipate awarding an Engineering Services Contract to develop and qualify replacement MRATA attenuators. The timeframe for this effort will be 12-18 months. It is anticipated that once the replacement attenuators are identified, procurement of the new attenuators can begin in FY07 and should be complete by FY08 provided BP21 modification funding is available ($1.175M).

Priority 3. ADT 222-B. The ADT 222-C will replace the ADT 222-B through attrition. The ADT 222-C is being tested and should be completed by Sept 05. This will be a true FFF replacement and will be replaced through attrition using MSD Buy Funding ($3M). It is anticipated that procurement for the replacements can begin in FY07 at 8 ea per year with total fielding to be completed in FY11.

Priority 4. ESTS A-16 Relay CCAs. All ESTS A-16 Relay CCAs including all spares are now well past their 10 year combination storage and operating life. We are currently at 22 years. These Relay CCAs exhibit catastrophic failures due to internal relay contact shorts which apply 28vdc to 5vdc signal lines. These CCAs will not be replaced through attrition. Each ESTS will have all it's Relay CCAs replaced at one time. The replacement date will be recorded and the Relay CCAs will be replaced again at the end of life date (10 years). Relay CCAs will be removed from the supply system and from the scrapped warehouse ESTI. All relays will be removed from each relay circuit card. New relays will be installed on the cards.

Priority 5. 36VDC Power Supply. This item is no longer manufactured. A modified COTS unit would be the only practical solution. Replacement will be through attrition. This will need be an MSD Engineering Project in FY10 ($40K). Once replacement is identified/qualified, procurement is anticipated to begin in FY11 and completed in FY15 using MSD Buy Dollars ($592K)

Priority 6. 60V Power Supply. This item is no longer manufactured. A modified COTS unit would be the only practical solution. Replacement will be through attrition. This will need to be an MSD Engineering Project in FY15 ($40K). Once replacement is identified/qualified, procurement is anticipated to begin in FY16 and completed in FY20 using MSD Buy Dollars ($382K).

Priority 7. HP 1000 Computer, Monitor and Printer. These items are no longer manufactured. The computer itself is very reliable. The printer and monitor are not. Replacement will include a PC running HP 1000 emulation software, a PC monitor and printer. Replacement will not be through attrition and will require BP21 modification funding. This will be an MSD Engineering Project in FY15 ($300K). Once replacement is identified/qualified, procurement of replacement computer/printer/monitors is anticipated to be FY17 provided BP21 funding ($1.5M) is available.

Priority 8. 1A10 Universal Counter. This item is no longer manufactured. A modified COTS unit would replace it. Replacement will be through attrition. This will be an MSD Engineering Project in FY18 ($100K). Once replacement is identified/qualified, anticipated procurement will begin in FY19 and be completed in FY23 using MSD Buy Dollars ($1.5M).

Priority 9. 1A11 Digital Multi-Meter. This item is no longer manufactured. A modified COTS unit would replace it. Replacement will be through attrition. This will be an MSD Engineering Project in FY20 ($150K). Once replacement is identified/qualified, anticipated procurement will begin in FY21 and be completed in FY25 using MSD Buy Dollars ($1.1M).

System Performance Risk:

The level of system risk is based on sustainment of the Cruise Missile ATS until the year 2030.

MRATA VCO. System risk is currently high. The VCO is a critical component of the MRATA. The MRATA cannot operate without it. The original VCO is no longer manufactured or repairable. We are currently cannibalizing to maintain system availability. It is estimated that MRATAs will start to become inoperable within two years if the replacement VCO is not made available.

MRATA Programmable RF Attenuators. System risk currently is high. These attenuators are critical components of the MRATA. The MRATA cannot operate without them. The original attenuators are no longer manufactured. Repair parts are unavailable and no longer manufactured. We are able to repair them with cannibalized parts. As parts become scarce we will lose repair capability. It is estimated that MRATAs will begin to become inoperable within 3 years if replacement attenuators are not made available.

ADT 222-B. There is no system risk. The 222-B is obsolete. The 222-C is the replacement. This unit is a modified COTS unit that meets the CM ATS requirements. The 222-B will be replaced through attrition.

ESTS A-16 Relay CCAs. System risk is currently high. The ROI is excellent. The plan is to re-populate the existing relay cards with new relays. The relays are now well past their 10 year combination storage and operating life. Failure to replace the relays will not cause a complete loss of system availability. However it will continue to degrade system availability and cause additional damage in the ESTS due to catastrophic failure modes.

<u>36VDC Power Supply.</u> System risk is currently low. This unit is no longer manufactured. We have several spares. There is currently contract repair capability. Depot repair capability can be developed. A modified COTS unit would replace the current unit through attrition.

<u>60V Power Supply</u>. System risk is currently low. This unit is no longer manufactured. We have several spares. Depot repair capability is being developed. A modified COTS unit would replace the current unit will be through attrition.

<u>HP 1000 Computer, Monitor and Printer</u>. System risk is currently low. These items are no longer manufactured. The computer itself is very reliable. The printer and monitor are not. Contract repair is currently available. Future contract repair availability is unknown. Replacement will <u>not</u> be through attrition.

<u>1A10 Universal Counter HP 5328A.</u> System risk is currently low. This item is no longer manufactured. We have several spares. Although used counters are available from contractors, the 010, 011 and 041 options are required. The option requirement limits the number of used units that qualify. There is current contract repair capability. Future contract repair availability is unknown. A modified COTS unit would replace the current unit. Replacement will be through attrition.

<u>1A11 Digital Multi-Meter HP 3455A.</u> System risk is currently low. This item is no longer manufactured. We have several spares. Used refurbished units are available from used test equipment suppliers. There is current contract repair capability. Future contract repair availability is unknown. A modified COTS unit would replace the current unit. Replacement will be through attrition.

Below is a summary of proposed upgrades and associated funding.

Proposed Upgrades	Funding Required	Types of Funding Required	Years Funding is Required
MRATA VCO	$500K	BP21 (modification)	FY06
MRATA Attenuators	$1.7M	MSD Eng/BP21(modification)	FY05, FY07
ADT 222C ESTS A-16 Relay CCAs	$3M	MSD Buy Dollars	FY07 - FY11 (attrition)
36V DC Power Supply	$632K	MSD Eng / MSD Buy Dollars	FY10, FY11 - FY15 (attrition)
60V Power Supply	$422K	MSD Eng / MSD Buy Dollars	FY15, FY16 - FY20 (attrition)
Computer/Printer/Monitor	$1.8M	MSD Eng/BP21(modification)	FY15, FY17
Universal Counter	$1.6M	MSD Eng / MSD Buy Dollars	FY18, FY19 - FY23 (attrition)
Digital Multimeter	$1.3M	MSD Eng / MSD Buy Dollars	FY20, FY21 - FY25 (attrition)

Appendix N: Cruise Missile Group Questionnaire for IQ4

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

1. Do units get the parts they need to support their assigned equipment? Please explain.
(*XXXX Redacted XXXX*) Several instances where they ordered parts and didn't get them. They don't get good answers when asking questions about their parts. Historically they haven't had a good belly button. Propagated so bad that field units stopped trying so hard to manage the problem—they seemed to give up. Units are using bay queens to fill parts, eventually they have to deal with the SPO to work parts issues. However, the ACC liaison is doing stellar work now that he's in place. Good results from moving him down there.
2. Do units get the replacement parts in a timely fashion? Please explain.
Things have gotten better since (*XXXX Redacted XXXX*). Basically, (*XXXX Redacted XXXX*) is stealing parts similar to how field units are stealing from bay queens. However, there is no good plan, other than FFF. Band-ade fixes.
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.
Seems to be several of these issues, but he perceives these as troubleshooting issues. There are a lot of workarounds. Most of the ideas come from the field. Field is frustrated with LEA support. The best support comes from the CM software lab—(*XXXX Redacted XXXX*).
4. Are TOs of good quality? Please explain.
Doesn't think they're in good shape. Little has been done to translate factory manuals into good TOs. Unit technicians use cheat sheets for many procedures. Technicians seem to accept the tech data as is because they're used to poor tech data. Basically, everyone is used to it. Doesn't think it has to do with LEA support, every body accepts it.
5. Are TCTOs of good quality? Please explain.
Power Supply Cal Load procedures was the last one he can recall from several years ago and that was a depot field assist. TCTO appeared to be good.
6. Do units receive adequate SPO troubleshooting support when formal technical data is exhausted? Please explain.
Not really in the past, they usually call the SIL. Now that (*XXXX Redacted XXXX*) is at LEA, units are calling him at WR-ALC. The pendulum is swinging.

7. Are there relatively more, fewer, or about the same number of MICAPs as in the past? Please explain.
(*XXXX Redacted XXXX*) thought there were about the same, maybe a slight increase. However, obsolescence issues are more critical than in the past. More show stopping issues. (*XXXX Redacted XXXX*) felt the FFF study was inflated as well—separate subject but I felt it should be noted. Several people have stated this and feel the cost estimate of $150M for a replacement was high.
8. Are backorders longer than 30 days common? Give examples of recurring problems.
Not sure; probably need to talk to (*XXXX Redacted XXXX*).
9. Please add any additional information you feel would aid in answering Investigative Question #4.
(*XXXX Redacted XXXX*) most field unit technicians think the equipment is managed by CMPG because they work the issues. When (*XXXX Redacted XXXX*) arrived, that has started to change. Discussed the problem of transitioning from San Antonio to WR-ALC.
10. Please e-mail completed questionnaire to william.ford@afit.edu. Thank you for your assistance.

Appendix O: Cruise Missile Group Questionnaire for IQ4

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

1. Do units get the parts they need to support their assigned equipment? Please explain.
The units get the parts but by canning parts off the extra stations in WR-ALC's warehouse. Some parts are on backorder for longer than two years. No good action plan to acquire these parts extremely long lead items.
2. Do units get the replacement parts in a timely fashion? Please explain.
Stations in the field don't have empty spots very long because of canning. Andersen takes a while. There are empty holes however. Units have 1 spare ESTS as Bay Queen.
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.
Occasionally it happens, but not routinely. Interesting: MAJCOM/units prefer to go to Tinker for troubleshooting issues even though LEA has responsibility.
4. Are TOs of good quality? Please explain.
They're Ok.
5. Are TCTOs of good quality? Please explain.
Not done any in a long time, but DD is coming up.
6. Do units receive adequate SPO troubleshooting support when formal technical data is exhausted? Please explain.
MAJCOM uses Tinker vs (*XXXX Redacted XXXX*). Doesn't happen often, but it does come up. Real good support from SIL folks.
7. Are there relatively more, fewer, or about the same number of MICAPs as in the past? Please explain.
Don't know. My opinion it's slightly higher.
8. Are backorders longer than 30 days common? Give examples of recurring problems.
Don't know.
9. Please add any additional information you feel would aid in answering Investigative Question #4.
SPO is doing the best they can, but better foresight/planning in the past could have prevented some of our problems. Also mentioned how poor the TAGs are.

10. Please e-mail completed questionnaire to william.ford@afit.edu. Thank you for your assistance.

Appendix P: Cruise Missile Group Questionnaire for IQ1

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

1. What is your duty title and job description?
(*XXXX Redacted XXXX*). Mentioned San Antonio didn't adequately support the ATS the last seven years they had it. Discussed the configuration control problem with the dash numbers being rolled on nonsuitable sub CCAs. Lack of funding was covered. AFMC and ACC bicker over who is responsible for funding. The CM-ATS has 15 year design life—we're at 23 years. DD was the killer, but should be fixed this spring. Also mentioned the TAGs are in bad shape. Generally felt ATS has been overlooked.
2. What activities are part of your daily work that pertain to the management of this equipment?
Reactive to all the problems. Particularly, how to plan around the obsolescence issues. Always working field issues. Funding is required to fix the problems.
3. What activities do you perform that pertain to short-, mid- and long-term planning for this equipment?
Short—field level support, correct Kelly problems; mid—obsolescence issues; long—replacement plans.
4. What activities do you perform in support of or in response to issues that arise from field-level users of this equipment?
Same as above
5. When was this equipment initially fielded?
1982. 15 year design life—23 now. 7 years beyond design life. Optimistic about FFF approach.
6. What did this equipment replace, if applicable?
GSM-TAS—(*XXXX Redacted XXXX*).
7. Have you encountered any obsolescence issues pertaining to this equipment? If so, please explain.
See (*XXXX Redacted XXXX*). The contractor pitched to replace ESTS. There proposal seemed biased and many felt the cost of $150M was inflated. The contractor (AES) proposed a replacement cost of $67 Mil. (*XXXX Redacted XXXX*) estimated a real cost of twice that, close to $150 Mil.

8. What managerial challenges do you perceive as unique to this equipment?
Funding is biggest. Finding creative ways to address issues without money. No one wants to pay for common equipment.
9. With whom do you routinely work in support of managing this equipment? (duty titles and job descriptions)
Tinker SIL (*XXXX Redacted XXXX*)—tests all potential solutions—symbiotic relationship. (*XXXX Redacted XXXX*)
10. Are you familiar with DoD policy regarding the acquisition and development of common test equipment? (AFPD 63-2)
Yes, but it doesn't apply in this case. Money is the problem.
11. How does this DoD policy affect this equipment, if at all?
It doesn't apply because they're pursuing a FFF solution instead of procuring new ATS.
12. Please add any additional information you feel would aid in answering Investigative Question #1.
13. Please e-mail completed questionnaire to william.ford@afit.edu. Thank you for your assistance.

Appendix Q: Cruise Missile Group Questionnaire for IQ1

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

1. What is your duty title and job description?
(*XXXX Redacted XXXX*)
2. What activities are part of your daily work that pertain to the management of this equipment?
(*XXXX Redacted XXXX*)
3. What activities do you perform that pertain to short-, mid- and long-term planning for this equipment?
(*XXXX Redacted XXXX*). Obsolescence issues are being addressed by FFF. Trying to develop TPS to repair circuit cards. Mentioned RF attenuators, ESTS monitors. Looking for low hanging fruit that doesn't cost money. Making XB3 items repairable because they didn't have good replacements. Long term is the support plan, extending the ATS to 2030 which is the service life for the cruise missiles. Mentioned the funded study that (*XXXX Redacted XXXX*) sent me. Everyone feels this equipment can be sustained by addressing FFF. Excess equipment in the warehouse is being used as a source for salvage of spares.
4. What activities do you perform in support of or in response to issues that arise from field-level users of this equipment?
Depending on the situation, waivers are granted. They basically troubleshoot the process. At times they cannibalize parts from warehouse equipment because of the obsolescence problems.
5. When was this equipment initially fielded?
Early 80s (~1981).
6. What did this equipment replace, if applicable?
AN-ASM-133 GSM/TAS.
7. Have you encountered any obsolescence issues pertaining to this equipment? If so, please explain.
Yes. See the report and the (*XXXX Redacted XXXX*). Disk Drive was specifically mentioned. DRI funding is being used. Demand Reduction Initiative is new to WR-ALC which came out of AFMC, came out in the budget call—this is kind of a beta test. DD are being procured with DRI funds. DDs will be replaced by this summer. DD was the Achilles Heal. DRI was designed to procure requirements as a result of MSD studies.
8. What managerial challenges do you perceive as unique to this equipment?
Biggest challenge has been who is responsible for funding. No one major command is

responsible for funding. Who should actually do the POMing? No one seems to know. Funding has been the long pole. O&M and 583 has been roughly funded at 60%. For previous 7 years they received no funding. This year they started getting some UUT funding. No PEM at Air Staff for common ATE, but PE exists.
9. With whom do you routinely work in support of managing this equipment? (duty titles and job descriptions)
SIL lab at Tinker, CMPG, ACC and AFMC headquarters.
10. Are you familiar with DoD policy regarding the acquisition and development of common test equipment? (AFPD 63-2)
Not really.
11. How does this DoD policy affect this equipment, if at all?
It doesn't
12. Please add any additional information you feel would aid in answering Investigative Question #1.
Can't think of anything else at this time.
13. Please e-mail completed questionnaire to william.ford@afit.edu. Thank you for your assistance.

Appendix R: Cruise Missile Group Questionnaire for IQ2

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

1. Who is responsible for funding your related equipment?
We don't know—this has been the largest problem associated with this program.
2. Are there any funded/unfunded requirements for the equipment? Please explain.
Yes. No avenue for POM. Have been doing small UUT projects with MSD and DRI funding. See (*XXXX Redacted XXXX*).
3. What equipment funding requirements were included in the last 2 POM cycles? Please include the associated BES input.
Nothing. Can't find PEM to back our requirements. Much confusion over ACC or AFMC bill to pay. Trying for the 08 POM. ACC sent a letter to AFMC requesting a support plan so they would know how to budget for MSD replacements. 08 POM is essential to get requirements in because UUTs are expected to drop dead. In many cases, we're talking about only \$500K for replacements.
4. Do you get the funds needed to adequately support your equipment program? Please explain.
60% is what they've been getting. However, overall we don't get money needed.
5. Are your equipment POM inputs funded? If not, how far below the Air Staff/MAJCOM funding line did the requirements fall?
No. The issue has attention however. Nuclear Steering Group is getting involved. 0-6s are meeting with the GOs.
6. Please add any additional information you feel would aid in answering Investigative Question #2.
Replacement bill was far too large. FFF is only way to secure appropriate money—everyone agreed.
7. Please e-mail completed questionnaire to william.ford@afit.edu. Thank you for your assistance.

Appendix S: Cruise Missile Group Questionnaire for IQ3

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

1. What specific sustainability issues (e.g. hardware, components) does this equipment have?
See document (*XXXX Redacted XXXX*) emailed me (*XXXX Redacted XXXX*).
2. Is there an action plan to address these issues? Please explain.
See the prioritized plan.
3. Are these issues solvable? If not, why? What roadblocks, if any, are hindrances to reaching a solution?
Funding is the roadblock. They have the solutions, but need money to replace components.
4. Are there timelines for reaching a solution? Please explain.
FY08 was for disk drive. Fy10-15 is new drop dead date. FY10 is advertised date to keep it on the scope.
5. When did these issues first arise?
DD started cropping up in 2000 if not sooner. Major attention started in 2001. Equipment transferred there in 2001 so dates are sketchy.
6. How urgent of a priority are these issues?
High. Nuclear systems get attention. Some of the items are high risk (MRATA parts). 2 stars have been involved, and the 583 study was funded because of the attention. The DD was the #1 DRI for WR.
7. Please add any additional information you feel would aid in answering Investigative Question #3.
8. Please e-mail completed questionnaire to william.ford@afit.edu. Thank you for your assistance.

Appendix T: Cruise Missile Group Questionnaire for IQ3

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

1. What specific sustainability issues (e.g. hardware, components) does this equipment have?
(*XXXX Redacted XXXX*) emailed me an update paper (*XXXX Redacted XXXX*) sent to 8 AF. It's a draft but has the specifics.
2. Is there an action plan to address these issues? Please explain.
FFF is the way ahead; basically it's a modified option 3 of what the contractor recommended. (*XXXX Redacted XXXX*) is e-mailing me the contractor briefing.
3. Are these issues solvable? If not, why? What roadblocks, if any, are hindrances to reaching a solution?
These issues are solvable by FFF. No technical reasons exist that would prevent sustainment. Funding is the hindrance. ESTS is considered a piece of B-52 common. Common system PEC won't fund; MSD is only source of money. (AFMC HQ PEM—they've never funded anything for ESTS). That PEC isn't set up for 583, but only procurement money. MSD is very limited and competitive. All programs are living on MSD funds.
4. Are there timelines for reaching a solution? Please explain.
Timelines are in work. ACC went to AFMC to back MSD funding. MSD funds will dictate timelines because of limited funds. *(XXXXRedeactedXXXX)* is sending a prioritized list via e-mail.
5. When did these issues first arise?
Around 1990. Contract fell out for Boeing and (*XXXX Redacted XXXX*) relied on Kelly. In 1996, field units confronted Kelly with major sustainment issues. Kelly felt ESTS would go away around 2000—lack of priority. (*XXXX Redacted XXXX*) felt support equipment is first to be cut. (*XXXX Redacted XXXX*) is looking for an old BBP covering the highlights.
6. How urgent of a priority are these issues?
2010 or beyond. DD was the long pole, leading to a 2008 drop dead date. Printer has snuck up as a recent problem as well as other odd components. They use Tinker to test ideas and look for innovative solutions to recommend to LEA. (*XXXX Redacted XXXX*) does most of the work. (*XXXX Redacted XXXX*) e-mailed priorities—key is how to fund.
7. Please add any additional information you feel would aid in answering Investigative Question #3.
Believes units are working hard to mask unit expenses. Because units must spend limited O&M funds, they try to find cheaper ways to band-aide a problem before committing unit funds to the more correct and more expensive repairs that have the depot/MAJCOM visibility. Masking only makes the sustainment uglier.   Depot/MAJCOM can't plan accordingly as a result.

8. Please e-mail completed questionnaire to william.ford@afit.edu. Thank you for your assistance.

Appendix U: Cruise Missile Group Questionnaire for IQ4

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

1. Do units get the parts they need to support their assigned equipment? Please explain.
(*XXXX Redacted XXXX*) moved to LEA to help with this type of problem. (*XXXX Redacted XXXX*) maintains a record of all backorders for all equipment. As of 13 Dec, 54 backorders. (*XXXX Redacted XXXX*) scrutinizes the report to proactively work parts issues. The units get the parts they need basically because of his involvement. (*XXXX Redacted XXXX*) can prioritize between the units as well. (*XXXX Redacted XXXX*) an IM on steroids.
2. Do units get the replacement parts in a timely fashion? Please explain.
Units do get parts in a timely fashion. Units always need education on priorities. They routinely misprioritize parts which is a source of untimely parts arrivals.
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.
Not often; only infrequent, unique situations. Combination of several organizations come up with the answer.
4. Are TOs of good quality? Please explain.
As of right now, no. 71-1 needs work, 2 mar 81 change 25. New mods drive late TO updates. Authorizing the field technicians with a 1 time procedure is the way they do the work. Money isn't the issue—it's planning and oversight. Contractors at WR-ALC are responsible for updating the TOs. (*XXXX Redacted XXXX*) puts out changes, but the change takes a while (6 months to a year).
5. Are TCTOs of good quality? Please explain.
Haven't done any TCTOs in last 8 years. In the past, they were good.
6. Do units receive adequate SPO troubleshooting support when formal technical data is exhausted? Please explain.
Yes. Telecons between Tinker, WR, ACC.
7. Are there relatively more, fewer, or about the same number of MICAPs as in the past? Please explain.
MICAPs are increasing based on his direction. Otherwise, flatline, slight trend up because of age. Always afraid of the single event that will kill them—hasn't happened yet.

8. Are backorders longer than 30 days common? Give examples of recurring problems.
Typically yes. Many are approaching a year—DMSMS/obsolescence is part of it. Also have configuration control problem. Dash numbers are frustrated on drawings/IPBs. Apparently, Kelly routinely rolled dash numbers to part numbers for parts that were not suitable subs. Field units have been getting these incorrect parts issued to them. WR-ALC personnel are trying to figure out a good solution to correct the configuration control problem. OEMs are constantly being overtaken by competitors also compounding the problem.
9. Please add any additional information you feel would aid in answering Investigative Question #4.
AFMC has no mechanism for maintaining continuity of programs. Kelly sent no one to WR-ALC for the CM ATS. (*XXXX Redacted XXXX*) rotated out. Endemic to AFMC programs. (*XXXX Redacted XXXX*) is in a constant learning curve. Hard to convey priority of nuclear certified equipment to LEA leadership because of their high turnover as well.
10. Please e-mail completed questionnaire to william.ford@afit.edu. Thank you for your assistance.

Appendix V: Cruise Missile Group Questionnaire for IQ2

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

1. Who is responsible for funding your related equipment?
It depends. New buys come from 3020 procurement. Repairables like CM ATS use AF working capital fund—it's subdivided. New ESTS would be 3020, repair would come from Depot Level Repairables (DLR) dollars—AFMC, working capital funds. The group agreed a FFF replacement is better/more cost effective than entire ESTS replacement. AFMC must plan (not POM—working capital fund is just there—there is a prioritization) and fund FFF replacements. ACC must requisition from AFMC—spending O&M funds when unit is replaced. Material Support Division (MSD) process strives to take in as much money as it puts out. https://www.afmc-mil.wpafb.af.mil/hq/afmc/fm/fmr/msd/
2. Are there any funded/unfunded requirements for the equipment? Please explain.
Several unfunded—some funded. Disk Drive is funded. (*XXXX Redacted XXXX*) might be helpful with specifics. A "Paper" was sent to AF Board—(*XXXX Redacted XXXX*) emailed me a draft.
3. What equipment funding requirements were included in the last 2 POM cycles? Please include the associated BES input.
N/A. If group would have decided to replace ESTS, would have gone this route. ACC would have been POMing. Air Staff thought ACC should be responsible for paying; ACC disagreed because of common equipment. (*XXXX Redacted XXXX*) e-mailed me the specifics regarding the decision on who is responsible for funding.
4. Do you get the funds needed to adequately support your equipment program? Please explain.
No; these issues started to surface in days of SA-ALC. (*XXXX Redacted XXXX*) had a handle on the issues, but didn't look very far out. Started trying to get SLEP funded by ACC in SERP, LGY disagreed. SA routed requirement to AFMC, SA—LEA, (*XXXX Redacted XXXX*) got "quick-look" study done in 2002 timeframe which led to the full up study.
5. Are your equipment POM inputs funded? If not, how far below the Air Staff/MAJCOM funding line did the requirements fall?
n/a
6. Please add any additional information you feel would aid in answering Investigative Question #2.
Gut feeling is MSD is spending a lot of money repairing parts. Don't know how much.

2010 is new date because of DD replacement. The whole ESTS problem has suffered from long-term planning from roughly early 90s—1991-1992. Opinion is there is a lack of a master plan that maps success. (*XXXX Redacted XXXX*) would like to see ESTS go to OC-ALC. Reason, test equipment would reside with engineers that work with cruise missiles. Cruise missiles and equipment is technical—would make sense to combine them in one place. Problems would be more easily handled. Urgency would be higher. OC-ALC is willing to take on procurement of new system and turn over sustainment to WR-ALC.
7. Please e-mail completed questionnaire to william.ford@afit.edu. Thank you for your assistance.

Appendix W: Cruise Missile Group Questionnaire for IQ3

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

1. What specific sustainability issues (e.g. hardware, components) does this equipment have?
1) Parts obsolescence. Expecting a big problem could stop operations. 2) Aging issue. Example: wiring harness isn't obsolete, but it is old. Tag groups/patchboards would be another example. Opinion is VACE masks aging problem. (*XXXX Redacted XXXX*) will have components by name.
2. Is there an action plan to address these issues? Please explain.
See e-mail from (*XXXX Redacted XXXX*) regarding FFF. MSD is the way ahead and each issue will be addressed one at a time—it's based on demand. PMs can inject artificial levels, but need to map out smart way to inject replacement parts—to date this has not been done. Expecting AFMC to go to ALCs to develop a specific FFF plan. Then, another meeting to clarify the priorities.
3. Are these issues solvable? If not, why? What roadblocks, if any, are hindrances to reaching a solution?
Most of the issues are solvable. Not as afraid of obsolescence as used to be. Specific FFF plan written and agreed to by all interested parties. FFF places big responsibility on government bureaucracy. Success completely depends on whether single projects receive MSD funding. LEA will be developing the plan and will have to stick to it.
4. Are there timelines for reaching a solution? Please explain.
2010 is the new drop dead date for now (previously 2008). DD in being fielded in Spring 05. The other timelines for the remaining projects are being developed by LEA engineering. The timelines will follow after the FFF plan is finalized. AF GONSG is involved and interested in ATS issue.
5. When did these issues first arise?
(*XXXX Redacted XXXX*) previously covered. Roughly early 90s.
6. How urgent of a priority are these issues?
2008 to 2010. LEA appears to be taking it serious. AFMC attention seems to be dropping off since funding was sorted out. In 1999 to 2000 timeframe, issue staggered at a/o level for a period until priority was appropriately elevated. LEA doesn't seem to get the seriousness of cruise missiles and they're not very experienced—much turnover. Frustration with explaining AFMC processes to AFMC personnel.

7. Please add any additional information you feel would aid in answering Investigative Question #3.
n/a.
8. Please e-mail completed questionnaire to william.ford@afit.edu. Thank you for your assistance.

Appendix X: Cruise Missile Group Questionnaire for IQ4

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

1. Do units get the parts they need to support their assigned equipment? Please explain.
Most of the time they do. At times, (*XXXX Redacted XXXX*) gets involved.
2. Do units get the replacement parts in a timely fashion? Please explain.
Same as above. In attention to follow up bites us at all levels. Some times supply/item managers drop priorities or don't connect there is a problem. Comes back to inexperience.
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.
Easy to get caught up on single time events. Generally, not a problem. Tech. Orders were written for more system knowledge. It seems to happen at both extremes (either a lot or a little). ICBM technicians may be source because ICBM tech data is written for technicians with less systems knowledge.
4. Are TOs of good quality? Please explain.
Good shape.
5. Are TCTOs of good quality? Please explain.
Not many TCTOs lately. However, several TCTOs will be needed to replace obsolete components.
6. Do units receive adequate SPO troubleshooting support when formal technical data is exhausted? Please explain.
Highly personality and experience driven. Tinker does a great job of supporting our field units. They are a major source of troubleshooting test equipment issues that should be supported by LEA. LEA is highly variable; not a lot of expertise. By LEA's own admission, they significantly rely on Tinker expertise.
7. Are there relatively more, fewer, or about the same number of MICAPs as in the past? Please explain.
Talk to (*XXXX Redacted XXXX*). Would be surprised if it is increasing exponentially. Expect it to be fairly level.
8. Are backorders longer than 30 days common? Give examples of recurring problems.
Usually 1-2 items like this. DD heads are coming up as an issue.

9. Please add any additional information you feel would aid in answering Investigative Question #4.
In general, they do pretty well. Many successes, occasionally a problem.
10. Please e-mail completed questionnaire to william.ford@afit.edu. Thank you for your assistance.

Appendix Y: ICBM Group Questionnaire for IQ4

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

1. Do units get the parts they need to support their assigned equipment? Please explain.
Not always, parts are the challenge with the current E-35 test station and one of the main reasons for the current test station replacement effort. Instruments used in the E-35 ATS are stock listed in the AF supply system and therefore available to anyone who uses the same instruments. This limits the availability and coupled with the age of the instruments, repair of these items is very difficult.
2. Do units get the replacement parts in a timely fashion? Please explain.
No, the current ATS is an antiquated piece of equipment that makes it challenging at best to sustain. Parts to repair a "down" test station can sometimes take months to procure through the normal supply system. Many "work-arounds" have been used to get LRU's repaired outside the normal supply system in order to maintain operational test stations.
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.
We do not perform procedures outside existing technical data at the direction of the SPO. If there is a problem that exhausts our existing technical data, we will request Depot support via the 107 process. If the request is approved through higher headquarters (HQ AFSPC & Twentieth Air Force), a depot team will be sent TDY to the location to correct the problem. When they are on-site, the unit will support and provide technical assistance where necessary.
4. Are TOs of good quality? Please explain.
Tech data is generally of very good quality. Wings and Twentieth Air Force do a good job of identifying technical order deficiencies and recommending specific changes when needed.
5. Are TCTOs of good quality? Please explain.
Yes, the process for validating and verifying TCTO's includes the using organizations and actual technicians that will perform the TCTO, so they typically go through a pretty extensive QA check before implementation.
6. Do units receive adequate SPO troubleshooting support when formal technical data is exhausted? Please explain.
Typically, we use the 107 process to request depot (not SPO) support when existing technical data does not cover a specific area. The SPO does not generally get involved

with specific troubleshooting support unless the depot team includes them in their process.
7. Are there relatively more, fewer, or about the same number of MICAPs as in the past? Please explain.
We can sometimes be our worse enemy when it comes to MICAP of the ATS. With two test stations at each operating location, we can usually keep one operational and thus don't MICAP for parts. We'll "borrow" from one test station to keep the other operational so we accomplish the mission. Since we've employed that philosophy since the beginning of time, I would say MICAP's are about the same.
8. Are backorders longer than 30 days common? Give examples of recurring problems.
Yes, ATS instruments are becoming more difficult to obtain and sustain, therefore, the supply system usually cannot support the needs of the units.
9. Please add any additional information you feel would aid in answering Investigative Question #4.
Specifically focusing on the E-35 ATS, the SPO has allowed our spares to decline to a point that makes it difficult at best to maintain the test stations in operating condition. With the development of the replacement new test station, we hope we have learned from our mistakes and will take the necessary steps to preclude having the same supply issues. Our goal is to have some sort of on-site CLS to maintain the replacement ATS that will support in maintenance, trouble analysis, and spares.
10. Please e-mail completed questionnaire to william.ford@afit.edu. Thank you for your assistance.

Appendix Z: ICBM Group Questionnaire for IQ3

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

1. What specific sustainability issues (e.g. hardware, components) does this equipment have?
2 fold problem. 1) End items in bench (primarily HP) are all commercial, and these manufactures gave up supporting these old lines long ago. 2) The other half of the problem resides with how the IMs manage the remaining end items needed to support the E-35. The IMs for these items are at WR-ALC and don't have ICBM expertise. They have been purging the old equipment (which we need) and send us "suitable subs" that are not usable with the E-35. Example: they removed 7906 disc drives from service, but suggest an optical drive in its place. Digital side is very unreliable.
2. Is there an action plan to address these issues? Please explain.
Two main plans were considered. 1) Find updated replacement parts to make the E-35 sustainable. This plan was never attractive because of the E-35's notorious unreliability. The effort was also considered high risk because of the excessive amount of outdated COTS equipment in the E-35. 2) Easier to build system from ground up, and everyone expected ATS reliability to improve greatly. GMATS is the way ahead. Side note: There are 12 at operational locations, 2 at tech school, 10 at depot. Spring 05-Fall 06.
3. Are these issues solvable? If not, why? What roadblocks, if any, are hindrances to reaching a solution?
Issue is solvable with GMATS. Roadblocks; two major stumbling blocks. 1) Rehosting software was a difficult climb. 2) CLS contract has been point of discussion. We give up capability, while waiting for contractor. Feel more comfortable with equipment in hands of contractor than in depot IM's hands. By keeping the equipment not stock listed, the IMs can't begin disposition of the equipment.
4. Are there timelines for reaching a solution? Please explain.
GMATS is the way ahead. Spring 05-Fall 06.
5. When did these issues first arise?
Educated guess of 6-8 years ago.

6. How urgent of a priority are these issues?
We have had 0 operational E-35s at wings, but rare; high priority when this happens. Wings have 3 E-35 to keep at leas one bench serviceable. Looking forward to replacement.
7. Please add any additional information you feel would aid in answering Investigative Question #3.
The success of E-35 sustainability boiled down to the effort of the technicians despite the availability of sufficient parts. Commented on depot's PMEL stellar effort and ability to keep the equipment running far past expectations of many.
8. Please e-mail completed questionnaire to william.ford@afit.edu. Thank you for your assistance.

Appendix AA: ICBM Group Questionnaire for IQ4

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

1. Do units get the parts they need to support their assigned equipment? Please explain.
Two extremes. If parts are in supply system, units get the parts in the expected period of time. If they are obsolete, they can take for ever. Can take over a year with a lot of variability.
2. Do units get the replacement parts in a timely fashion? Please explain.
Same as above.
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.
If tech data is exhausted, they automatically do a 107 request. No one time authorizations are sought or granted. (*XXXX Redacted XXXX*) does a good job at fixing the benches and supporting the field.
4. Are TOs of good quality? Please explain.
(*XXXX Redacted XXXX*) was happy before SGML conversion. ATS TOs before conversion were good. One book has been pumped through conversion and it had several problems. There are small problems that came out of the conversion. Drawings are inaccurate, pages that don't make it in the book, references are incorrect. Sounds like depot is making the process better, but it needs significant improvement.
5. Are TCTOs of good quality? Please explain.
Frequently do them to do software programs, and they're in good shape. No outside the norm TCTOs. Only one in recent history, and that was performed by depot technicians.
6. Do units receive adequate SPO troubleshooting support when formal technical data is exhausted? Please explain.
Depot technicians can usually fix the problem in short order.
7. Are there relatively more, fewer, or about the same number of MICAPs as in the past? Please explain.
Anecdotally there have been more in recent years—an increase.
8. Are backorders longer than 30 days common? Give examples of recurring problems.
50% of the time they do. The parts that break most frequently are those that are obsolete.

9. Please add any additional information you feel would aid in answering Investigative Question #4.
Sounds like (*XXXX Redacted XXXX*) provide good assist helps. Parts availability is outside of their control because other depots are responsible for items.
10. Please e-mail completed questionnaire to william.ford@afit.edu. Thank you for your assistance.

Appendix AB: ICBM Group Questionnaire for IQ3

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

1. What specific sustainability issues (e.g. hardware, components) does this equipment have?
Almost every piece of equipment in the E-35 is obsolete. WR-ALC appeared to dump a lot of the equipment and didn't consult with the ICBM community. Also, because it is stock listed, other DoD agencies could order the equipment. Once supply was used, the IMs began pushing what they thought were suitable subs to units. Aging isn't an issue but obsolescence of the parts is. In other words, if there was an endless supply of the old parts, the E-35 could be supportable (disregarding its poor reliability).
2. Is there an action plan to address these issues? Please explain.
Entire ATS replacement is the plan. Peacekeeper is using the E-35s until that system retirement. Plan is to cannibalize remaining E-35s to maintain the PK E-35s. In theory, the E-35s will last through PK retirement.
3. Are these issues solvable? If not, why? What roadblocks, if any, are hindrances to reaching a solution?
N/A
4. Are there timelines for reaching a solution? Please explain.
E-35s need to last through PK retirement. Empty holes will still have operating ground equipment for the foreseeable future. No known date on entire PK deactivation.
5. When did these issues first arise?
Started to crop up as far back as 1996-1997.
6. How urgent of a priority are these issues?
Incredibly high. We are facing mission no gos with the E-35 as is. Used pulse generators as example.
7. Please add any additional information you feel would aid in answering Investigative Question #3.
8. Please e-mail completed questionnaire to william.ford@afit.edu. Thank you for your assistance.

Appendix AC: ICBM Group Questionnaire for IQ4

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

1. Do units get the parts they need to support their assigned equipment? Please explain.
With regards to the E-35, partially. IMs at WR-ALC send the wrong parts as previously discussed. Parts in the depot are correct (those that are fenced from WR-ALC). The ICBM SPO/depot does a good job at supporting the units.
2. Do units get the replacement parts in a timely fashion? Please explain.
It depends. If MICAP, they get it a lot faster. If not, they wait.
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.
TO procedures are pretty good. When problems do come up, 107-request is the way ahead. Rarely do units have to perform unusual procedures at the direction of the SPO; when they do, they get good support. Echoed the SGML problem mentioned previously.
4. Are TOs of good quality? Please explain.
Yes, with the exception of SGML translation. Some of this problem could be attributed (*XXXX Redacted XXXX*).
5. Are TCTOs of good quality? Please explain.
N/A
6. Do units receive adequate SPO troubleshooting support when formal technical data is exhausted? Please explain.
Yes. Significant to note; they also have the right people like Northrop and Boeing working closely with the SPO to provide the required expertise. These defense contractors don't work directly in the SPO, but provide continuity and system knowledge we probably lack.
7. Are there relatively more, fewer, or about the same number of MICAPs as in the past? Please explain.
No good guess.
8. Are backorders longer than 30 days common? Give examples of recurring problems.
Significant portion of parts are on BO longer than 30 days.
9. Please add any additional information you feel would aid in answering Investigative

Question #4.
Generally, field level's ability to support equipment is excellent due to the countless hours of troubleshooting the benches. We wouldn't have made it this far with the E-35 without the effort.
10. Please e-mail completed questionnaire to william.ford@afit.edu. Thank you for your assistance.

Appendix AD: ICBM Group Questionnaire for IQ1

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

1. What is your duty title and job description?
(*XXXX Redacted XXXX*)
2. What activities are part of your daily work that pertain to the management of this equipment?
(*XXXX Redacted XXXX*). TPSs are being focused on at this time. Northrop is prime PM for oversight of software; however, the government is still the integrator. She is offering the wing's perspective to ensure field units get a good system. GMATS will begin being fielded 15 Mar. Minot-FE-Malmstrom-VAFB-Depot. Basis for beddown is the wings have less TPSs than the depot and the TPSs are still being developed/built. Total of 55 LRU TPS's and 191 SRU TPS's being developed.
3. What activities do you perform that pertain to short-, mid- and long-term planning for this equipment?
No answer because of the fielding of new ATS.
4. What activities do you perform in support of or in response to issues that arise from field-level users of this equipment?
Typically, they investigate the specific issue to figure out if the problem is with the test stand or the TPS. If it can be fixed by ES over the phone, great. If not, (*XXXX Redacted XXXX*) finds the needed expertise for telephone troubleshooting or sends them TDY for repair. (*XXXX Redacted XXXX*) specifically mentioned the heroic efforts of depot PMEL—without them, the E-35 would have been dead long ago.
5. When was this equipment initially fielded?
E-35 roughly 87-88.
6. What did this equipment replace, if applicable?
9500 was the shop name. (Automatic Test Capability for Minuteman Ground Systems) No idea on when that was fielded. Was fielded in 1977
7. Have you encountered any obsolescence issues pertaining to this equipment? If so, please explain.
E-35 has numerous issues and was the reason for replacement. Manufacturers and even second sources only produced out of configuration items that required modification. PMEL has band-aided it for years—kudos. GMATS; already has minor problems, but because they're COTS items, they have remove/replace solutions. Each base will have an entire spares kit—major components only (kind of like a mini supply).

Hill has 8 test stands they've been tinkering with to determine the high fail items, so they know what to expect in the future and what to put into the spares kits.
8. What managerial challenges do you perceive as unique to this equipment?
E-35; biggest thing was just keeping them running—real high failure rate (just not reliable). GMATS; not a big problem yet--not even software. Units are gun shy about trusting the GMATS because of the poor reliability of the E-35. As a note, the 9500 was even better than the E-35. but needed to be replaced due to obsolescence issues.
9. With whom do you routinely work in support of managing this equipment? (duty titles and job descriptions)
Northrop Boeing Teradyne Anteon MASMA at Hill AFSPC 20AF
10. Are you familiar with DoD policy regarding the acquisition and development of common test equipment? (AFPD 63-2)
(*XXXX Redacted XXXX*) is familiar with it.
11. How does this DoD policy affect this equipment, if at all?
Hard to say.
12. Please add any additional information you feel would aid in answering Investigative Question #1.
13. Please e-mail completed questionnaire to william.ford@afit.edu. Thank you for your assistance.

Appendix AE: ICBM Group Questionnaire for IQ3

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

1. What specific sustainability issues (e.g. hardware, components) does this equipment have?
E-35; obsolescence was the issue and is spread throughout the whole stand. Pulse Generators were real bad. As a practice, each unit has a spare E-35 used as a source for parts to keep the operational E-35 up and running.
2. Is there an action plan to address these issues? Please explain.
Replacing E-35 with GMATS.
3. Are these issues solvable? If not, why? What roadblocks, if any, are hindrances to reaching a solution?
None to date; schedule is on track so far. Funding requirements have crept up significantly during software development.
4. Are there timelines for reaching a solution? Please explain.
GMATS will begin being fielded in March 05 and last one will be installed at Hill in 07-08. Total number of stands is 18.
5. When did these issues first arise?
E-35 obsolescence problems began 4-5 years after fielding, maybe even less.
6. How urgent of a priority are these issues?
Eventually it would have gone belly up; the E-35 had little chance of lasting much longer. Kudos to PMEL at the depot. 107s were the mechanism or fix over the phone. Maybe 4,5,6 years would have been possible.
7. Please add any additional information you feel would aid in answering Investigative Question #3.
8. Please e-mail completed questionnaire to william.ford@afit.edu. Thank you for your assistance.

Appendix AF: ICBM Group Questionnaire for IQ1

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

1. What is your duty title and job description?
(*XXXX Redacted XXXX*)
2. What activities are part of your daily work that pertain to the management of this equipment?
(*XXXX Redacted XXXX*)
3. What activities do you perform that pertain to short-, mid- and long-term planning for this equipment?
For the acquisition activity I am involved in the (*XXXX Redacted XXXX*). For the sustainment activity, recent planning involves (*XXXX Redacted XXXX*).
4. What activities do you perform in support of or in response to issues that arise from field-level users of this equipment?
For the acquisition project we work with the user (at the MOB site) and the organic developer and PRIME TEAM to upgrade the Maintenance and Operation TO's.
5. When was this equipment initially fielded?
1985
6. What did this equipment replace, if applicable?
GMATS (fielding in 2005) replaces the E35 (1985). The E35 replaced the HP9500 (1976). There was another ground electronics system before that, but I'm not sure what the name was.
7. Have you encountered any obsolescence issues pertaining to this equipment? If so, please explain.
Yes. This type of equipment is generally obsolete before it even gets fielded and gets worse from there. Previous to GMATS the systems were stock-listed. That allows anyone that really needs the commercial electronics equipment (O-scopes, signal generators, power supplies,…) to grab them. Sometimes its easier to get equipment off the Internet (really) than it is to get it out of the system.
8. What managerial challenges do you perceive as unique to this equipment?
For GMATS we did lifetime buys of spares and are using ICS with organic partnership to handle breakdowns/sparing. At the depot, we are intending to use ICS and organic partnership to maintain the equipment and handle spares.

9. With whom do you routinely work in support of managing this equipment? (duty titles and job descriptions)
(*XXXX Redacted XXXX*)
10. Are you familiar with DoD policy regarding the acquisition and development of common test equipment? (AFPD 63-2)
Yes. My programs procure common commercial test equipment for use in an ATE environment.
11. How does this DoD policy affect this equipment, if at all?
We procure from approved families of equipment.
12. Please add any additional information you feel would aid in answering Investigative Question #1.
GMATS, as verses E35, its predecessor, is very different in how it is to be managed in its lifecycle. The E35 was designed under a prime/subcontractor and fielded using organic maintenance and support personnel. Spares were drawn from government supply sources and contracts. The GMATS, on the other hand, is designed by an organic group, with SPO oversight and PRIME TEAM input, and it will be fielded using a partnered approach to field and depot maintenance. Ready spares will be available on-site through ICS/CLS management at both MOB/depot locations. CAL will still remain organic in both instances.
13. Please e-mail completed questionnaire to william.ford@afit.edu. Thank you for your assistance.

Appendix AG: ICBM Group Questionnaire for IQ3

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

1. What specific sustainability issues (e.g. hardware, components) does this equipment have?
For E35 – the test station is wearing-out, and although most of the commercial equipment is being kept-up, the HP1000 processor and several key digital switching groups are regularly failing. I would say that the station infrastructure in which the equipment functions is not sustainable for much longer. For the GMATS – its just going into the field. The test stations used during development (8 of the 18 total purchase) have/will be used pretty hard and will probably give and early indication of just how well the whole system will stand-up. Again, the digital switching system will probably be the weak link.
2. Is there an action plan to address these issues? Please explain.
For E35 – the action plan is to withdraw it from service in April 2008 1yr after GMATS is fully deployed. For GMATS – I think we have a better plan (see IQ1). Some of the difficulty maintaining E35 is the long waits to procure replacement commercial test equipment (See IQ1). Also, some of the drawers TPS's were not good candidates for an ATE environment (computer-intensive drawers and mechanical monsters), and have been removed and replaced with dedicated test setups for diagnostic and certification activities.
3. Are these issues solvable? If not, why? What roadblocks, if any, are hindrances to reaching a solution?
Yes.
4. Are there timelines for reaching a solution? Please explain.
Yes. For the GMATS, one only needs to plan from the outset. But with the E35, the management problems seem to lead only to replacement, and doing business differently.
5. When did these issues first arise? See IQ1.
6. How urgent of a priority are these issues?
The supply issue is exasperating enough to turn hair grey. It's one of those issues where you vow never to go there again.

7. Please add any additional information you feel would aid in answering Investigative Question #3.
8. Please e-mail completed questionnaire to william.ford@afit.edu. Thank you for your assistance.

Appendix AH: ICBM Group Questionnaire for IQ1

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

1. What is your duty title and job description?
(*XXXX Redacted XXXX*)
2. What activities are part of your daily work that pertain to the management of this equipment?
(*XXXX Redacted XXXX*)
3. What activities do you perform that pertain to short-, mid- and long-term planning for this equipment?
(*XXXX Redacted XXXX*)
4. What activities do you perform in support of or in response to issues that arise from field-level users of this equipment?
(*XXXX Redacted XXXX*)
5. When was this equipment initially fielded?
E-35 -1986 GMATS - 2005
6. What did this equipment replace, if applicable?
GMATS (AN/GSM-315A) is replacing the legacy E-35, (AN/GSM-315)
7. Have you encountered any obsolescence issues pertaining to this equipment? If so, please explain.
Yes, everything on the E-35 is obsolete and several components (COTS items) on the GMATS are out of production before GMATS goes to IOC.
8. What managerial challenges do you perceive as unique to this equipment?
E-35 was an unique end item to manage as over 70-percent of the budget code 8 components embedded with the E-35 were common (COTS items) managed outside of OO-ALC Hill AFB & the ICBM program. As the test set aged, priority differences arose between the managers of the embedded COTS items within the E-35 and the ICBM program. Declared but not actual obsolescence occurred, configuration conflicts, loss of repair sources, incorrect factoring for spares buys, in short ICBM in large part lost control of their ICBM ATS because of logistical disconnect or the specialized needs of the ICBM world being swallowed up by the greater Air Force supply system, which is driven by the Air Craft world.

9. With whom do you routinely work in support of managing this equipment? (duty titles and job descriptions)
(*XXXX Redacted XXXX*)
10. Are you familiar with DoD policy regarding the acquisition and development of common test equipment? (AFPD 63-2)
No, I would have to study up on the specifics called out. I do know there is a depreciation taxed charged equipment owners which is suppose to go into a fund for equipment replacement of test equipment – problem is the money is not fenced per specific programs so the money is usually not available when a major equipment replacement is needed, this was the case with the GMATS.
11. How does this DoD policy affect this equipment, if at all?
See comments on number 10.
12. Please add any additional information you feel would aid in answering Investigative Question #1.
See # 1
13. Please e-mail completed questionnaire to william.ford@afit.edu. Thank you for your assistance.

Appendix AI: ICBM Group Questionnaire for IQ2

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

1. Who is responsible for funding your related equipment?
AFSPC
2. Are there any funded/unfunded requirements for the equipment? Please explain.
I worked an unfunded issue due to a budget cut in FY2003. It was UUT MSD money regarding software support of the legacy E-35 (AN/GSM-315)
3. What equipment funding requirements were included in the last 2 POM cycles? Please include the associated BES input.
N/A the GMATS money was POM'd for before I was spun up on the program
4. Do you get the funds needed to adequately support your equipment program? Please explain.
Yes, DPEM 3400 money provides a level of effort for sustaiment of E-35 hardware repair for budget code 8 items mostly. MSD UUT money has been the sustainment for software SDR support but will be rolling over to a DMAG account in FY06 and no one seems to know how the requirements will be written and how the program office will control the work.
5. Are your equipment POM inputs funded? If not, how far below the Air Staff/MAJCOM funding line did the requirements fall?
Again, not applicable for me to answer. GMATS was funded in FY2001-2006 but you'd have to ask the acquisition folks for the specifics.
6. Please add any additional information you feel would aid in answering Investigative Question #2.
7. Please e-mail completed questionnaire to william.ford@afit.edu. Thank you for your assistance.

Appendix AJ: ICBM Group Questionnaire for IQ3

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

1. What specific sustainability issues (e.g. hardware, components) does this equipment have?
Obsolescence, the life cycle of the test set is much longer than the NDI/COTS components embedded in the ICBM automated test equipment.
2. Is there an action plan to address these issues? Please explain.
For the new ICBM automated test station (GMATS) we have not stock listed (traditionally provisioned) the COTS components needed to support the GMATS. Instead a CLS provider is being tasked with supply & inventory support responsibilities which include COTS components failure trend analysis, provisioning, and configuration management. The potential CLS provider (Boeing) has demonstrated in other CLS equipment taskings the ability and flexibility to stay ahead of the COTS obsolescence curve. An ability that is sorely lacking for small programs (embedded with COTS) within the organic Air Force supply system.
3. Are these issues solvable? If not, why? What roadblocks, if any, are hindrances to reaching a solution?
A one-size fits all supply system will never ever solve the logistic pitfalls for small equipment programs mostly embedded with COTS components which grow obsolete within 2-5 years. The CLS solution described for the GMATS program above in # 2 is a model, and a growing support method trend throughout the AF.
4. Are there timelines for reaching a solution? Please explain.
N/A
5. When did these issues first arise?
Lessons were learned about the logistics problems bedeviling the E-35 program. The problems again were obsolescence and loss of configuration control when the greater supply system came up with a suitable substitute COTS component that did not work properly with all the legacy system applications still on line
6. How urgent of a priority are these issues?
It was my number one priority as (*XXXX Redacted XXXX*) and I was the (*XXXX Redacted XXXX*) of the (*XXXX Redacted XXXX*) maintenance (sustainment) concept.
7. Please add any additional information you feel would aid in answering Investigative Question #3.
See (*XXXX Redacted XXXX*) attachments regarding the SORAP & partnered GMATS

issues.
8. Please e-mail completed questionnaire to william.ford@afit.edu. Thank you for your assistance.

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Vita

Captain William C. Ford was born in Tacoma Park, Maryland, and was raised in White Pine, Tennessee, where he graduated from Jefferson County High School in 1986. He enlisted in the US Air Force in September 1986, and completed missile electronics equipment technical training at Chanute AFB, Illinois.

His first duty assignments were Plattsburgh AFB, New York, and Dyess AFB, Texas, where he was responsible for maintaining the AGM-69A Short Range Attack Missile stockpiles and the FB-111/B and B-1B weapon systems. In 1993, he was hand-picked as a member of the B-2A bomber integrated development/operational test team at Edwards AFB, California. While stationed at Edwards AFB, he completed his Associates in Applied Science in Electronic Systems Technology from the Community College of the Air Force and his Bachelors of Science in Industrial Technology from Southern Illinois University.

After completing Officer Training School in 1998, he was assigned to Malmstrom AFB, Montana, as a missile maintenance officer. In 2001, he was assigned to Headquarters Air Combat Command, Virginia, where he worked within the Munitions Division as an action officer.

In August 2003, he entered the Graduate Logistics Management Program at the Air Force Institute of Technology. Upon graduation, he will be assigned to the F/A-22 System Program Office, Wright-Patterson AFB, Ohio.

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14. ABSTRACT
From 1980 to 1992, the DoD spent over $50 billion acquiring Automatic Test Systems (ATS) used to test weapon systems. At that time, procuring unique ATS to support single weapon systems was the norm. In 1994, the DoD made a dramatic change to their ATS acquisition policy; common ATS that supported multiple weapon systems was preferred over ATS tailored to support a single weapon system. Expected benefits of this new policy included: more reliable equipment, increased supportability, decreased cost, smaller logistics footprint, and decreased manning. To date, the common ATS initiative has garnered little support AF-wide due to lack of substantive data supporting the expected benefits in a practical setting. The majority of the ATS procured in the 1980-1992 "bubble" is still in service but is facing severe aging and obsolescence issues.

The purpose of this research was to compare two ATS programs selected because of their numerous similarities, with their singular difference being whether the equipment was managed as common core (Cruise Missile ATS) or managed as part of the weapon system (ICBM ATS). This research seeks to satisfy two goals. The first goal of this case study was to determine if the expected benefits of common ATS are being realized in a practical setting. Second, if the expected benefits are not being met, the hindrances should be understood so they may be corrected.

15. SUBJECT TERMS
Automatic Test Systems, ATS, Automatic Test Equipment, ATE, Cruise Missile, Intercontinental Ballistic Missile, Common Core, Weapon System Specific, Test Program Set, Unit-Under-Test, Rotary Launcher, Launch Facility, Minuteman III, ESTS, E-35, GMATS, MWS, ATS Policy, Sustainment, Funding

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