

ATE and TPS Management

A Look into Air Force ATS Strategies and Challenges

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Abstract— The purpose of this paper to discuss Automatic Test Equipment (ATE) and Test Program Set (TPS) management strategy efforts to improve support and reduce logistics costs within the Air Force. The emphasis of this paper will be on two subtopics; efforts to reduce proliferation of unique Automatic Test Systems (ATS) and the impact of technology and software advances as they relate to how the Air Force (AF) works to standardize the TPS process. Both subtopics have a focus on standardization and reduction in life cycle costs for the Air Force.

I. INTRODUCTION

The average age of the U.S. AF aircraft fleet is over 23 years, ranging from less than a year to fifty years old. [1] The AF ATS Product Group Manager (PGM) must maintain testing capability for the full range of aircraft, continuing support for aging aircraft avionics systems while fielding testing capability to meet new advanced aircraft systems. Budget and other resource constraints limit the resources available to tailor solutions to all the systems supported by the AF ATS PGM. The obvious solution to the problem is standardization and commonality in testing with solutions that are sustainable for the life of the weapon system. Considering that around ninety percent of ATS costs are the applications, we need more focus on the process of Unit Under Test (UUT) requirements, standardized Test Program Sets (TPS), and all that drives the ATE requirements and TPS transportability.

Steps are being taken to make improvements including the current efforts to revise MIL-PRF-32070. Standardization of software efforts should result in savings of cost and time along with the additional benefit of moving the DoD closer to TPS transportability. In turn, TPS transportability removes some of the risk historically seen in making ATE system changes. The knowledge that changes to the ATE hardware can impact the TPSs has historically resulted the AF missing many opportunities for added capability, decreased obsolescence risk, or increase efficiencies.

The DoD faces the task of keeping up with industry software innovation and smartly capitalizing on efforts that could help the government work smarter and more efficiently. Within the past decade the commercial industry has seen many advances and positive changes with the DoD not able to implement changes as quickly due to constraints and mission

requirements. In a field where advances are regularly happening, it is hard to discern which advances can and should be integrated into DoD TPS management activities. The DoD is often seen as moving slowly behind the commercial sector resulting in lost opportunities and missed savings. Many examples exist of DoD adopting industry technology later in life once the technology is proven and support is established. This strategy reduces risk upfront but considering how long the government maintains systems the technology is all too often obsolete by the time the technology is fielded. The challenge is to effectively and efficiently implement a process that allows for faster flow of innovation into government acquisition processes. The effort of streamlining implantation needs to weight in the risk factors along with the life cycle cost benefit that could be achieved through an earlier introduction of new technology.

II. REDUCING THE PROLIFERATION OF UNIQUE ATS SOLUTIONS

A. Background

Historically in the Air Force, each weapon system purchased its own ATS, resulting in an abundance of redundant capability within the AF ATS inventory. This became more evident as ATS was consolidated under the ATS Product Group Manager (PGM) umbrella. In 2003, a GAO Audit [2] brought to light the fact that the AF was maintaining a great number of unique testers supporting the fleet of AF aircraft. The problem clearly stated in the GAO Audit Report that maintaining a collection of aging non-standard testers was costing the AF billions of dollars and negatively impacting warfighter support.

B. Air Force Acquisitions Logistics

Within the AF traditionally, there was an acquisition community and a sustainment community. The two entities were situated at different geographic locations and the pass off from one to the other could be rough with little communication happening between the two. ATS and support equipment (SE) were usually chosen by the System Program Office (SPO) based on recommendations from the Original Equipment Manufacturer (OEM). More often than not this test equipment

was unique and rarely was there any discussion with the AF ATS PGM to determine if there was something in the AF or DoD inventory that could already perform the testing or be modified to perform the testing. The end result of this practice was over 300 different testers in the Air Force inventory with an abundance of redundant capability [2]. Recognizing that the two community system is not working, efforts are in work to change to a process that includes a cradle to grave management perspective.

As part of the efforts to change the process, the AF ATS PGM has been working on getting the AF regulations changed and getting the acquisition and sustainment communities to bring their requirements to the AF ATS PGM for review and waivers when not using a standard tester. The ATS PGM has seen significant progress in getting the AF communities educated on the process but still has more work before the process is culturally embraced.

C. Air Force Policy and Regulation Changes

Currently ATS is procured by either the organization with the need or the organization that manages the ATS. This means the list of organizations procuring ATS includes the AF ATS PGM, three AF depots, and many weapon system SPOs and commodity PGMs. For standardization to occur, all of these organizations must be familiar with ATS policies on standardization. The single best way to reach each location with the policy is getting the AF regulations and policies on acquisition and sustainment to reflect DoD and AF ATS policies.

Outlined below are the changes that have been made to AF regulations and directives in an effort to educate community members on ATS standardization policy. As the AF gets further down the road, more regulation changes are expected to further expound on AF ATS standardization.

- Air Force Program Directive 63-1/20-1, Acquisition and Sustainment Life Cycle Management - This directive superseded 15 AFPDs. This AFPD consolidates publications to provide a life cycle integrated framework for acquisition and sustainment.
 - Key statement change:

Proliferation of system-unique support equipment/automatic test systems (ATS) shall be minimized, while ensuring the maintenance and deployment requirements of existing and developing systems are met. SPM/PM/PGMs shall use approved DoD ATS Families as the preferred choice to satisfy automatic testing support requirements.
- Air Force Instruction 63-101, Acquisition and Sustainment Life Cycle Management - This document provides instruction for the acquisition and management of all programs identified on the Acquisition Master List (AML) and Sustainment Program Master List (SPML), space programs, designated weapon systems cited in AFPD 10-9, *Lead Command Designation and Responsibilities for Weapon Systems*, and systems,

activities, and projects that support warfighter capability planning and validated needs.

- The key statement changes include:

The PM shall minimize the proliferation of system-unique equipment at all levels

The PM shall acquire SE/ATS which is to the maximum extent possible common and interoperable with other Services and across multiple weapon systems and munitions. Peculiar SE/ATS shall be developed only as a last alternative

Endeavor to design systems, subsystems and end-items to minimize new ATS development while still optimizing the life cycle users' operational capabilities and product support requirements

- Air Force Pamphlet 63-128, Guide to Acquisition and Sustainment Life Cycle Management – This pamphlet provides guidance and recommended procedures for implementing Integrated Life Cycle Management (ILCM) for AF personnel who develop, review, approve, or manage systems, subsystems, end-items and services.

- Key statement changes:

If system-unique SE/ATS is planned, justify why standard or family SE/ATS was not feasible and/or cost-effective

Minimize the introduction of unique types of SE/ATS minimized in considering hardware and software

Address collaboration with the SE/ATS PGM.....for equipment acquisitions to standardize equipment or make it compatible with other systems

ATS should be kept to a minimum and the use of common SE is strongly preferred rather than peculiar SE/ATS

A system should be designed to use standard SE/ATS and common, embedded test, measurement, and diagnostics equipment (TMDE) to support organizational maintenance and depot support

- Air Force Independent Logistics Assessment Handbook, Department of the Air Force Guide for Conducting Independent Logistics Assessments

- Key checklist question additions include:

Does Automatic Test Equipment (ATE) comply with USD (AT&L) policy for standardization?

Is the development of new ATE minimized?

Are ATE standard families or COTS components being used to the fullest extent possible to promote commonality and interoperability of equipment?

- Robins Air Force Base Instruction 21-111, Depot Maintenance Activation Planning - This instruction is used by the WR-ALC as part of the depot stand-up process.

- The key statement changes include:

The DoD ATS Selection Process Guide which can be found at the DoD ATS Executive Directorate Website shall be used to guide ATS selection

The PM shall contact the ATS Product Group Manager (PGM) as repair requirements are identified and in sufficient time to allow budgeting, funding, and delivery of testers/test equipment system. This includes the hardware and software to run the required tests

The PM shall provide parametric testing requirements to the ATS PGM to include details of the test ranges as well as any additional requirements, i.e., must be able to be nuclear certified, must be portable, etc

The PM shall ensure that requirement to use DoD Standard ATS is a part of the repair/depot stand-up contracts for all new acquisitions

The PM shall obtain an approved waiver from the ATS PGM to buy non-standard equipment prior to the purchase of the non-standard equipment

D. Effecting Change and Cultural Barriers

Now that AF regulations and policies have been changed to better reflect the ATS standardization requirement; there is a need to address a more basic issue involved in bringing about change. Organizational culture is an influential force that runs through every organization. [3] It is defined as the attitudes, experiences, beliefs, and values working within an organization define people's behavior and sets how things get done either positively or negatively. To enact any change within an organization, these cultural factors play a considerable role. All AF organizations have at some point had a negative experience with change and this experience puts up a roadblock when attempting to make future changes. [4]

Within the acquisition and sustainment communities, most people are more comfortable doing what they know and what has worked in the past. Often times the mentality is "If it ain't broke, don't fix it". Weapon system SPOs acquiring ATS for their systems cannot see the big ATS picture of all the other requirements in the AF. They do not see the amount of redundancy in capability that results in wasted resources throughout the AF. In general, known risk is easier to accept than unknown risk and in the ATS world, known risk is usually a unique solution created for the weapon system being tested. This unique ATS solution, especially if created by the OEM, is seen as less risky to the weapon system SPO than a standard ATS solution not created specifically for their requirement. The belief also remains prevalent in a lot of weapon system SPOs that a standard solution will not be able to meet the cost, schedule, or performance requirements of their program. These beliefs concerning standard ATS solutions will require education and examples of success in order to impact these barriers that are limiting acceptance of ATS standardization.

E. Facilitating Change in the AF ATS Community

The goal of the AF ATS PGM is to bring about a cultural change where all the members in the AF ATS community are working together to achieve ATS standardization. To get to that point, the AF ATS PGM must continue to educate the AF ATS community on ATS standardization policies and the benefits of ATS standardization. Members of the community must be vested in standardizing the ATS and TPS for this to work. There must be a common understanding of the standards being followed and the processes to implement them.

The AF ATS PGM is making changes happen by educating the AF ATS community through Roadshows and ATS policy briefings, distributing additional policy guidance within the AF community, moving more management of ATS under the AF ATS PGM, standardizing the ATS acquisition process including policies and processes for TPS acquisition/rehost, and adapting the DoD ATS Generic OTPS solicitation package for AF TPS acquisitions. The AF ATS PGM is also involved in updating DoD ATS TPS Life Cycle Management Handbook and the MIL-PRF-32070A.

III. ATS MANAGEMENT IN AN EVER CHANGING ENVIRONMENT

A. Past Attempts to Standardize AF ATS

In 1976, the AF developed the Modular Automatic Test Equipment (MATE) system. [5] The idea was to develop a standardized approach to the definition, acquisition, and support of ATE. The system was expressed in a series of guides including hardware, software, human factors, and data required to implement the approach. Basic goals of the program were to standardize the approach for AF ATS efforts and reduce proliferation of ATE. This reduction was to be accomplished by limiting the need to develop unique test equipment for AF weapon systems by providing a set of standard procedures, software, and tools for AF activities to use in developing ATE. A few examples of testers that were created under MATE that are still in use today are the Depot Automated Test Station for Avionics (DATSA) and the B-52 Modular Intermediate Depot Automatic Test System (MIDATS).

The objectives of the MATE program were excellent goals to work towards but the program failed to get input from industry or users before starting the program. The program also failed to understand that either conforming to industry standards or getting industry buy-in for the AF standard was essential for success. As a result, the MATE program ended in the mid-90's and is no longer a requirement for new AF ATS designs.

B. *Government and Industry Differences in ATS Management*

The AF is a government organization and cannot operate like commercial electronics industry does. Industry members focus on providing services and products to customers while turning a profit. The basic goals of any business are survival and growth. Investment of resources must lead to innovation or should set a company apart from their competitors while still implementing standardization. Over time, companies will evaluate their efforts and change their policies and habits in an attempt to continue growth or increase profits. Often times the changes companies make are in response to environmental/industry changes and how often the company changes is proportional to how quickly the industry is changing.

The AF, on the other hand, focuses on providing services and products to their customer (the warfighter) while staying within budgetary constraints. A need for profit is not a motivating factor in the equation. Government policies and regulations direct activities and procedures in such a way that AF organizations cannot change quickly. The bigger the change required the longer it will take to make the change within the organization. If the change the AF is looking to make requires financial resources, budgeting needs to be done lead time in advance or resources moved, if available elsewhere. As the industry changes and moves forward, government organizations lag behind due to the inability to change quickly. At times, the lag is significant enough that the AF is implementing technology that industry is already planning the replacement.

C. *Air Force ATS Management Constraints*

The AF focuses its efforts on maintaining capability for the warfighter. This may be achieved through continued use of aging weapons systems or better served by replacing the weapon system or the support systems with new technology. At its core, the AF is looking at the best way to sustain the war fighting capability that the weapon systems provide. A few constraints the AF faces that differ from the industry environment include:

- The product life cycle in the AF is much longer than in industry. This is often due to the depth and breadth of resources (funds, time, and human resources) it takes to stand up and maintain a weapon system so weapon systems are not easily or quickly replaced.
 - In the ATS world, the AF product's life span is many generations of tester technology.
- Standards and procedures outlined by government policies and regulations add in checks and balances that significantly add to the time it takes to develop and acquire new technology or systems.
- Federal Acquisition Regulations (FAR) sets up contracting and completion requirements that result in the AF having less contracting flexibility than industry.

- Lack of data on older weapon systems and their Units Under Test (UUT) is a constant challenge resulting in the need to reverse engineer in order to rehost in many cases.
- Individual weapon system SPOs manage their UUT Test Program Sets (TPSs) and Interface Test Adapters (ITAs) along with their UUTs, separately from the ATE and test station software. The reason is that the TPSs and ITA's contain the essential performance criteria and interfaces necessary to ensure the UUT's Operational Safety, Suitability, and Effectiveness (OSS&E) when employed within the weapon system IAW USAF policy. Having multiple managers of TPSs requires strong TPS standardization policy, like MIL-PRF-32070A.
- Weapon systems in the inventory and the ATS that supports them have been developed over the course of decades and the hardware and software are not standard.
 - Within the AF, the software on fielded TPS include everything from ATLAS to custom languages made by the Original Equipment Manufacturers (OEM) when developing the ATS.
 - The variety of AF ATE hardware interfaces in use makes it difficult to leverage existing TPS interface designs for rehost or reuse.
- There are over 20,000 TPSs throughout the AF.
- With older ATS, there is a significant risk of causing TPS issues when making hardware system changes to the ATE (newer ATS should include a buffer between the TPS and the ATE). This risk limits the flow of improvements on older systems that the AF doesn't want to break in the process of fixing.

D. *Example of an AF Missed Opportunity*

Due to the many constraints the AF faces, there are various examples of good initiatives the AF didn't implement till years after industry. One example is the use of a common, widely used programming language for test program software.

The AF chose to use ATLAS [6] as a standard programming language for ATS efforts in past decades. ATLAS is defined by standards, but is not widely used outside of the DoD and the airline industry. Even within the AF, ATLAS is not as widely used as it could have been. With the UUT TPSs managed by individual AF weapon system SPOs and many of those TPS development/rehost efforts done by contractors, software language standards can be difficult to regulate without strong governing guidance.

Since ATLAS is not an accepted industry standard, it is not traditionally taught as part of an engineering or software curriculum. It has a massive amount of unique structure and syntax which takes a longer time to learn. Developers have to be taught ATLAS before they can be useful in writing ATLAS-based test programs. Based on these facts, ATLAS

was not an ideal choice for a standard programming language for the AF to utilize.

While the AF was creating TPSs using ATLAS, industry was moving towards common programming languages such as “C”. Programming languages like “C” are taught at most engineering schools and have programmer communities in the millions. Industry test programmers have used common programming languages for many years. Years after the industry’s acceptance of common languages such as “C”, the AF is just beginning to standardize with industry accepted common programming language.

E. The Way Forward (AF Initiatives to Improve and Standardize)

Working closely with industry, the AF can bring about greater standardization in the AF ATS community by increasing communication with industry stakeholders and becoming more aware of changes in industry. The AF ATS PGM is working to increase AF capability and understanding for developing and implementing standardized solutions. A key difference between current efforts and past efforts to standardize is the fact that the AF is using industry products and standards, not creating their own software or standards. This change in AF operations brings the AF up to industry standards instead of making industry conform to the AF.

The Air Force ATS Policy Office is a part of the Capabilities and Integration Section of the Automated Test Systems (ATS) Division. The ATS Division at the Warner Robins Air Logistics Center, Aerospace Sustainment Directorate, Robins AFB is the Air Force’s ATS Leadership Office and represents the Air Force on the DoD ATS Management Board (AMB). The AMB sponsors several IPTs that are responsible for standardizing DoD ATS systems [7]. The Air Force is an active member of these IPTs. The ATS Policy office is responsible for managing the DoD ATS Selection process for the Air Force and providing representation on the various standardization IPTs.

The DoD AMB IPTs are NxTest, Test Program Set Standardization, Information Assurance, and ATS Processes. The Air Force is active on all of these IPTs. The NxTest IPT includes the ATS Framework Working Group. ATML was created to standardize the DoD ATS Framework.

The DoD AMB TPS Standardization IPT is responsible for MIL-PRF-32070 “Performance Specification, Test Program Sets”. The TPS IPT has been working on revising MIL-PRF-32070. MIL-PRF-32070A will be released soon. It will be published on the DoD printing office website [8]. The TPS IPT is responsible for DoD ATE and TPS acquisition and lifecycle support guidance. The IPT will be updating the ATE and TPS acquisition and sustainment handbooks and guides from the various services and consolidating them into common DoD documents. The TPS standardization IPT has started working on standardizing and modernizing the DoD’s use of

TPS programming languages. The goal is to define a single TPS programming language.

The ATS Leadership Office for each service is represented on the IEEE Standards Coordinating Committee 20 (SCC20). The Air Force has been involved with all SCC20 efforts to standardize the DoD ATS Architecture Framework. The various IEEE standards that specify the Automated Test Markup Language (ATML) are all under the auspices of SCC20 and its four subcommittees. The subcommittees are the Diagnostics and Maintenance Control Subcommittee (DMC), the Test Information Integration Subcommittee (TII), the Test and ATS Description Subcommittee (TAD), and the Hardware Interfaces Subcommittee (HI). These subcommittees are responsible for IEEE Std 1232, IEEE Std 1505, IEEE Std 1636, IEEE Std 1641, and IEEE Std 1671. These are the standards that specify ATML and common ATS hardware interfaces [9].

F. Bringing New Capability to the AF ATS Community ~ VDATS & the AF ATS SIL

The DOD AMB designated the AF Versatile Depot Automatic Test Station (VDATS) as a DoD approved Family of Testers during the AMB meeting on 19 Sep 07. The VDATS is a modular open architecture test station designed and built by WR-ALC using industry standards. VDATS is managed by the AF ATS PGM and was built to replace many unique aging tester stations. To date 50 VDATS have been fielded with over 156 UUT TPS hosted on the system and over 250 TPS development/rehost efforts in work. [10]

As the designated AF Family of Testers, VDATS is the first choice for AF depot level ATS needs. The ATS selection process involves looking at the overall technology required for UUT testing and determining if a VDATS configuration is the appropriate tester. If it is not then an alternative ATS solution is considered. Generally, an analysis of the UUT requirements is performed to see if a VDATS configuration can be used without changes. If there is a difference between the UUT capabilities required and the VDATS capabilities available, a report is generated detailing the differences. The AF ATS Policy Office validates the report and passes the information on the VDATS program office. The VDATS program office further analyzes the data to determine cost and schedule required to augment VDATS.

The most stable configuration element for a VDATS tester is the core. The original core, now designated DA-1, was designed as an eighty percent modular solution to address the UUT test requirements covered by legacy testers in the WR-ALC repair depot’s inventory. The first testers targeted had extreme supportability issues, primarily test instrument obsolescence. The DA-1 core was later expanded. The expanded core is now designated as the DA-2. The expansion consisted of adding digital test channels and their corresponding cross-point switch matrix connections added to the existing cross-point matrix design. The expansion only required adding digital channel cards and switch matrix cards. The existing chassis for each type of cards was selected with

expansion room. The next increment of test capability was added as two augmentation racks. The augmentation supports additional RF test capability and is designated the RF-1. The RF-1 is mechanically and electrically tethered to either core. The VDATS RF capability was extended to microwave frequencies. The RF-1 instrumentation includes RF network analyzers, an RF spectrum analyzer, two RF signal generators, an RF power meter, a Rubidium-based time standard, an RF switch, and a microwave frequency counter. The RF-1 capability extended the tester to cover about ninety-five percent of the test requirements of the legacy testers in the WR-ALC repair depot's inventory.

Augmentations are developed using the VDATS hardware and software modular architecture concepts. A set of software wrapper functions is developed according to the VDATS Wrapper Style Guide [11]. AF ATS policy restricts test programs to wrapper functions to interface with the test instruments. Details are listed in the current VDATS Test Program Style Guide [12]. The AF ATS policies are constantly being refined and are used as guidance for AF PMs acquiring new TPSs and rehosts of legacy AF TPSs.

With the introduction of the VDATS, came the need to stand up a facility to support the VDATS and other standardization efforts. The AF ATS Systems Integration Laboratory (SIL) at WR-ALC was established in 2009. The intent of the ATS SIL is to bring about organic capability for which the AF was previously tied to contractors. The primary function of the ATS SIL is to ensure the VDATS and other ATE remain viable standard test solutions and to facilitate implementation of DoD Information Technology Standards and Profile Registry (DISR) standards into AF standard ATS solutions. A secondary function is to identify/capture future ATS capability requirements, identify an integration/implementation plan and to optimize the capabilities of current and future AF standard ATS solutions using incremental development beyond the initial configuration. [13] The SIL staff also performs the engineering investigations to resolve VDATS system issues and prototypes VDATS configuration changes. The SIL does a great deal of TPS regression testing without having to have the UUTs there. They have maintained a list of the test requirements of UUTs that have come through so they can anticipate whether an ATE software change will impact the TPS.

The VDATS and the SIL bring new capability to the AF ATS community. They provide a method to improve AF ATS standardization and bridge some of the gap between the AF and industry. The VDATS, which is modular and built with commercial components, can be tailored to the testing requirements of AF users. It is more in line with industry standards than past AF ATE systems that used unique interfaces and custom software programs. It decreases the need to learn multiple test systems or programming languages as it uses an industry accepted common programming language. Since VDATS is in line with industry standards for programming, it can help decrease confusion for contractors when developing TPS for the AF. Through the use of standard

testers, more common software language (as outlined in the new MIL-PRF-32070A), and the AF ATS SIL, the way forward for AF ATS is clearer to both the AF and industry.

IV. CONCLUSION

The mission of the AF ATS PGM is to provide common testing capability to the war fighter that is sustainable for the life of the weapon systems. The long term goal of the AF ATS PGM is to reduce the number of unique testers in the AF inventory and reduce the life cycle cost of AF ATS through the standardization of TPSs. The way forward is achieved by bringing about further standardization throughout the ATS community and implementing practical in-house efforts to integrate technology. Through the use of designated standard testers, more common software language, and the utilization of the AF ATS SIL, the way forward for AF ATS is clearer to both the AF and industry. As the capabilities of the AF standard family testers become more robust, there will be additional buy-in from AF ATS community members. The point at which real change happens within the AF will be seen when the acquisition professional's frame of mind changes from asking the question, "How can I fill my ATS need?" to the AF looking within its community at the consolidated requirements and asking, "How can we fulfill the ATS requirements of the AF?"

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