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MANAGEMENT OF ELECTRONIC  
TEST EQUIPMENT  
VOLUME 1. PREPARATION,  
AND MAINTENANCE

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MANAGEMENT OF ELECTRONIC  
TEST EQUIPMENT

VOLUME II: PREVIOUS STUDIES  
AND INITIATIVES

July 1986

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## PREFACE

The Department of Defense (DoD) has a long history of problems with the acquisition and support of test equipment. In a previous report, Test Equipment Management, January 1985, we summarized the nature and extent of the underlying problems and recommended the Assistant Secretary of Defense (Manpower, Installations, and Logistics), ASD(MI&L), take the lead in effecting needed improvements. The ASD(MI&L) concurred with that recommendation and established a "DoD Test Equipment Management Improvement Program" under the overall guidance of the Maintenance Directorate. This report recommends a set of actions for that program.

The report is published in four volumes. Volume I presents a program of action for improving test equipment management and support within the DoD. Volume II reviews previous studies and initiatives pertaining to test equipment management and support. Volume III describes how the Military Services are organized to carry out that management and support. Volume IV reviews and assesses the adequacy of related DoD policy.

Throughout the report, all references to military organizations apply to the situation in early 1985. Subsequent organizational changes, such as the Navy's disestablishment of the Naval Material Command and the reorganization of Naval Electronic Systems Command into Space and Naval Warfare Systems Command, are not reflected in the text. As a result, several old office symbols and references are used. Similarly, several events that have taken place after mid-1985 with regard to test equipment management and support may not be included.



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## 1. INTRODUCTION

This volume reviews and comments on the major studies undertaken in recent years to improve test equipment management and support. Its purpose is to illustrate the complexity and persistence of the "test equipment problem"; the different solutions emphasized by the Military Services; the difficulties encountered in implementing joint or coordinated actions; and, by implication, the problem areas that either have not been addressed or are receiving inadequate emphasis within the Department of Defense (DoD).

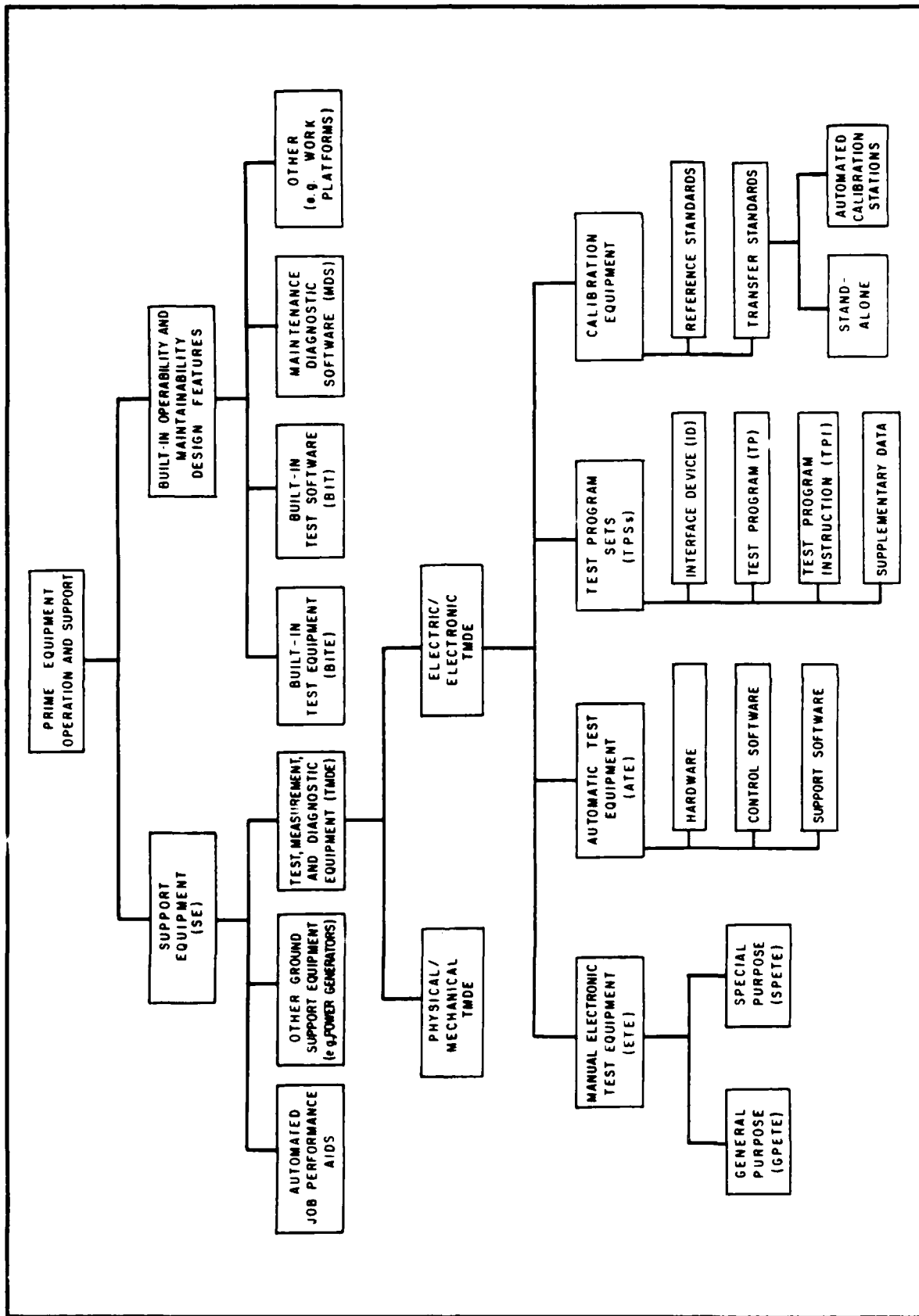
### TERMINOLOGY

Each of the Military Services, as well as the Office of the Secretary of Defense (OSD), uses its own nomenclature for test equipment. Throughout this report, we use the term "test equipment" as a specific category of support equipment: i.e., electric/electronic test, measurement, and diagnostic equipment (TMDE), defined to include manual electronic test equipment (ETE), automatic test equipment (ATE), test program sets (TPSs), and calibration equipment (reference and transfer standards and associated equipment). Each of these four categories of test equipment can be further subdivided as shown in our taxonomy for test equipment classification (Figure 1-1). That taxonomy is somewhat nonstandard in that the term TMDE, as used by the Military Services, frequently includes built-in test software/equipment (BIT/BITE) – a category beyond the focus of this report. We also exclude two other categories of test equipment: automated job performance aids (support equipment that differs from test equipment in that it is not hooked up to the prime equipment) and physical/mechanical test equipment. While the latter represents a significant portion of the test equipment inventory, its management and support are considerably simpler than those for electric/electronic TMDE.

### ORGANIZATION

This review of key studies and initiatives is organized by sponsoring organizations, starting with OSD (Chapter 2), the Congress (Chapter 3), the Joint Logistics Commanders, JLC. (Chapter 4),

FIGURE 1-1. TAXONOMY FOR CLASSIFYING TEST EQUIPMENT





and the Military Services (Chapter 5). The text consists of summaries of the studies and initiatives, supplemented with observations on implementation status and results, insofar as available. The recommendations of selected studies are presented in tabular form in the Appendix for easy reference.

## 2. OSD EFFORTS

The OSD has sponsored three major efforts aimed at improving test equipment management: (1) a study conducted from 1974 to 1976 by the Defense Science Board Task Force on Electronic Test Equipment (also known as the "Fluke Committee" after the chairman of the task force) and associated efforts to implement the recommendations; (2) the activities of the "DoD Ad Hoc TMDE Standardization Working Group," which was chartered in 1980; and (3) the actions undertaken to implement Acquisition Improvement Program Initiative #30, "Improved Management of Support Resources for Selected Weapon Systems," beginning in 1981.

### DEFENSE SCIENCE BOARD STUDY

In October of 1974, the Director of Defense Research and Engineering and the Assistant Secretary of Defense (Installations and Logistics), requested the Defense Science Board to establish a task force to review acquisition and management of ETE within the DoD. The task force was chartered to examine the potential for greater use by the DoD of commercially available ETE in order to achieve economy and reliability benefits over ETE built to military specifications, and to recommend policies and procedures that would maximize these benefits. After conducting its review, the task force, chaired by John M. Fluke, Sr., and composed of representatives of industry, Military Services, and the OSD, submitted a report to the Secretary of Defense<sup>1</sup>. That report contained 28 major recommendations addressing problems in four broad areas: requirements, procurement, logistics, and management.

The task force defined ETE to be "all electronic devices used to measure, gauge, test, inspect, diagnose or otherwise examine materials, supplies, and equipment to determine compliance with

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<sup>1</sup>The Task Force on Electronic Test Equipment, "Use of Off the Shelf Electronic Test Equipment to Reduce Costs, Shorten Leadtimes, Assure Reliability and Simplify Logistics" (Washington, D C - Defense Science Board, Office of the Director of Defense Research and Engineering, February 1976).

requirements established in technical documents." It further subdivided ETE into off-the-shelf ETE, which is equipment in regular commercial production, and modified off-the-shelf ETE, which is equipment in regular production but modified, however slightly, to meet DoD specifications.

The recommendations of the task force, by problem area, are presented below.

#### Requirements

The task force recommended several actions to improve the ETE requirements process. First, it recommended that early major system reviews consider the support costs of the associated ETE needed to perform mission requirements. It also recommended that DoD policies and procedures for acquisition and support of ETE, which encouraged use of the system prime contractor and sub-contractors, be reexamined to assure that this approach was the most economic.

The task force found that the Military Services were not sharing the "lessons learned" in major weapons system ETE. To correct this situation, it recommended that formal procedures be established to promote sharing of "lessons learned," both within and among Military Departments.

The task force also found that the Military Services frequently used military specifications for ETE when off-the-shelf equipment with similar capabilities was available. As a consequence, they incurred increased acquisition and support costs, delayed delivery, increased likelihood of developing obsolete ETE, and more operational, maintenance, and calibration problems. As corrective action, the task force recommended that the use of military specifications in areas where off-the-shelf ETE can meet the requirements be justified and reviewed. It further recommended that military specification MIL-T-28800C ("Test Equipment for Use with Electrical and Electronic Equipment, General Specification for") be revised to encourage procurement of off-the-shelf ETE.

To improve the compatibility, versatility, and usability of ATE, the task force recommended that joint DoD/industry guidelines be developed for the design, development, acquisition, use, and support of ATE. The task force also recommended that the DoD include testability as a design consideration in weapons systems and subsystems, select a common ATE software test language, and require that ATE purchases be justified on both economic and technical grounds.

ETE manufacturers routinely obtain commercial market information by soliciting potential customers, attending electronics industry meetings, and studying advances in electronics technology. Those manufacturers cannot use the same techniques to anticipate the DoD's requirements. In recognition of this deficiency, the task force recommended that a formal program be undertaken to define equipment needs early and make the information available to industry.

#### Procurement

In the area of procurement, the task force found that the procedures for DoD purchase of off-the-shelf ETE were unnecessarily complex and costly. It recommended use of multiple-award Federal Supply Schedule purchase methods to reduce costs, save time, and simplify the process. A minority recommended that the multiple-award Federal Supply Schedule method be required for purchase of off-the-shelf ETE.

The task force also found that contracts for off-the-shelf ETE were generally awarded to the lowest bidder in acquisition cost rather than to the lowest life-cycle cost offerer. To correct this situation, it recommended that the guidelines for evaluating ownership costs of ETE be improved and that those costs, in addition to bid price, be considered in awarding contracts.

To provide increased flexibility in the procurement of ETE, the task force recommended that DoD procurement policies and practices be revised to encourage the use of bid samples and to allow consideration of a manufacturer's capability to provide spare parts as well as technical and service support after the ETE is purchased.

To reduce the proliferation of different makes and models of ETE, the task force recommended that the DoD prepare guidelines for standardizing on specific off-the-shelf ETE by taking into account operating and support costs, obsolescence, and technology improvements in ETE. The task force noted that preferred items lists (PILs) is one method of reducing proliferation, but the use of such lists should not limit purchases to one manufacturer's equipment when other off-the-shelf ETE is available to perform the same function. A minority recommended that PILs refer primarily to specification requirements and not to a single manufacturer's piece of equipment unless it is military-specification equipment with Government-owned rights and manufacturing data.

The task force also found that DoD supply systems and administrative procedures make it difficult for the DoD to take advantage of manufacturers' warranties. It recommended that those procedures be revised to assure that the DoD obtains maximum benefit from warranties. It further recommended that DoD policy be revised to specifically call for enforcement of contract terms and use of remedies to establish the expectation of compliance by manufacturers. In addition, to minimize the processing of claims by manufacturers of off-the-shelf ETE, the DoD should modify its contracting regulations to simplify the assignment of receivables on contracts up to \$250,000 at the contractor's discretion under the Uniform Commercial Code.

#### Logistics

In the area of logistics, the task force found that the Military Services fail, in many cases, to take advantage of commercial support resources, including repair parts, repair and calibration services, and training. To correct this situation, the task force recommended the DoD issue revised policy which requires the Military Services to increase their use of commercial resources to support ETE when economical and effective. They also should be authorized and funded to establish a pool of selected ETE end items at appropriate locations to replace equipment temporarily out of service.

The task force also found that the DoD needs to place a higher priority on surveying the resources, costs, and utilization of military ETE calibration and repair facilities. The task force recommended that those facilities be consolidated or disestablished, whenever possible, and that procedures be developed to encourage the use of ETE manufacturers in calibration and repair, possibly through the General Services Administration. It further recommended that the DoD pursue alternatives to reduce requirements for skilled personnel in calibration and repair of ETE.

The support of older, out-of-production ETE is difficult for the DoD. In recognition of this difficulty, the task force recommended that the DoD systematically replace older ETE, using procedures that assure budgeting the required resources and recovery of the value of the old equipment directly to the ETE programs.

To increase the standardization of technical documentation, the task force recommended that the DoD establish uniform requirements so that manufacturers can submit commercial ETE manuals rather than military manuals without need for revision. It also recommended that the DoD establish uniform provisioning documentation requirements for off-the-shelf and modified ETE and eliminate the requirement for this documentation except when military need dictates.

#### Management

In the area of ETE management, the task force recommended that both general-purpose and special-purpose ETE be placed under a single manager within each Military Service. A minority recommended that those single managers be assigned responsibility for reviewing special-purpose ETE purchases and assuring that off-the-shelf ETE could not satisfy the requirement, but that otherwise management of special-purpose ETE be separate.

The task force also recommended that the DoD take into consideration the administrative and other indirect costs associated with purchase of military specification ETE, modified commercial ETE, and off-the-shelf ETE under prepriced arrangements. Those costs were not being considered even when significant differences existed.

#### Follow-Up

The task force identified a wide range of problems with the acquisition and management of ETE within the DoD. Those problems covered the gamut of acquisition and management issues, from the use of military specifications, PILs, and commercial support capabilities to the establishment of a single manager for ETE within each Military Service. The recommendations of the task force were accepted by the study sponsors. The Assistant Secretary of Defense (Installations and Logistics) issued a memorandum to the Assistant Secretaries of the Military Departments, dated 28 April 1976, announcing establishment of a program to monitor implementation of the task force's recommendations. The task force was extended for 1 year to assist in, and report on, implementation progress.

In its final report, the task force noted that some progress had been accomplished, notably in the areas of bid-sample testing and standardization of commercial manuals, but that many

of the recommended actions had not yet progressed beyond the "just underway"<sup>2</sup> stage. In response to its recommendation to provide a means of continuing a dialogue between the Military Services and industry on ETE acquisition policy and procedures, the Deputy Secretary of Defense authorized formation of an advisory committee and requested the Army to sponsor that committee as an extension of its lead responsibility for standardization of Federal Supply Class (FSC) 6625, which consists of general-purpose ETE.

#### Comments

We were unable to obtain additional information on the Assistant Secretary of Defense (Installations and Logistics) program to monitor implementation of task force recommendations after 1977. Moreover, the specific long-term results of the task force study are difficult to assess.

On the one hand, the study was effective in opening up a dialogue between the Military Services and industry (a dialogue that still continues through the ETE Division of the American Defense Preparedness Association and its annual program review), in increasing the awareness of the penalties associated with unnecessary military specifications, in elevating management priority on consolidation of metrology and calibration facilities, and in fostering agreement on the concept of "fly before buy" in the acquisition of ETE. For example, the Military Services have recognized, de facto, the benefits of using commercial off-the-shelf test equipment rather than equipment designed to military specifications. As a consequence, they are procuring proportionately more commercial test equipment than in the past. All have adopted bid-sample testing as a standard procedure for competitive procurement of commercial test equipment, using either organic testing laboratories (Navy and Air Force) or contractor services (Army). (The Army is planning to perform its own bid-sample testing, starting in fiscal year 1985, following completion of an advisory study by the National Bureau of Standards about the appropriate laboratory equipment and testing procedures.)

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<sup>2</sup>The Task Force on Electronic Test Equipment, "Implementation Status: Use of Off-the-Shelf Electronic Test Equipment to Reduce Costs, Shorten Leadtimes, Assure Reliability, and Simplify Logistics" (Washington, D.C.: Defense Science Board, Office of the Director of Defense Research and Engineering, January 1977).

On the other hand, the potential for further cost savings in commercial test equipment procurement and support remains considerable because many of the task force recommendations have not been implemented. For example, current procedures (1) do not exploit commercial support channels and warranties; (2) do not reflect life cycle cost factors beyond the limited "facility of use" factors considered in competitive bid samples; (3) seldom result in multiyear procurement contracts so that like-items must be reprocured year after year, resulting in the proliferation of different makes/models; and (4) result in the duplication of resources committed to bid-sample testing and test equipment evaluation. The potential savings associated with these four items alone have been estimated to range upward from tens of millions of dollars a year.

In sum, most of the task force recommendations have not been fully implemented by the Military Services as confirmed by the OSD effort described next.

#### DoD AD HOC TMDE STANDARDIZATION WORKING GROUP

Noting the "numerous studies and reports concerning commercial off-the-shelf ETE and the need for more effective standardization," the Deputy Under Secretary of Defense (Acquisition Policy), DUSD (Acquisition Policy), issued in May 1980 an action memorandum for the Director, Defense Material Specifications and Standards Office (DMSSO). That memorandum stated:<sup>3</sup>

Failure to impose a viable standardization program for TMDE severely impacts maintenance, manpower resources and readiness. For these reasons, DMSSO is requested to: (1) expedite a review of the FSC 6625 situation; (2) determine and take action to accomplish a major reduction in the existing NSNs [National Stock Numbers] and specifications within the FSC; and (3) establish a more effective and efficient tri-Service standardization program to avoid future uncontrolled proliferation

The memorandum further authorized DMSSO to establish a "DoD Ad Hoc TMDE Standardization Working Group" under DMSSO direction, with the charter to "develop a comprehensive DoD-wide action plan to improve standardization management, methods and procedures for FSC 6625." It also required that the standardization program plan be completed in 1 year and that program tasks

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<sup>3</sup>DUSD (Acquisition Policy), Memorandum for the Director, DMSSO, Subject: "Test, Measurement, and Diagnostic Equipment (TMDE), FSC 6625," 13 May 1980.



be accomplished within a 3-year period "with continuing single-manager operations for TMDE standardization."

#### Actions

In July 1981, DMSSO convened the first meeting of the working group, which was composed of Military Service representatives. In that meeting, the working group determined that ten of the Defense Science Board ETE task force recommendations pertaining to standardization had not been fully implemented. It also made two decisions. One, it decided that the best approach for achieving the goals of the DUSD (Acquisition Policy) was through a Standardization Program Analysis and Plan in accordance with the Defense Standardization and Specification Program (DSSP).<sup>4</sup> Second, it decided to conduct an item reduction study for FSC 6625, using the methodology and scope developed in a May 1981 meeting of DMSSO, U.S. Army Communications-Electronics Command (CECOM) representatives, Defense Logistics Agency, and Defense Electronics Supply Center (DESC). The Army (CECOM), as assignee for FSC 6625, assumed the chair of the working group, with meetings planned at quarterly intervals to clarify and monitor the item reduction study and implementation of the Defense Science Board ETE task force recommendations pertaining to standardization.

In October 1981, the first meeting of the item reduction study team took place at DESC. Military Service participants discussed differences in maintenance concepts for TMDE, basis of selection of TMDE, and procedures for performing item reduction studies. DESC noted that a working group method (in lieu of the standard procedures of the DSSP) was necessary because of the different PILs utilized by the Military Services and the absence of interchangeability/substitution criteria for standard item selection. The participants approved the initial categories of TMDE

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<sup>4</sup>Office of the Under Secretary of Defense (Research and Engineering), "Defense Standardization and Specification Program Policies, Procedures and Instructions," Defense Standardization Manual DoD 4120.3-M [Washington, D.C.: Office of the Under Secretary of Defense (Research and Engineering), August 1978].

selected for the item reduction study (frequency counters, function generators, pulse generators, signal generators, and multimeters).

In April 1982, DESC representatives briefed the working group on progress accomplished to date. DESC identified 132 distinct families (types of TMDE) within FSC 6625. These families contained approximately 13,360 makes and models, from which an estimated 7,214 (54 percent) would be eliminated from the Federal Supply System through cancellation or coding the NSN "not for procurement" (i.e., item standardization code "3" as defined in Defense Standardization Manual DoD 4120.3-M). DESC reviewed the TMDE categories analyzed to date and showed a schedule for item reduction studies continuing into fiscal year 1986. It noted, however, that without Military Service agreement on a method for documenting a DoD standard item of TMDE, many of the actions requested by the DUSD (Acquisition Policy) could not be accomplished.

In July 1982, CECOM released its first report on progress achieved by the working group in accordance with DSSP procedures.<sup>5</sup> It issued a second report in June 1984.<sup>6</sup> The latter report stated that 12 generic groups of TMDE had been reviewed for item reduction as of January 1984, and that 28 percent of the NSNs contained in those groups had been identified for elimination (1,428 of a total of 5,118 NSNs). The report provided a schedule for the remaining FSC 6625 item reduction reviews covering 19 families of TMDE containing 7,756 NSNs. It noted, in spite of the item reduction studies, that the proliferation of TMDE, as measured by NSN population, was continuing and that approximately 44 percent of the NSN population consisted of "one-of-a-kind" makes and models with little or no potential for elimination through formal item reduction studies (see Tables 2-1 and 2-2). Further, it reviewed the status of the Defense Science Board ETE task force recommendations and the problems encountered in implementing a more effective standardization program for FSC 6625, including those associated with cataloging and a new General Services

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<sup>5</sup>Department of Defense, "Standardization Program Analysis: Electrical and Electronic Properties Measuring-Testing Instruments," FSC 6625 (Washington, D.C.: Department of Defense, 1 July 1982).

<sup>6</sup>Department of Defense, "Standardization Program Analysis: Test, Measurement and Diagnostic Equipment (TMDE)," FSC 6625 (Washington, D.C.: Department of Defense, 29 June 1984).

TABLE 2-1. FSC 6625 INVENTORY TREND

YEAR	NSN POPULATION <sup>1</sup>						
	Total	DoD	Army	Navy	Air Force	Marine Corps	Other DoD
Dec 1978	103,975	83,811	16,917	26,805	52,290	4,548	119
Dec 1980	108,202	85,122	17,334	27,667	53,570	4,288	187
Dec 1982	115,414	87,286	18,110	29,302	54,948	4,081	433

<sup>1</sup>Quantities for DoD components do not add up to the DoD total because of common items.

TABLE 2-2. FSC 6625 STANDARDIZATION STATUS

(December 1982)

CATEGORY	ISC <sup>1</sup>	DESCRIPTION	NSN POPULATION		
			Total	With Manager	Without Manager
Procurable	0	DNA/NSA <sup>2</sup> cognizance	339	314	25
	1	Standard item	434	427	7
	2	Substitute item	7,711	6,602	1,109
	5	Not yet subjected to IRS <sup>3</sup>	42,279	38,385	3,894
	6	One-of-a-kind item	50,521	43,003	7,518
	C	IRS completed, no decision	12,748	10,524	2,224
Nonprocurable	3	IRS completed, item canceled	1,589	1,536	53

<sup>1</sup>ISC = Item Standardization Code

<sup>2</sup>DNA = Defense Nuclear Agency; NSA = National Security Agency.

<sup>3</sup>IRS = Item Reduction Study.

Administration policy requiring Navy and Army usage of Federal Supply Schedules in procuring FSC Group 66 items (instruments and laboratory equipment). Finally, the report concluded the following:

FSC 6625 standardization issues presented in the Deputy Under Secretary of Defense (Acquisition Policy) Memo dated 13 May 1980, subject: TMDE, FSC 6625, and the 1975-1976 ETE Task Force-Defense Science Board recommendations, frequently have been addressed, in varying degrees, by each military service rather than on a coordinated tri-service basis. This is due to the fact that a Tri-Service, DoD Ad Hoc Working Group has never officially convened for the purpose of effectively carrying out a coordinated program for the aforementioned recommendations and policies.

The working group also met in July 1984 to review progress and to discuss development of a DoD-wide action plan with a new charter for a permanent DoD TMDE Working Group. At that meeting, the working group decided to continue the planned item reduction studies and to complete a Standardization Program Plan in accordance with the DSSP. A first draft of that plan was scheduled for completion by mid-1985. In its September 1985 meeting, the working group deferred promulgation of that plan until early 1986. It also decided that any further action on a coordinated program for standardization of common test equipment should await more specific tasking by the Office of the Under Secretary of Defense (Research and Engineering). It is currently preparing a letter to request such tasking.

#### Comments

The DoD has made little progress toward developing and implementing a DoD-wide plan to improve ETE standardization management, methods, and procedures. The plan is scheduled to be completed next year, 10 years after the Defense Science Board ETE task force report and 6 years after the DUSD (Acquisition Policy) action memorandum. It will represent the first major effort toward test equipment standardization – an issue that has surfaced in all test equipment studies dating back to the early 1960's. In the meantime, actions by the DoD Ad Hoc TMDE Standardization Working Group have been limited to item reduction studies, i.e., the elimination of military specifications for obsolete items of test equipment.

According to a DMSSO representative, substantial progress toward ETE standardization will not be forthcoming until the Assistant Secretary of Defense (Manpower, Installations,

and Logistics), ASD(MI&L), becomes an active participant in the standardization efforts. Yet, since late 1977, the ASD(MI&L) has not been involved in test equipment management and support issues, other than peculiar issues addressed in the weapons system acquisition process. With the organizational change in 1984, moving the Directorate for Weapons Support from ASD(MI&L) to the Under Secretary of Defense (Research and Engineering), the ASD(MI&L)'s involvement in test equipment management has ceased completely. However, the 1985 reorganization, combining all acquisition and logistics management responsibilities under the Assistant Secretary of Defense (Acquisition and Logistics) offers the opportunity for more effective action.

#### ACQUISITION IMPROVEMENT PROGRAM INITIATIVE #30

Studies conducted in support of the weapons system acquisition improvement program, initiated by the Deputy Secretary of Defense in 1981, identified three major problems in the programming and budgeting for system support:<sup>7</sup>

- Support program and budget requirements are based upon standard planning factors that may not match readiness objectives of a new weapons system
- Development and fielding of a weapons system involves numerous different appropriations, while the budget is reviewed by appropriation. As a result, budget decisions are often made in isolation without visibility of the impact on individual system support and readiness.
- Some weapon support funds are controlled by functional managers not responsible to the program manager, and their priorities do not always match those of the program manager. As a result, budget decisions are made without coordination with the program manager and without visibility of the impact on individual system support and readiness.

One of the support elements affected by these three problems was support and test equipment.

Initiative #30, "Improved Management of Support Resources for Selected Weapon Systems," was designed to resolve these problems. It required the Military Services to involve the program manager in the development of support resource requirements and to improve the visibility of those requirements and the readiness objectives for all weapons systems entering initial production at any given time. It also required OSD to conduct a single, integrated review of support associated with

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<sup>7</sup>Deputy Secretary of Defense Memorandum, Subject: "Improving the Acquisition Process" (with attachments), 30 April 1981.

individual weapons systems at key decision points in the planning, programming, and budgeting system (PPBS) process. It called for a 2-year trial period for the implementing procedures. Responsibility for following up this decision was assigned to the ASD(MI&L). A joint OSD/Military Service Steering Group and a working group were established to oversee implementation.

#### Actions

In the 1983 PPBS cycle, support requirements and funding information for 23 weapons systems entering or in early production was provided at key decision points. OSD reviewed that information and, as a result, raised several funding issues to the Defense Resources Board. In the 1984 PPBS cycle, approximately nine weapons systems within each Military Service were reviewed by OSD. A description of the procedures and some of the problems encountered in the reviews can be found in a Logistics Management Institute report.<sup>8</sup> In late 1984, the Military Services submitted their proposed implementation plans in accordance with OSD guidelines.<sup>9</sup> Following OSD concurrence, they will put those plans into effect with the 1986 PPBS cycle.

#### Comments

The procedures tested thus far have been successful in making support visible in the PPBS by weapons system. They have demonstrated that the steps required to identify the support requirements and funding for specific weapons systems are feasible and that the information identified can be used beneficially by the OSD to influence resource allocation decisions made during the PPBS cycle. The reviews, however, also highlighted the need for a disciplined support-funding management system that will (1) provide credible, validated estimates of support requirements and funding; (2) assign clear accountability for changes to those estimates; and (3) track changes and their effects in both the acquisition system and the PPBS

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<sup>8</sup>David V. Glass and Donald W. Snull, Improved Management of Support Resources, Final Report, Task ML202 (Bethesda, Maryland: Logistics Management Institute, April 1983).

<sup>9</sup>Deputy Secretary of Defense Memorandum, Subject: "Management of Integrated Logistic Support Funding," 28 August 1984.

### 3. CONGRESSIONAL STUDIES AND REPORTS

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Standardization and improved management coordination among the Military Services, both with respect to acquisition and support of prime equipment as well as support equipment, are issues of long-standing interest and concern to the Congress and the General Accounting Office (GAO). Of the numerous congressionally mandated studies on those two issues, three appear to be particularly relevant: (1) centralized management of calibration, (2) increased standardization of aviation ground support equipment (AGSE), and (3) increased standardization of avionics.

Although the topic of the third study includes factors other than test equipment, many of the factors impeding standardization of prime equipment also apply to test equipment. Furthermore, prime equipment standardization is one way of fostering standardization of support equipment.

#### CENTRALIZED CALIBRATION MANAGEMENT

In 1977, the GAO completed a study of the calibration systems of the Military Services and Federal agencies. It found that each operated and maintained its own calibration system, with the Military Services operating over 700 calibration facilities, employing 9,000 civilian and military technicians, and making about 3 million calibrations each year, using calibration equipment valued at \$1.8 billion. Adding the calibration equipment used by four major nonmilitary Federal users, the GAO estimated the total cost of Federal Government-owned calibration equipment at \$2.7 billion.

In examining the operations and workloads of the various organizations responsible for planning or executing the calibration programs in the Military Services, the GAO noted the following:<sup>1</sup>

- Metrology Centers. Each of the three Military Services operates its own metrology center for technical guidance of its calibration program, including development of calibration equipment and standards, development of calibration procedures, establishment of calibration intervals, and specification of technical training requirements. Only the training of calibration technicians has been standardized and consolidated. The centers use different criteria in setting calibration intervals so that similar pieces of equipment are

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<sup>1</sup>United States General Accounting Office, A Central Manager Is Needed To Coordinate The Military Diagnostic and Calibration Program, Letter Report to the Secretary of Defense, LCD 77-427 (Washington, D.C.: U.S. General Accounting Office, 31 May 1977)

calibrated at different intervals. They also use different calibration procedures so that identical measurements are accomplished using different calibration standards, equipment, and manuals. The JLC's Joint Technical Coordinating Group for Metrology and Calibration (which is discussed in Chapter 4) has attempted to standardize calibration procedures, but has not been successful. As a result, the GAO notes, "the centers continue to triple overhead costs for preparing separate procedures and using different standards and test equipment to make the same measurements."

- Primary Standards Laboratories. The Military Services operate four primary standards laboratories (the Navy has two, one on each coast), employing over 250 personnel with facilities and equipment worth \$33 million (in 1976). During fiscal year 1976, those laboratories performed approximately 26,000 calibrations at a cost of over \$7 million. Though their measurement capabilities are quite similar, interservice support was less than 5 percent at each laboratory. The GAO points out four areas of inefficiency.
  - First, workload capacity far exceeds the requirement at each laboratory. Three of the four laboratories individually have sufficient capacity to support the combined workload of all laboratories, if operated on three shifts. The largest of the four, the Air Force's measurement standards laboratory, could support the combined workload on a single shift.
  - Second, lower-level facilities often send their test equipment or calibration standards to their own Military Service's laboratory rather than using the closest laboratory.
  - Third, expensive facilities and calibration equipment are utilized poorly.
  - Fourth, the four laboratories employ indirect-labor personnel performing duplicate functions.
- Secondary, Intermediate, and User Calibration Facilities. The lower-level calibration activities use "transfer standards" or "shop standards" to calibrate the test equipment of using units in a certain geographic area. In turn, each level of calibration standard is supported by a higher-level calibration activity; e.g., shop standards from intermediate calibration activities are calibrated on transfer standards at secondary calibration facilities, and transfer standards are calibrated on reference standards at the primary standards laboratories. With more than 700 calibration facilities spread around the world, many regions have multiple facilities that offer the potential for significant savings through consolidation and interservicing. Yet, many of these opportunities for consolidation have not been pursued by the Joint Technical Coordinating Group.

The GAO concluded that "DoD continues to underutilize its resources and incurs unnecessary costs for transportation, equipment, staff, and facilities." It recommended that the Secretary of Defense "establish a single, central manager for the entire diagnostic and calibration program."

#### Follow-Up

The OSD did not concur with the GAO's recommendation to place all diagnostic equipment under a single manager because "the technical background and disciplines involved in diagnostic equipments are so vast that any attempt to place all of this equipment under a single manager



would be impractical and, in fact, counter productive.”<sup>2</sup> However, the OSD concurred, in principle, with the second part of the recommendation because “metrology and calibration are service type functions . . . [that] do lend themselves to single, central management.” The OSD did point out that any effort to consolidate calibration activities must be carefully planned because of the complexity and magnitude of the service being provided by those activities. Additionally, it stated that calibration facilities could be consolidated provided that military capabilities are not adversely affected and that wartime surge requirements are protected.

#### Comments

The OSD has not yet implemented the GAO’s recommendation to establish a single manager for the DoD’s calibration program. Although regional consolidation of secondary/intermediate calibration facilities is receiving more attention, the situation, as described by GAO, has changed little in the past 8 years.

#### STANDARDIZATION OF GROUND SUPPORT EQUIPMENT

In 1978 and 1979, the GAO examined the issue of standardized ground support equipment for military aircraft. Its report noted the proliferation of like-type equipment in the DoD inventory and urged that actions be taken to increase standardization, thereby reducing acquisition and support costs.<sup>3</sup> Some examples of the proliferation found by the GAO are shown in Table 3-1, including selected types of ETE as well as other classes of support equipment.

The GAO’s conclusions and recommendations regarding the actions that should be taken to control proliferation are summarized under the following headings: obstacles, support equipment planning, data systems, review process, and management visibility

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<sup>2</sup>Letter response by the Principal Deputy Assistant Secretary of Defense (Manpower, Reserve Affairs, and Logistics), Robert B. Pirie, Jr., to the Director, Logistics and Communications Division, General Accounting Office, Fred J. Shafer, dated 14 September 1977.

<sup>3</sup>Comptroller General of the United States, Increased Standardization Would Reduce Costs of Ground Support Equipment for Military Aircraft, LCD-80-30 (Washington, D.C.: U.S. General Accounting Office, 7 February 1980).

**TABLE 3-1. EXAMPLES OF PROLIFERATION OF AIRCRAFT  
GROUND SUPPORT EQUIPMENT**

FEDERAL SUPPLY CLASS	ITEM NAME	NUMBER OF DIFFERENT ITEMS IN INVENTORY (1979)
<b>1730</b> (Aircraft Ground Servicing Equipment)	Maintenance platform	163
	Tow bar, aircraft	129
	Sling, aircraft maintenance	1,040
	Ladder, aircraft boarding	71
	Pin, aircraft ground safety	486
	Cover, aircraft ground servicing	517
	Shield, aircraft ground servicing	464
	Jack hydraulic tripod	63
	Adapter, hoisting	610
	Lock, aircraft ground safety, landing gear	108
<b>4920</b> (Aircraft Maintenance and Repair Specialized Equipment)	Power supply	623
	Cable assembly, power electrical	337
	Test set, fire control system	235
	Test set, flight control system	348
	Test set, radar	174
	Test set, indicator	144
	Test set, amplifier	122
	Maintenance stand, aircraft engine	111
	Electronic components assembly	1,552
	Wiring harness, branched	309
<b>6625</b> (Electrical and Electronic Properties Measuring- Testing Instruments)	Shunt, instrument	790
	Oscilloscope	784
	Voltmeter, electronic	490
	Cable assembly, radio frequency	2,161
	Lead, test	1,927
	Ammeter	8,512
	Dolly, test equipment	51
	Transducer, motional pickup	228
	Indicator, digital display	394
	Galvanometer	273

SOURCE: Comptroller General of the United States, Increased Standardization Would Reduce Costs of Ground Support Equipment for Military Aircraft, LCD 80-30 (Washington, D.C.: U.S. General Accounting Office, 7 February 1980)

## Obstacles

The GAO identified four obstacles to increased standardization:

- Lack of integrated support planning systems. Weapons system acquisition programs are oriented toward meeting a single aircraft's program schedules and performance requirements rather than providing standard support equipment. "Program managers are hesitant to accept the risks of using standard equipment on any new development programs if the contractor recommends new equipment."
- Lack of management visibility. The Military Services possess limited visibility and accounting over support equipment. As a result, equipment that may never be needed is bought and opportunities for more equipment commonality are missed. "The services should be able to tell the contractor what equipment they prefer rather than routinely accept the contractor's recommendations."
- Lack of incentives. According to DoD contractors, the following factors impede more standardization:
  - Standardization efforts tend to have an unfavorable image.
  - Standardization is considered a constraint against technological improvements.
  - It is nearly impossible to demonstrate the savings that are derived from standardization.
- Lack of emphasis on early support equipment planning. The Military Services as well as the OSD have recognized that little development planning for support equipment has taken place because such planning has not been emphasized. With the Military Services, support equipment requirements are not identified and screened early enough in a weapons system's life cycle to achieve commonality or to influence system design to match existing support equipment. Within the OSD, there is no focal point for support equipment. Such a focal point is needed for emphasizing reduced support equipment costs, with standardization as a primary means.

To overcome these obstacles, the GAO recommended that the Secretary of Defense:

- Vigorously pursue a policy for support equipment standardization
- Establish a focal point in the OSD to guide and direct the Military Services in carrying out such policy
- Systematically review Military Services' activities in implementing the policy
- Develop and implement incentives for contractors to use existing aircraft support equipment in the design of new weapons systems

The OSD concurred, in principle, with three of the recommendations, but objected to the second recommendation because it believed that DMSSO should provide the policy direction and

guidance for implementing ground support equipment standardization. (DMSSO currently is responsible for providing policy and guidance on standardization of all DoD materiel items.) In addition, the Navy and the Air Force already have "focal points" for support equipment standardization and have adopted Joint Service standardization programs such as SISMS (Standard Integrated Support Management System). Consequently, there is no reason to establish another special DoD focal point for standardization of AGSE.<sup>4</sup>

#### Support Equipment Planning

In the area of support equipment planning, the GAO found that the Military Services have not been participating early in new acquisition programs. Although the Military Services recognize that early participation in the aircraft equipment development and selection process is necessary, such participation normally does not take place until the aircraft design has been fully developed. At that point, design changes to permit more standardized support equipment are typically impractical and not cost effective. GAO concluded:

The services need to formally coordinate efforts of weapon system program managers and support equipment managers to ensure not only that schedules and aircraft performance requirements are met but also that support equipment is designed and intended for application among many aircraft systems where practicable. Controls to prevent unnecessary item proliferation should start at the earliest possible stage, that is, during the design of new aircraft and its equipment.

The GAO recommended that the Secretary of Defense:

- Develop a general planning strategy for support equipment that not only identifies acquisition problems and areas for increased management attention but also takes advantage of opportunities to promote standardization and reduce the number of different support equipment items.
- Require the services to assess, during aircraft design, whether support equipment needs can be satisfied (1) by using the existing supply system without redesigning the aircraft, (2) by altering the design to accommodate an existing piece of equipment, or (3) if new equipment is justified, by evaluating whether it could be used for other aircraft.

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<sup>4</sup>Office of the Secretary of Defense, "Rationale for Non-Concurrence with Four Recommendations in Comptroller General Report No. LCD-80-30 of 7 February 1980," enclosure in Letter Report to the Comptroller General, 10 April 1980.

- Monitor the services' planned use of standard support equipment items to ensure that they have participated in the equipment's design and development stages.

The OSD did not accept the last recommendation because it believed that it would be extremely difficult for DMSSO to monitor the planned use of all support equipment items in the DoD. However, the OSD did state that it should be feasible for DMSSO to monitor the effectiveness of the DoD departmental standardization offices in implementing DoD policies and guidelines for AGSE standardization.

#### Data Systems

The GAO also found that the Military Services need access to accurate and timely data on equipment already in DoD inventories or under development in order to limit the introduction of unnecessary support equipment. The data systems currently in use, however, contain information that is inaccurate, incomplete, and outdated and they are not readily accessible. Moreover, cataloging problems caused by the use of unapproved item names weaken the item identification process. The overall result is that it is not uncommon for more than one NSN to be assigned to the same item, thus precluding effective control over unnecessary proliferation. The three FSCs containing most of the AGSE include approximately 222,450 NSNs, but 53 percent are cataloged without approved item names. The GAO recommended that the Secretary of Defense:

- Evaluate the capabilities of the various support equipment data systems to determine which system(s) can most promptly provide the most complete, up-to-date, accurate, and readily accessible information.
- Direct the services to include all necessary support equipment items in their data systems. The systems should include data on item descriptions, sizes, shapes, reliabilities, capabilities, and applications. The systems should also designate preferred items that the Government wants contractors to use when they design new equipment.
- Impose tight controls where new items enter the supply system so that their assigned names are recognized by all potential users when screening available data systems and manuals.

The OSD, in principle, concurred with these recommendations

## Review Process

In their review and analysis of support equipment recommendation data (SERD), engineers from the Military Services currently base their decisions largely on their knowledge of and experience with the general functions the items are intended to perform. No concrete methodology exists to logically guide the engineers through the review process so that they can decide whether the items are needed and, if needed, whether a standard item can be substituted. For a sample of items studied, the GAO found that very little documentation was available to justify accepting the items.

The time allowed for approving or disapproving a contractor-recommended item is generally 60 days, both for initial and subsequent SERD submissions. (A SERD is submitted for each piece of support equipment, with resubmissions required throughout the life of the contract when functional requirements change or previous submissions become invalid. A contractor who does not receive a response within 75 days from SERD submission can request the ordering activity to issue an order for the support equipment item(s) involved, though the contractor must notify the authorizing activity and reviewing activity 7 days prior to the effective automatic order date.)<sup>5</sup> As a result, reviewing activities are under great time constraints and often must delete SERDs "pending evaluation" if they anticipate that the time limit will be exceeded. The GAO found that a large portion of the SERDs it examined were not processed within the specified time limit and concluded that the process should be simplified and streamlined.

The GAO recommended that the Secretary of Defense:

- Develop specific methodology to guide reviewers through the review process so that they can decide realistically whether items are necessary. The methodology should include the requirement to screen existing inventories and justify why existing assets are unacceptable.

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<sup>5</sup>See the "Standard Integrated Support Management System (SISMS)," 17 September 1982, which is a joint Air Force/Army/Navy/Marine Corps publication developed in the late 1960's under auspices of the JLC for multi-Service aeronautical programs and adopted in 1972 by the Assistant Secretary of Defense (Installations and Logistics) as part of its long-range plan for improving the DoD logistics system. The SISMS documentation was changed in 1978 and subsequent years to facilitate broader application to both single- and multi-Service systems. An extract of SISMS is included in Volume III of this report.

- Require that Air Force and Navy top management oversee the adequacy of the review process and take an active part in the approval or denial of contractor-recommended items. [The GAO investigation did not extend to the Army.]
- Clearly define the review roles and responsibilities of essential organizations and eliminate those activities which provide little or no substantive assistance in deciding the adequacy of recommended items.
- Decide whether the time constraint imposed for unusually complex items, such as avionics testing equipment, is appropriate. If not, devise different strategies to ensure that complex equipment can be carefully reviewed and delivered when needed.

The OSD did not concur with the last recommendation because the process outlined is consistent with the need to ensure timely processing of support equipment recommendations and the deadline simply provides a checkpoint for review; it does not authorize the contractor to initiate "unapproved" development of support equipment.

#### Management Visibility

The GAO also found that, organizationally, the Military Services are too fragmented to play a larger role in initially determining what support equipment items they need for new aircraft. They have not established a centralized activity to manage support equipment and its acquisition. The various organizations involved with support equipment are isolated from each other through either breakdown in communications or philosophical differences. In many instances, support equipment users fail to inform weapons system and support equipment managers of the problems encountered in using the equipment.

Furthermore, the Military Services do not routinely coordinate their support equipment programs when they introduce new aircraft or support equipment into their inventories; nor do they have a systematic method for evaluating equipment planned or in use by the other Military Services.

The GAO believes that by taking advantage of some existing in-house capabilities, such as that provided by the Air Force's Cataloging and Standardization Office, the needed visibility over support equipment standardization could be achieved. However, the role of that office in standardization has been limited because of the lack of command emphasis and trained personnel. Many of its specifications and standards are outdated, and more than 30 percent of them have not been reviewed

within the last 5 years. Furthermore, the standardization program analyses of the various FSCs comprising support equipment, conducted in accordance with the DSSP, are of limited value because the input from contributing agencies has been minimal.

Representatives from the Military Services frequently identify acquisition regulations as the greatest obstacle to increased standardization. Yet, those regulations offer several opportunities to foster standardization, including multiyear procurements and the use of design specifications for follow-on procurements. Additionally, the Secretary of each Military Department is authorized to negotiate contracts for equipment whose standardization and interchangeability of parts are necessary in the public interest and whose procurement through negotiation ensures this.

The GAO concluded that the Military Services should increase their management visibility over the entire support equipment spectrum to advance standardization opportunities, to preclude procuring unneeded equipment, and to act on support equipment problems at user levels. It recommended that the Secretary of Defense:

- Establish an activity to coordinate the efforts of item and system managers, equipment specialists, design engineers, users, and any other group participating in support equipment acquisition. The activity should maintain management visibility over support equipment and assess whether more standard equipment should be developed.
- Require the services to coordinate their research and development efforts so that they do not duplicate support equipment items performing similar functions, particularly for aircraft common to both services.
- Require the services to use design specifications and multiyear procurements, if authorized by law. The Secretary should provide instructions for the services to use negotiated procurements when competitive means to increase standardization cannot be applied.
- Direct support equipment managers to coordinate with weapon program managers and field activities to provide and get feedback to enhance standardization.
- Reinforce the services' cataloging and standardization organizations' role in approving new equipment by requiring their input before such equipment enters the system.

The OSD did not fully agree with the first recommendation because it would be very difficult for an activity established at the OSD level to manage selection of AGSE for the Military



Services. However, it did state that a study will be conducted to determine the feasibility of establishing a tri-Service technical advisory organization or a Defense Logistics Agency technical advisory activity with AGSE standardization responsibilities similar to those of the Military Parts Control Advisory Groups.

#### Follow Up

With the exceptions noted above, the OSD agreed with several of the GAO recommendations. It also established a "DoD Ad Hoc Working Group for Standardization of AGSE," chaired by DMSSO, to review the recommendations in more detail. The working group agreed, on 14 February 1980, to focus on the following seven tasks:

1. Examination and evaluation of DoD acquisition policies and implementation instructions
2. Evaluation of AGSE acquisition management
3. Evaluation of AGSE data storage and retrieval systems
4. Investigation of the feasibility of establishing an AGSE Technical Advisory Group for assistance to the Military Services and contractors
5. Investigation of the acquisition practices utilized by commercial airlines for achieving standardization of AGSE
6. Evaluation of Standardization Program Analyses for FSCs 1730, 1740, 4920, and 6625
7. Continuing audit by DMSSO of the implementation of AGSE standardization policies and instructions and the degree of inter-Service and interproject standardization activity and achievement.

The working group also decided that the JLC would conduct Tasks 1, 2, 3, 4, and 6; the AGSE standardization study would not include TMDE (FSC 6625); and DMSSO would be the OSD point of contact and the DoD coordinating office for the standardization study, including the preparation of the OSD's response to GAO at its conclusion.<sup>6</sup>

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<sup>6</sup>Office of the Under Secretary of Defense (Research and Engineering) and Defense Material Specifications and Standards Office, Memorandum for DoD Ad Hoc Working Group for Standardization of Aircraft Ground Support Equipment (AGSE), Subject: "Assignment of AGSE Standardization Study Tasks," 16 July 1980.

The results of the JLC study effort, which was completed in 1983, are reviewed in Chapter 4. We have no information on the planned "final OSD report to GAO."

### STANDARDIZATION OF AVIONICS

Congressional interest in the standardization of military equipment as a cost-saving management principle dates back to 1952, when the Congress enacted the Defense Cataloging and Standardization Act. In response to that act, the OSD issued DoD Directive 4120.3, "Defense Standardization and Specification Program" (first issue: 15 October 1954; current issue: 10 February 1979). The objective of the DSSP is to improve readiness and assure the cost-effective performance of equipment by fostering standardization. Responsibilities for establishing standardization policies, procedures, and controls rest with DMSSO and with the Military Services responsible for the implementation and enforcement of those policies, procedures, and controls. Each Military Service has established a departmental standardization office to manage its portion of the standardization program, but those offices do not have responsibility for specific standardization efforts.

The standing Congressional committee that has taken a particular interest in DoD standardization is the House Committee on Government Operations, which has both legislative and oversight jurisdiction for "the economy and efficiency of Government operations and activities, including Federal procurement." In 1970, this committee found that "standardizing even fairly simple items . . . was extremely difficult in the face of differing service practices and preferences and manufacturing variations" and concluded that ". . . [in] standardization, as in so many other important but neglected Government functions, sufficient resources are not made available, and the savings potentials are hardly realized."<sup>7</sup>

Under its current chairman, Congressman Jack Brooks, the Committee and its Legislation and National Security Subcommittee have conducted numerous hearings and studies to monitor the

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<sup>7</sup>Committee on Government Operations, Military Supply Systems: Cataloging, Standardization, and Provisioning of Spare Parts, Report to Congress (Washington, D.C.: U.S. Government Printing Office, 10 December 1970).

DoD's progress toward standardization. The following section summarizes the Committee's most recent report to the Congress, approved and adopted by the Committee on 31 July 1984.<sup>8</sup>

#### Status of DoD Standardization

The Committee noted that "under the existing organizational relationships and lines of responsibility, standardization initiatives taken within DoD have often failed to bring results." As supporting evidence, it referenced the following studies:

- The Defense Science Board Task Force on Specifications and Standards concluded in its report (April 1977) that little improvement could be expected until senior management became more actively involved with program details rather than general directions.
- The Board recommended strengthening DoD management of the DSSP. Since then, DoD has promulgated various initiatives and standardization policies, but has not enforced them.
- The Defense Science Board Task Force on Command and Control Systems Management recommended in its report (July 1978) a central organization to oversee Joint Service systems to ensure compatibility and operational effectiveness. The recommendation has not been implemented.
- In its report "Management of the Development and Procurement of Airborne Electronics (Avionics) by the DoD" (May 1978), the GAO recommended that the Secretary of Defense accelerate efforts to develop, issue, and implement a standardization policy for avionics and other electronics and then monitor the development and procurement. After issuing the policy, the OSD did not take any action to implement it.
- The Defense Science Board 1983 Summer Study on Joint Service Acquisition Programs (Briefing Report, August 1983) found lack of attention to Joint Service standardization to be a problem and concluded that ad hoc management is not consistent with sound, stable programs. The Board recommended a formal process be instituted to ensure the necessary level of Military Service involvement.
- A recent OSD contractor study (R B Toth Associates, "An Assessment of the U S Defense Standardization and Specification Program," Final Technical Report for the Standardization and Acquisition Support Directorate, 1984) found that many of the constraints on standardization result from the decentralization of standardization responsibilities and the prevalence of parochialism among the Military Services. It did not find any evidence that standardization personnel within the Military Services were following the objectives set by the Defense Materiel

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<sup>8</sup>Committee on Government Operations, Failure To Standardize Avionics Equipment Has Cost Millions, Forty-First Report by the Committee on Government Operations, House Report 98-935, 98th Congress, 2nd session (Washington, D.C.: U S Government Printing Office, 2 August 1984).

Specifications and Standards Board and concluded that most personnel remained uninformed of those objectives.

### Avionics Standardization Initiative

In 1980, the DoD recognized the potential gains from standardization by establishing the Joint Services Review Committee on Avionics Components and Subsystems Standardization (JSRC). The JSRC was tasked to identify opportunities for standardizing avionics subsystems, to coordinate efforts in developing those opportunities, and to facilitate progress toward agreed objectives. It is staffed by one member, on a part-time basis, from each Military Service. Funding, administration, and management of JSRC-sponsored standard subsystem programs is the responsibility of the appropriate agencies within the lead Military Service.

The JSRC decided to concentrate its efforts on core avionics (equipment fulfilling common aircraft requirements such as communications, navigation, and attitude/heading reference systems) since they incorporate mature, stable, and low-risk technology and their standardization would meet with less resistance from the Military Services than would that of mission avionics. (Moreover, several recent development programs for mission avionics show increased emphasis on Joint Service sponsorship. The AN/ALQ-165 Airborne Self Protection Jammer program for Navy and Air Force tactical aircraft and the Integrated Electronic Warfare Systems, which is a joint Navy/Air Force program are just two examples.) JSRC members proposed over 30 candidate subsystems and selected five low-risk items for initial sponsorship in 1981: standard central air data computer, digital audio distribution system, attitude heading reference system, data transfer loader/verifier, and flight data recorder.<sup>9</sup> In 1983, two additional candidates were selected for joint development. The potential cost avoidance for producing the initial five subsystems (compared to nonstandard, unique subsystems) was conservatively estimated by the JSRC at \$770 million (1983 dollars).

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<sup>9</sup>For further details on these subsystems and their current development status, refer to the Committee's report or the U S General Accounting Office, Increased Joint Avionics Standardization Could Result In Major Economies And Operational Benefits, Report to the Secretary of Defense, NSIAD-84-127, 10 July 1984

The Committee's assessment of the JSRC's progress in developing, producing, and fielding standard avionics subsystems was that "the JSRC has failed to achieve the goals set for it "

The Committee attributed that failure to the following factors:

- The JSRC is a low-level, ad hoc management committee without a full-time staff and authority either to resolve requirements and disputes among the Military Services or to defend its programs during budget reviews.
- The JSRC has not been able to successfully support its funding requirements. As a consequence, project production schedules continue to slip because only about one-third of the required funds were budgeted. Such slippage, in turn, causes program managers to make alternative arrangements to protect their own weapons system programs.
- The success of a JSRC project requires that each of the Military Services fully fund its share. It is not uncommon for only the Military Service with lead responsibility to make the necessary funds available.
- Program managers are under no obligation to use Government-furnished equipment jointly developed under JSRC auspices. They may even favor alternative avionics whose funding could be provided under the same program element as JSRC-sponsored projects.
- The JSRC-sponsored projects appear to receive official command support, but in actuality do not. In some cases, JSRC projects have not received the desired support because of procedural problems. In September 1983, DMSSO attempted, during a major systems acquisition review, to have OSD restore \$5 million to the Army's program element that funds its share of JSRC-sponsored projects. DMSSO's request was rejected because DoD procedures allow only those programs costing at least \$50 million to be considered in OSD reviews. Both the Committee and GAO observed that "the potential for \$50 million or more in savings offered by funding avionics subsystem development is not accorded the same priority as an expenditure of \$50 million."

#### Conclusions and Recommendations

The following is quoted verbatim from the Committee's report.

#### VII. CONCLUSION

A substantial part of the Defense budget during the next five years – amounting to \$50 billion – will be spent for avionics. Since most aircraft require numerous avionics, with functions that vary little among different aircraft types, an effective way to control costs is to develop standard avionics whenever possible, instead of purchasing unique avionics for each aircraft

Unfortunately, in too many cases, military service program managers are still buying unique systems and components to fulfill common generic operational requirements. Funds for the development and production of avionics subsystems are directed to the major weapon system

manager rather than to a manager who is responsible for standardization. Also, avionics subsystems selected for standardization which are not committed to a major weapon system are ranked low in budget priority and, therefore, either fail to receive any funding or receive significant funding cuts.

The five avionics subsystems discussed in this report offer a potential savings of \$770 million. This is only a small percentage of the cost avoidance opportunities that are available through standardization of avionics equipment. However, the importance placed on standardization varies among the services, thus creating diverse degrees of support and funding. Each service budgets for standardization independently and disburses dollars differently.

The Committee believes that standardization efforts are likely to fail unless adequate funding is provided to develop and procure these items of equipment on a timely basis. The key is placing the accountability for standardization programs at a high level and establishing specific budgets for joint development programs.

The Committee's recommendations and their dispositions by the Secretary of Defense are shown in Figure 3-1.

#### Comments

The Committee's report, while scathing in its assessment of standardization within the DoD, appears to underestimate the potential for cost avoidance or savings through a sound standardization program.

The Acquisition Improvement Program initially included an initiative on standardization (Carlucci Initiative #21, "Develop and Use Standard Operational and Support Systems"), but the emphasis has apparently changed over the past years. Initiative #21 was not included in the Consolidated Acquisition Improvement Program of 1983;<sup>10</sup> it was dropped from the consolidated category – "Improved Support and Readiness" – to which it was previously allocated.<sup>11</sup>

The recent changes in DoD acquisition policy – specifically the revisions of DoD Directive 5000.39, "Acquisition and Management of Integrated Logistic Support for Systems and

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<sup>10</sup>Deputy Secretary of Defense Memorandum, Subject: "Priority Defense Management Initiatives," 5 May 1983.

<sup>11</sup>Deputy Secretary of Defense Memorandum, Subject: "Year-End Report on the Acquisition Improvement Program," 15 July 1982 (transmitting the Report of the Acquisition Improvement Steering Group).

FIGURE 3-1. CONGRESSIONAL MANDATE FOR AVIONICS STANDARDIZATION

DISPOSITION OF RECOMMENDATIONS PRESENTED IN  
FORTY-FIRST REPORT OF THE  
HOUSE COMMITTEE ON GOVERNMENT OPERATIONS  
2 AUGUST 1984

It has been recommended that the Secretary of Defense direct the Secretaries of the Army, Navy, and Air Force to take three actions:

"(1) Ensure review and selection of candidate avionics subsystems where joint acquisition would be appropriate, and assign the candidate project to a service at a level high enough to assure adequate support."

- By memorandum of the 18 June 1984, the Under Secretary of Defense, Research and Engineering, requested the Joint Logistics Commanders (JLC) to develop a plan for implementation of the Defense Science Board 1983 Summer Study recommendation to establish a formal mechanism for review and selection of joint acquisitions below the system level. While not limited to avionics subsystems and components, it is intended that a formal, institutionalized process established to evaluate requirements, technology, programs, and issues to identify properly joint Service candidates including those of the avionics community. Inclusion of the JSRC as an element of the JLC management review system was specifically recommended. It is anticipated that this will result in appropriate lead service assignments and subsequent management support to ensure effective development, documentation, and use of standard subsystems and components.

"(2) Ensure that funding levels set for projects sponsored by the Joint Services Review Committee on Avionics Components and Subsystems Standardization are sufficient to support development and production schedules necessary for avionics to be available as Government-furnished equipment in accordance with programmed installations in aircraft."

- By separate correspondence the Service Secretaries are being directed to set adequate funding levels. Use of Government-furnished equipment is a separate matter requiring case-by-case evaluation.

"(3) Establish a dedicated program element for research and development funds as well as a budget line item for procurement funds to support the joint avionics program"

- By separate correspondence the Service Secretaries are being directed to establish program elements for core avionics projects that will be separate and distinct from other development and procurement efforts. This should enable OSD and the Congress to identify readily such projects and support them accordingly, while retaining the ability to reprogram funds as may be dictated by unforeseen emergencies.

SOURCE Disposition of Recommendations presented in Forty-First Report of the House Committee on Government Operations, 2 August 1984

Equipment" (November 1983), and Military Standard (MIL-STD) -1388-1A, "Logistic Support Analysis" (April 1983) – are clearly designed to foster standardization when practical and cost-effective. For example, the new MIL-STD-1388-1A explicitly includes a task on standardization – Task 202: Mission Hardware, Software, and Support System Standardization. This policy emphasis, however, will not, by itself, achieve maximum standardization of test equipment; it needs to be supported by an aggressive program to implement the policy and to eliminate the factors impeding increased standardization.



#### 4. JOINT SERVICE EFFORTS

This chapter reviews the activities and results of four Joint Service efforts to improve test equipment management and support: the Industry/Joint Services Automatic Test Project, the JLC Panel on Automatic Testing, the JLC Panel on Standardization of AGSE, and the Joint Technical Coordinating Group for Metrology and Calibration (JTTCG-METCAL). The latter is a standing committee of the JLC, whereas the panels are working groups established by the JLC to study and report on particular issues.

##### INDUSTRY/JOINT SERVICES AUTOMATIC TEST PROJECT

The Industry/Joint Services Automatic Test Project was an outgrowth of the Industry Ad Hoc ATE Project for the Navy that was completed in April 1977 (see description in Chapter 5). Its objective was to examine management and technical issues involving automatic testing. It was chartered and sponsored by five industry associations and directed by a steering committee composed of senior executives and technical experts of the major industrial organizations affiliated with the sponsoring associations in close collaboration with senior-level advisors from the Military Services. The project was organized into three working committees (testing technology, acquisition support, and management) that coordinated the work of 17 task groups. Task group members included 275 experts from 86 industrial firms and 11 colleges/universities, supported by 225 representatives from the Military Services.

The task groups identified problem areas, their causes and impacts, and possible solutions. A week-long conference/workshop provided a forum for proponent and adversary positions on all aspects of DoD use of automatic testing (Automatic Test Conference and Workshop, San Diego, California, April 1978). It also provided the data that the task groups used to develop 110 specific recommendations. During 1979, those recommendations were subjected to a benefits analysis (largely

qualitative) and integrated into a cohesive program of action for implementation. The project's final report, published in 1980, represented a distillation of 45 staff years of study and analysis.<sup>1</sup>

### Summary

Although many of the 110 detailed recommendations in the project's final report pertain to acquisition and testing technology issues, the recommendations that are germane to test equipment management and support are summarized in the Appendix (Table A-1). The overall thrust of the project is indicated by the following summary recommendations (assimilating 74 of the 110 recommendations with the highest ranking based on projected impact on readiness and life cycle cost) that are quoted verbatim from the final report in order of priority.

## 1. ORGANIZATIONS, PEOPLE, FUNDING

### Problem

Despite an abundance of procedures, directives, specifications, and other documents governing maintenance planning, few complex weapon systems have been deployed with an adequate support capability. This paradox has its origin during the early phases of the acquisition process, when support authority is most needed but least effective, largely because resources are too easily allocated to more immediate problems.

### Recommendations

- Provide for a policy which imposes supportability requirements for acquisition of military systems, starting at the conceptual phase.
- Implement the above policy at the individual Service level by establishing centralized organizations with appropriate accountability, budget control, and responsibility for interservice coordination.
- Provide career paths and motivation for retention of management and critical technical personnel, military and civilian.

### Payback

- Potential annual savings of \$100 million in support equipment acquisition costs.
- Across-the-board improvement in military-equipment availability for major systems now under development.

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<sup>1</sup>Industry/Joint Services Automatic Test Project: Final Report (Washington, D C : Industry/Joint Services, June 1980).

## 2. MILITARY EQUIPMENT DESIGN

### Problem

The ability to test military equipment efficiently is prerequisite to supportability. Testability, as a design discipline, is currently inadequate because there is no accepted method for measuring it and no mechanism for imposing and enforcing it during the equipment design phase.

### Recommendations

- Develop verifiable testability requirements.
- Impose these requirements on the prime-system/automatic-test-system design process, and take measures to ensure compliance.

### Payback

- A potential 30 percent improvement in system availability.
- Significant reductions in the cost of support system hardware and software.

## 3. SPECIFICATIONS, DIRECTIVES, CONTROLS, DELIVERABLES

### Problem

Logistic-support directives, specifications, and standards are not applied uniformly or early enough in the acquisition process. Contract Data Requirements items are redundant and duplicative across the Services, and have proliferated to satisfy individual requirements.

### Recommendations

- Impose standardized Contract Data and Automatic Test Requirements documentation as program planning and life-cycle cost control deliverables.
- Require appropriately tailored versions of Logistic Support Analysis/Logistic Support Analysis Record (LSA/LSAR) development procedures early in weapon-system acquisition.

### Payback

- Increased interchange of data among the Services.
- Significant reductions in the cost of logistic support hardware and software across the Services.
- Program management better able to benefit from lessons learned

#### 4. NONELECTRONIC TEST DEVELOPMENT

##### Problem

Lack of effective automated maintenance equipment currently results in degraded equipment availability, and excessive turn-around times and costs associated with logistic spare-parts reclamation.

##### Recommendation

- Accelerate the application of automatic test in support of non-electronic systems and equipment. Technology is available which can significantly improve readiness and fuel efficiency, and significantly reduce life-cycle cost and maintenance man-hour requirements.

##### Payback

- A potential 30 percent reduction in maintenance man-hours per operating hour.
- A potential 20 percent reduction in the cost of spares.
- A potential 10 percent reduction in the fuel consumption of internal-combustion-engine-powered equipment.

#### 5. TEST PROGRAM SET DEVELOPMENT AND MANAGEMENT

##### Problem

Although Test Program Set costs exceed hardware costs, they are less predictable and less controllable. Moreover, there is no common definition of what constitutes a Test Program Set among designers, suppliers, and Government agencies. As a consequence, the user receives a different support and maintenance data package of varying quality with each automatic-test acquisition.

##### Recommendations

- Define and establish controls for acquisition and maintenance of Test Program Sets, including test software, interface hardware, and data.
- Support the development of automated test-program generation systems.
- Support ATLAS [Abbreviated Test Language for All Systems] as the common Joint Services test language.

##### Payback

- Reductions in the cost of Test Program Sets, which is the major cost factor associated with automatic test.

- Predictable, measurable, and therefore manageable Test Program Set development.

## 6. AUTOMATIC TEST TECHNOLOGY DEVELOPMENT

### Problem

New-technology devices in developmental weapon systems pose test problems that cannot be solved using traditional test techniques. Support-equipment developers need advanced test techniques and advanced automatic-test system architectures appropriate to these increasingly complex test requirements.

### Recommendations

- Establish continuing technology-development programs in specific aspects of automated test where the payback potential is high.
- Support a technology-forecasting activity for timely identification of technology advances destined to impose new automatic-test requirements or to enhance automatic-test capabilities.

### Payback

- A potential technological breakthrough capable of dramatically reducing the costs associated with support hardware and software.

## 7. DATA BANKS AND MODELS FOR LIFE-CYCLE COSTING, LOGISTIC SUPPORT ANALYSIS, AND TECHNOLOGY ASSESSMENT

### Problem

Within the Department of Defense, there are many similar but separate data banks, each with its own access procedures. The diversity of models and their implementation further weakens the integrity of the systems engineering process. The result is a less than optimum interchange of Joint Services and industrial information.

### Recommendations

- Establish common models and Logistic Support Analysis techniques tailored to the systems engineering process during various phases of acquisition.
- Establish a linking data-bank network to improve data commonality and the ability to use lessons learned across the Services.

### Payback

- Improved management understanding of the true costs of automated test, as differentiated from those of prime systems.

- Improved tools for effective prediction, measurement, and control of support costs.
- Utilization of lessons learned across Service lines.

## 8. SYSTEM-SOFTWARE DEVELOPMENT AND MAINTENANCE

### Problem

The development of automatic-test system software is a complex process, which differs subtly from that for other DoD software. Unfortunately, there is no consistent, top-down understanding of the complex hardware/software relationships involved. As a consequence, cost reduction and control are ineffective, and software maintenance is unnecessarily hampered by the many versions of nonrehostable, proprietary software products that are developed.

### Recommendations

- Rigorously define software life cycle, and requirements for configuration control and quality assurance.
- Develop guidelines for configuration management and for the maintenance of automatic-test system software.

### Payback

- Significant reductions in software-development costs, the result of managing the true cost drivers.
- A 20 percent reduction in software maintenance costs.
- Option for software organic maintenance across the Services.

## 9. METROLOGY AND CALIBRATION

### Problem

The establishment of test-system tolerances and accuracy requirements is hampered by the absence of technical criteria and discipline. Typically, test system specifications are characterized in terms of component measurement and stimulus units. Few automatic test systems have been specified to a common reference point, or take into account the effects of interfaces and adapters. The consequences: trial-and-error software changes, arbitrary accuracy derating, and unnecessary removal of units for calibration.

### Recommendations

- More actively involve Metrology/Calibration Centers at an early stage in automatic test design and support functions.
- Involve the National Bureau of Standards in basic measurement standards, and support research in technique development for in-place traceability

### Payback

- Greater consistency in the quality of measurements made in the field and at depots.
- Improved weapon-system and support-equipment availability and reduced on-site spares requirements.
- Fewer man-hours dedicated to test-equipment calibration.

## 10. TRAINING

### Problem

The effective skill levels of the automatic-test operator and maintenance technician are increasingly overwhelmed by the requirements of contemporary technology. Supervisor training is particularly weak and, aggravated by lack of motivation, results in a high rate of turnover among the better people. Training still relates to basic skills and traditional training methods, creating a mismatch between the instructional methodologies used and the highly sophisticated equipment involved.

### Recommendations

- Plan, formalize, develop, and fund innovative approaches to the training of support-equipment operators, maintenance technicians, and shop supervisors.
- Establish formal training courses for personnel at all levels—acquisition managers, engineers, and technicians

### Payback

- Improved motivation, retention, and time in service for technicians/supervisors.
- Increased individual and unit productivity
- Improved weapon-system and support-equipment availability

## 11. MAINTENANCE SHOP PRODUCTIVITY

### Problem

The Maintenance Shop Supervisor is hampered in his management of support-equipment resources by the absence of real-time data on such items as status, priority, production, manning, and inventory: automated processes cannot be efficiently managed through notes made on the back of an envelop with a stubby pencil.

Moreover, contemporary automatic test equipment requires a controlled environment and a stable power source for proper operation. It contributes an excessive level of added acoustic noise to the work area, and currently suffers from excessive downtime for calibration and repair, as well as from too many and too complex interface devices.

### Recommendations

- Improve support-equipment design and system performance by better integrating such specific Integrated Logistic Support elements as reliability, maintainability, and human factors.
- Establish career paths and provide adequate incentives to ensure retention of automatic-test trained and experienced personnel, both military and civilian.
- Develop and implement a real-time management information function under local control, to service the larger, automatic-test-equipped maintenance shops and to monitor productivity.
- Integrate facility environmental needs into shop-site planning.

### Payback

- Improved Maintenance Shop productivity in the form of more rapid turn-around and consistently higher repair quality.
- Intermediate-level shops better able to handle surge workloads in the forward area.

### Follow-Up

The project had extensive visibility within the DoD. The final report received wide distribution and attention and increased the awareness within industry and the DoD of the nature and extent of automatic test problems. Some of the recommendations have been reflected in changes in DoD acquisition policy (particularly the 5000-series of directives/instructions) and military standards. Most of the project's recommendations were adopted by the JLC Panel on Automatic Testing for further study, resolution, and action.

Furthermore, one of the sponsoring organizations, the National Security Industrial Association (NSIA), established an Automatic Testing Working Group (restructured into a formal NSIA Committee in 1982) to continue the dialogue between industry and Government and to support the JLC Panel on Automatic Testing. The activities of the NSIA Automatic Testing Committee include sponsorship of training courses, organization of conferences, liaison with the Military Services, and a number of special study projects such as standardization, integrated diagnostics, and



artificial intelligence. Current action items for this committee, resulting from the 1984 ATE Conference, "Supporting Weapon System Technology Through the 1990's," include the following:

- Methods for implementing required incentives and warranties to ensure supportable weapons systems (Policy and Acquisition Subcommittee)
- Follow-up workshop on new technology, including computer aided design/testability integration, modeling tools, and testing techniques (New Testing Technology Subcommittee)
- Technical input to the JLC Panel on Automatic Testing in developing common standards, guides, and tools for standard ATE applications (Test Software/Testability/Automatic Test Systems Subcommittees)
- Means for emphasizing the need for increased investment in technologies for testing nonelectronic equipment (Mechanical System Condition Monitoring Subcommittee)
- Methods for improving the support of existing weapons systems (Weapons system Technology Subcommittee)
- Design tools needed for built-in test (BIT) design in very-high-speed integrated circuits applications (Testability Subcommittee)
- Methods for improving communications with the Congress and the public on the need for improving supportability (Communications/Education Subcommittee).

#### JLC PANEL ON AUTOMATIC TESTING

At the request of a group of military advisors involved in the Industry/Joint Services Automatic Test Project, the JLC chartered a Panel on Automatic Testing in March 1978 and approved its study plan in October 1978. The Panel's mission was stated as follows:<sup>2</sup>

to develop and implement a long-range, definitive action program on automatic testing. The panel has identified over 80 closely related and interwoven tasks to be performed during the next five years. We believe significant savings in manpower and funds, along with improved operational readiness, can be realized from these efforts.

The panel is composed of two members from each of the four participating logistics commands [Army Materiel Command (AMC), Naval Material Command (NAVMAT), Air Force Logistics Command (AFLC), and Air Force Systems Command (AFSC)], plus associate members representing the U.S. Marine Corps and the Defense Logistics Agency. The Panel meets quarterly to review progress

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<sup>2</sup>"Joint Agreement on Support of the Automatic Testing Program," signed by the JLC, 16 July 1979.

and identify new task requirements and conducts an annual program review to assess the overall program and to update the Subtasks Descriptions, which identifies all subtasks in a standard format, including office of primary responsibility, milestones, and funding.

#### Summary and Current Status

The Panel's program, consisting of approximately 80 tasks, covers three broad areas:

- Management: Development of policies, procedures, guidance, and controls needed for weapons system acquisition program managers to integrate automatic testing into the acquisition process.
- Acquisition Support: Development of tools to improve procurement techniques for automatic testing, including design guides, standards, specifications, and training programs.
- Testing Technology: Research and development tasks to advance the state-of-the-art in automatic testing technology, including software tools and languages, testability concepts and techniques, BIT design, and new technology applications.

A more detailed listing of the tasks in the management and acquisition support areas, excerpted from the 1982 Subtasks Descriptions,<sup>3</sup> is provided in the Appendix (see Table A-2). Some of the tasks have been completed, others have been deleted, and many are still in progress. Those tasks that have been completed have resulted in publication of several Joint Service guides (see Figure 4-1), conduct of training courses, publication of a quarterly ATE newsletter, advances in testing technology, and issuance of improved policies and procedures.

In 1983, the structure of the program was revised into seven functional subgroups: policy and procedures, test program sets (TPSs), testability, new technology, off-line ATE, communications/education, and machinery testing. With the 1984 annual program review, conducted 30 October through 1 November 1984, the number of active subtasks declined to 52, divided among the seven functional subgroups. With most of the original subtasks completed in 1985, the Joint Secretariat recommended that the Panel be terminated in 1985. The Panel's membership, however, is in agreement on the need for continued Joint Service coordination on automatic testing

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<sup>3</sup>JLC Panel on Automatic Testing, Subtask Descriptions (Washington, D C.: Joint Logistics Commanders, 30 September 1982)

FIGURE 4-1. SAMPLE PRODUCTS OF THE JLC PANEL  
ON AUTOMATIC TESTING

*Joint Service Weapon System Acquisition Review Guidelines for Automatic Testing*

*Joint Service Automatic Testing Acquisition Planning Guide*

*Built-in-Test Design Guide*

*Selection Guide for Digital Test Program Generation Systems*

*MIL-STD-2165, Testability Program for Electronic Systems and Equipments, January 1985*

*MIL-HDBK<sup>1</sup>-XXX, Testability Analysis Handbook (Revised Draft, March 1985)*

<sup>1</sup>Military Handbook.

issues and dialogue with industry as technology advances. Consequently, the Panel is currently in a transition stage. The most recent annual program review, conducted 19 through 21 November 1985, is expected to result in establishment of a "Joint-Service Automatic Testing Review Board" as a successor to the Panel, with a broadened charter that includes the following responsibilities (in accordance with the draft Joint Service regulation that has not yet been approved):

- Develop methods for reducing hardware, software, and manpower costs associated with automatic testing
- Design policies, plans, and procedures in the use of automatic testing hardware and software to improve operational readiness of weapons systems.
- Facilitate exchange among the Services and OSD of technical, managerial, and operational information on automatic testing hardware and software as it applies to the support of weapons systems
- Manage the automatic test technology standards program as the DoD-designated agent under DMSSO.

#### Comments

The JLC Panel on Automatic Testing has fostered improved communication among the testing community and has increased the visibility of, and expertise in, testing issues in the acquisition process. Through the products identified in Figure 4-1 and the presentation of various training

courses, the Panel has had some impact on the management and support of automatic testing, but most of its program has focused on testing technology. The Panel claims that "the financial rewards have already shown that the cost avoidance of the present program equals the entire budget of the Panel's program by eliminating duplication of effort and development of a *Joint Service* approach to AT [automatic test] systems design and acquisition."<sup>4</sup>

A review of the funding profile of the subtasks identified in the 1982 Subtask Descriptions shows that the program is primarily focused on testing technology: 50 percent of the tasks and over 80 percent of the funds are devoted to testing technology (see Table 4-1). The top seven tasks, accounting for \$260 million of the total budget of \$320 million, are in testing technology and concerned with the following purposes:

- Advanced ATE Concepts: Air Force family of ATE and Navy family of ATE (\$128 million and \$80 million, respectively)
- Microwave ATE (\$7.5 million)
- Self-Improving Diagnostics (\$6.2 million)
- Fiber-Optic Technology (\$18.2 million)
- Vehicle Field Testing Systems (\$16.5 million)
- Unit-Under-Test Simulator (\$5.7 million)

In contrast, the subtasks in the management area received only a modest investment

Finally, the Panel is apparently encountering serious difficulties in reconciling different viewpoints among the *Military Services for the purpose of establishing Joint Service standards*. For example, the need for an improved military standard for TPS development and acquisition has been recognized since 1978. Revisions of MIL-STD-1519 (USAF), "Test Requirements Document," have been in process for several years, but the revised standard, planned for mandatory use DoD-wide, still has not been approved as of December 1985. The prospect for such a DoD-wide standard for the test

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<sup>4</sup>George W. Neumann, "The JLC Panel on Automatic Testing," 1981 Proceedings Annual Reliability and Maintainability Symposium (New York: The Institute of Electrical and Electronics Engineers, Inc., 1981) p. 261

TABLE 4-1 SUBTASK FUNDING PROFILE  
(1982 Program Review)

FUNDING LEVEL <sup>1</sup> (FY81 - FY85)	NUMBER OF SUBTASKS <sup>2</sup>								
	Management			Acquisition Support			Testing Technology		
	C	A	D	C	A	D	C	A	D
>\$100M								1	
\$10M - \$100M								3	
\$5M - \$10M								3	
\$1M - \$5M		1			4		3	11	5
<\$1M	6	8	3	4	17	1	1	17	4
Undetermined			1					1	2
Total: ~\$320M	6	9	4	4	21	1	4	36	11

<sup>1</sup>M = million; FY = fiscal year

<sup>2</sup>C = completed; A = active; D = deleted.

requirements document appears to be remote because of irreconcilable differences of opinion among Military Service representatives. In this respect, the JLC Panel on Automatic Testing has not brought the DoD closer to the goal of a uniform standard for the most critical document in the development and acquisition of TPSs.

JLC PANEL ON STANDARDIZATION OF AGSE

The JLC Panel on Standardization of AGSE was chartered in March 1980 pursuant to the Comptroller General's Report to the Congress, Increased Standardization Would Reduce Costs of Ground Support Equipment for Military Aircraft, LCD-80-30, 7 February 1980, and related task assignments from the DoD Ad Hoc Working Group for Standardization of Aircraft Ground Support Equipment (see Chapter 3). The purpose of the Panel was twofold: (1) to develop joint methods to more effectively implement current policy and directives addressing acquisition and standardization of AGSE and (2) to recommend new joint directives and systems where existing ones inadequately

promote Joint Service standardization.<sup>5</sup> In accordance with its study plan, which was approved in December 1980, the Panel established three subpanels to accomplish specific tasks:

- Policies and Procedures Subpanel: Review of current policies and procedures for AGSE standardization and development of recommendations to ensure the planning and implementation of a cost-effective AGSE standardization program.
- Data Storage and Retrieval Subpanel: Review of existing data storage and retrieval systems for AGSE with emphasis on the capability of those systems to provide decisionmaking information to contractors and Government program managers. Development of recommendations for improvement to existing systems or development of new systems to increase their effectiveness to avoid proliferation of AGSE.
- Contract Methods and Specifications Subpanel: Examination of AGSE contract methods with emphasis on defining alternatives for maximizing AGSE standardization within existing legal and regulatory constraints and recommending revisions to legal and regulatory restrictions that preclude achievement of AGSE standardization. Evaluation of the feasibility of contract incentives to encourage maximum selection of common AGSE. Evaluation of methods for follow-on procurement of AGSE to maximize standardization. Review of AGSE specifications and standards to determine their adequacy and impact on achieving standardization.

The Panel completed its study in 1983 with the publication of a single report, which integrated the technical reports of each subpanel.<sup>6</sup>

#### Summary

The Panel found that the DoD and Military Service policies and directives

are in place to adequately promote the achievement of intraservice AGSE standardization (i.e., non proliferation) objectives. However, the full application of these requirements is not being effected due to constraints on manpower and fiscal resources in all three services, and the basic organizational alignments in the Army and Air Force for AGSE management.<sup>7</sup>

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<sup>5</sup>General John R. Guthrie, Admiral A. J. Whittle, Jr., General Bryce Poe, II, and General Alton D. Slay, "Charter for Joint DARCOM/NMC/AFLC/AFSC Commanders Panel on Standardization of Aviation Ground Support Equipment" (Washington, D.C.: Joint Logistics Commanders, 19 March 1980).

<sup>6</sup>Joint DARCOM/NMC/AFLC/AFSC Commanders Panel on Standardization of Aviation Ground Support Equipment, Final Report (Washington, D.C.: Joint Logistics Commanders, 28 June 1983).

<sup>7</sup>*Ibid.*, Section III, "Summary." Note that the major changes in Army TMDE management, as are described in Chapter 5, became effective in 1983, after completion of the subpanel technical reports in mid-1982.

Beyond the need for increased, dedicated manpower resources (to review aircraft specifications and design for AGSE compatibility, identification, and selection and for common AGSE development and acquisition), the Panel singled out two factors of primary importance to intraservice AGSE standardization: (1) "the existence of an organizational element with specific authority, responsibility and accountability for the achievement of stated objectives"; and (2) "the faculty for developing AGSE independently from weapon system project auspices." With respect to the first factor, it concluded that both the Army and Air Force need to strengthen their management structures "to allow AGSE development/acquisition decisions to be made based on total service aviation support factors vice individual weapon system support factors alone." With respect to the second factor, it concluded that both the Army and Air Force "require the establishment of research and development budget line items specifically designated for engineering development of common AGSE."

While the same factors (manpower resources, fiscal resources, and organizational alignment) affect interservice AGSE standardization, the Panel found it is "further debilitated by the lack of specifically defined service policy on responsibility (except for multi-service weapon system projects) for interservice coordination/execution of AGSE development/acquisition." The Panel concluded that the Military Services "must establish dedicated interservice coordination positions, located in the [same] organizational element where AGSE selection policies and decisions are made" and that SISMS "must be revised to impose [its] application on single-service, as well as multiservice, weapon system projects."

From its review of data storage and retrieval systems for AGSE, the Panel found four major shortcomings: (1) a method for validating contractor compliance with Military Service requirements to screen existing AGSE data bases does not exist, (2) many AGSE data bases are not available to contractors or other Military Services, (3) MIL-HDBK (Military Handbook) -300 data submission requirements cannot be enforced; and (4) MIL-HDBK-300 needs to be automated and updated so it can be more readily used

The Panel concluded that

... the services need to revise the SISMS procedures to include provisions for contractor certification of data base screening, and improve and maintain the structure, application and use of MIL-HDBK-300 as the primary data storage and retrieval system for AGSE identification and selection among the services.

From its review of contract methods and specifications for AGSE, the panel found several relationships between long-range planning, procurement regulations, contracting methods, and specification currency that have adversely influenced AGSE standardization.

The Panel found that the Military Services seldom use the Defense Acquisition Regulations (DAR) standardization exception clause (DAR 3-213) "due to the extended (2-6 months) processing time and dubious nature of the outcomes of requests for authority to negotiate which currently require determinations and findings (D&F) by the Secretary of a Department." It concluded that "Congressional legislation should be sought to allow delegation of authority below the Secretarial level, to the head of the procuring activity for procurements less than \$50M in value" and that the Military Services should "encourage cognizant service AGSE acquisition managers to make maximum use of DAR 3-213 and factor the administrative lead time for processing the (D&F) into their procurement planning."

The Panel also found that multiyear contracting approaches and contractual options for additional quantities represent the primary methods used by the Military Services to ensure standardization but that "the effective use of these contracting methods requires precise long range planning for identification, development and procurement of AGSE, as well as advanced programming of required fiscal resources to fully support contractual commitments." It concluded that the "services need to emphasize the effective conduct of this long-range planning and programming."

The Panel observed a lack of experience in applying incentive clauses to weapons system contracts for the purpose of motivating contractors to maximize selection of common AGSE. It concluded that "notwithstanding the additional administrative burden associated with award fee provisions, the potential advantages in terms of AGSE standardization warrant trial application to a



major weapon system contract" and recommended that the Joint Service Vertical Lift Aircraft program be designated for this purpose.

Finally, the Panel noted that AGSE standardization is only one component of the DSSP and that "the existing problems with the upgrading of military standardization documents are not unique to AGSE, but are generic to the DSSP." It concluded that AGSE proliferation would not be ameliorated with greater emphasis on the DSSP effort because of "the incompatibility of the DSSP, as a program to manage standardization of DoD equipment, and the DAR." According to the Panel, the fundamental problem is the following:

The basic DAR philosophy to maximize competition, by its very nature, results in proliferation. Thus, while the DSSP gives DoD managers valuable tools to control the inventory, the DAR almost precludes their effective use. In fact, when viewed in light of existing DAR philosophy, the primary function of specifications becomes promoting competition rather than controlling proliferation.

The Panel concluded that the JLC should request a "comprehensive and programmatic review of the objectives and administration of the DSSP . . . to assess their relationships to the achievement of material standardization."

The Panel's recommendations, which are summarized in Figure 4-2, were approved by the JLC. They also agreed to implement 10 of the 12 recommendations "within each of our Commands to the maximum reasonable extent as resources permit" and to refer action on two recommendations to the Under Secretary of Defense for Research and Engineering. Even though the Panel focused on AGSE, we believe that its recommendations are applicable to all support equipment, including test equipment.

#### Follow-Up

The Panel was also tasked to monitor the implementation of its recommendations and report progress to the JLC. We have no specific information on the current status of implementation. However, the House Committee on Government Operations, in a report previously referenced in Chapter 3, concluded that implementation had not begun as of January 1984. More recently, the JLC awarded contracts to automate and integrate AGSE data bases, including MIL-HDBK-300; the

**FIGURE 4-2. SUMMARY RECOMMENDATIONS OF JLC PANEL  
ON STANDARDIZATION OF AGSE**

1. Establish dedicated inter-Service coordination positions in each Military Service, located in the organizations where AGSE selection policies/decisions are made, and having direct responsibility for interservice AGSE standardization.
- \*2. Seek Congressional legislation to delegate authority, below the secretarial level, to make determinations and findings with respect to entering into contracts by negotiation under DAR 3-213 and revise DAR Section III, Part 3, paragraphs 3-302 and 3-303 accordingly.
3. Revise procedures for contractor review of AGSE data bases and submission of AGSE recommendations to the Military Services, as established by SISMS, as follows:
  - Require contractors to: (a) submit AGSE candidate lists, (b) screen Military Service Standard Item lists/PILs, and (c) certify screening accomplished on each SERD;
  - Prepare new/revise existing Data Item Descriptions; and
  - Enforce SISMS.
4. Encourage cognizant Military Service AGSE acquisition managers to: (1) make standardization consideration a major technical factor in source selection criteria; (2) make effective use of both DAR 3-213 and multiyear or option contracts for procurement of AGSE; (3) utilize life cycle cost analysis in AGSE selection to substantiate any deviations from standardization policy; and (4) emphasize long-range planning to identify, develop, and standardize AGSE.
5. Designate the Joint Service Vertical Lift program as a prototype for evaluation of an award-fee concept to achieve AGSE standardization.
6. Strengthen AGSE organizational elements within Army and Air Force to focus authority and responsibility for achieving AGSE standardization.
7. Establish/increase dedicated manpower resources within each Military Service for aircraft specification and design review for AGSE compatibility, AGSE selection, and management of common support equipment acquisition.
8. Establish a separate Program Element in Air Force and Army budgets dedicated to engineering development of common AGSE.
9. Improve and maintain the structure, application, and use of MIL-HDBK-300 as the primary data storage and retrieval system for AGSE identification and selection among the Military Services.
- \*10. Recommend OSD conduct a pragmatic review of the objectives and administration of the DSSP and its relationship to the achievement of AGSE standardization.
11. Encourage aircraft and airborne system acquisition managers to consider AGSE proliferation impact in selecting system design alternatives and to impose design specification controls on aircraft-to-AGSE interfaces to allow interoperability of various AGSE on different aircraft.
12. Impose SISMS requirements in all acquisition and harmonize associated Data Item Descriptions to ensure conformity.

\*Action referred to the Under Secretary of Defense for Research and Engineering.

long-term goal, reportedly, is the development of a comprehensive DoD-wide data base management system on nonconsumable items in the DoD inventory.

#### JOINT TECHNICAL COORDINATING GROUP FOR METROLOGY AND CALIBRATION

The JTCG-METCAL was established in 1967 to coordinate the metrology and calibration programs within the DoD. That group was tasked to promote standardization and uniformity among the Military Services. Since the establishment of a separate Subgroup for Consolidation of Calibration Services in June 1975, the JTCG-METCAL has conducted a series of studies of the feasibility and cost effectiveness of consolidation on a regional basis. However, many of its recommendations have not been implemented. For example, its recommendations for the restructuring of calibration services in Europe have not been approved.<sup>8</sup> The GAO has routinely urged the OSD to centralize management and consolidate calibration and diagnostic programs (e.g., oil analysis).<sup>9</sup> Recommendations to replace the individual centers of expertise in metrology and calibration within the Military Services by a single Metrology and Calibration Center assigned to the Joint Chiefs of Staff date back to 1973.<sup>10</sup> The proposed center would be responsible for (1) developing and managing an integrated metrology and calibration program, (2) selecting all standards and calibration equipment, (3) procuring and distributing all standards, (4) conducting research and development, (5) developing and promulgating standard calibration procedures, (6) establishing/reviewing calibration intervals for all ETE and calibration standards, (7) auditing and evaluating calibration facilities, (8) determining location and ownership of all calibration laboratories/facilities/teams, (9) determining technical

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<sup>8</sup>Joint Technical Coordinating Group for Metrology and Calibration, Subgroup for Consolidation of Calibration Services, Consolidation of Department of Defense Calibration Facilities in Europe (Redstone Arsenal, Alabama: U.S. Army Metrology and Calibration Center, September 1976).

<sup>9</sup>U.S. General Accounting Office, A Central Manager Is Needed To Coordinate The Military Diagnostic and Calibration Program, LCD-77-427 (May 1977); and U.S. General Accounting Office, Centralized Direction Needed For Calibration Program, LCD-77-426 (Washington, D.C.: U.S. General Accounting Office, June 1977).

<sup>10</sup>Major James E. Deal (U.S. Air Force), "An Examination of the Metrology and Calibration Programs of the Three Military Departments," Research Study (Maxwell Air Force Base, Alabama: Air University, May 1973).

training requirements, and (10) representing the DoD single point-of-contact with the National Bureau of Standards.

### Charter and Organization

The current JTCG-METCAL charter states its purpose as follows:<sup>11</sup>

I. **PURPOSE.** Provide emphasis on improvements, interservice coordination and cost reduction/avoidance of metrology and calibration operations throughout the services. Ensure accomplishment of necessary interservice actions and coordination on specifications/standards, directives, equipment development and acquisition, data systems, training, procedures/documentation, interval determination, engineering, interservice support, and other issues relating to metrology and calibration. Determine need for present and additional DOD calibration facilities and resources, and maintain liaison with the National Bureau of Standards on requirements for calibration and calibration engineering services.

The JTCG-METCAL consists of a command representative and alternate from each of the four participating commands, with the Marine Corps and the Defense Logistics Agency represented as invited participants.

### Recent Studies

A study plan for the JTCG-METCAL, approved by the Joint Secretariat in March 1983, identified the following tasks:<sup>12</sup>

- A. **Task A:** Prepare a Joint Service Regulation (JSR) to implement that portion of DOD Directive 4155.1 relating to interservice coordination of the DOD metrology and calibration programs.
1. Revise the Handbook of Information and Guidelines (HIG) which provides the CRTs [Calibration Review Teams] with guidelines, methodology and criteria for conducting calibration reviews.
  2. Develop a proposed Joint Service Regulation (JSR) which prescribes policies and procedures for interservice coordination of the DOD

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<sup>11</sup>General John R. Guthrie; Admiral J. G. Williams, Jr.; General Bryce Poe, II; and General Robert T. Marsh, "Charter for Joint DARCOM/NMC/AFLC/AFSC Commanders' Joint Technical Coordinating Group on Metrology and Calibration (JTCG-METCAL)" (Washington, D C: Joint Logistics Commanders, 29 July 1981).

<sup>12</sup>Fred B. Seeley [DARCOM (U.S. Army Development and Readiness Command) Member], Joseph T. Siedlecki (Naval Material Command Member and Chairman), Selden W. McKnight (AFLC Member), and Major M. J. Murtaugh (AFSC Member), "Study Plan Joint Technical Coordinating Group on Metrology and Calibration (JTCG-METCAL)," Unpublished Working Paper, 22 November 1982.

metrology and calibration programs; coordinate the JSR and submit for publication.

B. Task B: Establish policies and procedures to enhance the use of common, interchangeable calibration procedures.

1. Obtain interservice approval of calibration requirements document (CRD) format/contents, consistent with maintenance policies of individual services; complete initial CRDs for interservice use.

2. Develop appropriate DOD specification/documentation for CRD preparation.

3. Analyze interservice applications for other generic documents, i.e., measurement method module and test instrument procedures.

4. Prepare documents for selected measurement systems/test instruments for interservice use.

5. Establish policies and procedures to ensure common, interchangeable calibration procedures are used wherever possible.

C. Task C: Review current methods for determining calibration intervals used by each service with the viewpoint of standardizing methodology; investigate the feasibility of standardizing intervals on like equipment in the DOD inventory and policy for common reliability targets.

1. Select sample of high workload test equipment from the three services and compare calibration intervals; identify and analyze differences to determine if they are the result of procedures, usage, environment or interval policy; report finding and recommendations.

2. Investigate feasibility and impact of DOD standard policy on calibration intervals.

D. Task D: Establish a coordinated DOD measurement technology and standards research, development and engineering program and update annually; coordinate funding and evaluate performance; establish National Bureau of Standards (NBS) projects, as required.

1. Establish and update annually the DOD measurement technology and standards research, development and engineering program.

2. Establish engineering projects at NBS and with other industrial and professional groups as appropriate; evaluate performance.

E. Task E: Establish uniform procedures for determining DOD requirements for calibration services to be provided by the National Bureau of Standards (NBS); estimate cost, coordinate budgeting/funding and establish a schedule for NBS services.

1. Develop schedule for NBS calibration services.

2. Coordinate funds for NBS calibration services.

F. Task F: Complete reviews of possible duplication of calibration services and make recommendations for consolidation of DOD calibration facilities or increased use of interservice support agreements where appropriate.

Initiate calibration review studies for those areas listed below; complete the study, submit draft study for OPR [office of primary responsibility] review and prepare the final study; coordinate the study with major commands and submit the final study and proposed agreement to JLC for approval.

1. Philadelphia
2. Washington DC
3. North Central (North Dakota, South Dakota, Northern Nebraska, Minnesota, Wisconsin, Northern Iowa)
4. Southwest
5. Carolinas
6. New England
7. Southeast Georgia/Florida
8. West Central
9. North Central (Michigan, Indiana, Ohio, Northern Kentucky, Western West Virginia, Western Pennsylvania)
10. Central CONUS [Continental United States]
11. South Central

G. Task G: Perform a feasibility study to determine potential [sic] uses and cost benefits of a common data base for the services; determine potential costs of developing and maintaining such a data base.

1. Perform feasibility study to determine potential uses and cost benefits of a common data base for the Services; determine potential costs of developing and maintaining a common data base.
2. Submit feasibility study to OPRs for review and comment.

#### Status and Comments

We do not have any specific information on the status of the above tasks other than Tasks C and D. With respect to Task C, the Calibration Coordination Group found dramatic differences among the Military Services in calibration intervals for like equipment. The factors contributing to those differences are summarized in Figure 4-3. Until those differences are resolved, however, a DoD standard policy on calibration intervals will not be feasible. Furthermore, the differences also tend to preclude consolidation of the metrology centers, as urged by the GAO. With respect to Task D, the Calibration Coordination Group prepared the first edition of the Tri-Service Metrology Research, Development, and Engineering Plan in 1983, specifying measurement needs in electro-optics, microwave/millimeter wave, electronics/mechanical/physical test equipment, test

**FIGURE 4-3. SERVICE DIFFERENCES IN CALIBRATION INTERVAL DETERMINATION**

1. End of Period (EOP) versus Average Over Period (AOP) Reliability:
  - a. Air Force EOP reliability is 85 percent with an AOP reliability of approximately 95 percent.
  - b. Navy EOP reliability is approximately 73 percent with an AOP reliability of 85 percent.
  - c. Army EOP is approximately 75% reliability with an AOP of 85% reliability.
  - d. Calibration interval difference for EOP versus AOP is a factor of two.
2. Procedures for same part number items show significant difference (preliminary study results).
3. Army and Air Force do not have a dog-and-gem removal process before running of their algorithms. Navy claims a 20% extension with this technique.
4. Army and Navy depots do not consider repair data in their analysis only in tolerance and out-of-tolerance condition. Their repairs often take place at different locations than those at which the calibrations are performed.
5. Key data elements in Navy and Army programs are part number and manufacture code. Air Force uses part number and work unit code.
6. Army and Air Force accumulate time using a renewable-at-failure concept, where as Navy uses a renewable-at-calibration concept.
7. Exponential Distribution Statistics are now being used by all three Military Departments (recently standardized). Previously Air Force and Army used Weibull Distribution Statistics.
8. Navy produces a dog-and-gem list with a suggested different interval than the part number family; Air Force and Army do not.
9. Army adjusts intervals to nearest 120 days to correspond to calibration van trips. Air Force and Navy adjust to nearest month.
10. Air Force publishes TO [Technical Order] 33K-1-100, calibration interval changes, twice a year; Army publishes once a year; and Navy makes monthly adjustments.
11. Methods for establishing initial calibration intervals are different.
12. Review criteria for suggested interval changes are different.

SOURCE: Calibration Interval Working Group of the Calibration Coordination Group, "Areas of Significant Difference" (undated working paper).

equipment behavior analysis, automatic testing, and systems metrology. The second edition of this plan, published 6 June 1984, addresses specific projects for fiscal year 1987 through fiscal year 1991, with a funding requirement of \$98 million.



## 5. MILITARY SERVICE INITIATIVES

This chapter reviews the major studies and initiatives undertaken by the Military Services in recent years to improve the management and support of test equipment.

### ARMY INITIATIVES

In 1979, the Army introduced an improved, more effective TMDE calibration and repair concept. Previously, TMDE calibration and repair had been characterized by (1) split responsibility for calibration and repair of TMDE, and (2) complicated support channels arising from two levels of calibration in the field (below the secondary reference standards). The new concept provided total TMDE calibration and repair support from a single source on an area basis, with AMC management and control of all calibration and repair of common TMDE and selected special TMDE.<sup>1</sup> The transition began with U.S. Army Europe (USAREUR) in October 1979, followed by Korea and the United States.

A second initiative was AMC's decision, formally announced in December 1979, to standardize Army ATE by adopting the AN/USM-410 EQUATE (Electronics Quality Assurance Test Equipment) as the Army's standard general-purpose ATE for use at general-support and depot levels. The rules for determining whether system-peculiar ATE already planned or in development could deviate from the standard ATE policy were promulgated by AMC in 1980.<sup>2</sup> Those rules, in effect, emphasized the benefits of standardization and approved a "one-shot" cost increase, if necessary, to convert planned ATE to AN/USM-410 when long-term cost or readiness benefits could be anticipated.

A third initiative was the TMDE Modernization Program developed jointly by the U.S. Army Communications-Electronics Command (CECOM) and the Army Signal Center in 1980 to "correct

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<sup>1</sup>Department of the Army, DA Concept Study for Improved Army-wide TMDE Calibration and Repair Operations (Washington, D.C.: Department of the Army, March 1977).

<sup>2</sup>Letter, Headquarters DARCOM, Subject: "Implementation Plan for Single ATE (GS [general support] and Depot) Policy," DARCOM, 5 June 1980.

the technical inadequacy, obsolescence and proliferation within the present inventory."<sup>3</sup> Under this program, obsolete manual ETE of many different makes and models was replaced by a much smaller variety of modern commercial test equipment. The program was originally scheduled to be executed over a 5-year period at a cost of \$184 million (CECOM-managed TMDE items only), but manpower and funding constraints caused it to be extended over a 10-year period. In the program's first year (fiscal year 1981), with a budget of \$22 million (out of \$38 million requested), 5 items (types of test equipment) were procured (total count of 3,600), replacing 21 different makes/models in the inventory. In fiscal year 1982, 10 items were procured, replacing 650 makes/models. With the TMDE management reorganization in 1982, program responsibility was transferred to the product manager, TMDE Modernization (TEMOD), and the program expanded to non-CECOM items.

A fourth initiative was the establishment of a TMDE centralized management structure by Secretary of the Army Charter, April 1982. That Charter designated the Commanding General, AMC, as the Department of the Army TMDE Executive Agent responsible for total Army TMDE acquisition, logistics, and financial management in accordance with Army Regulation (AR) 750-43 ("Test, Measurement, and Diagnostic Equipment"), and the Deputy Commanding General for Materiel Readiness as the Executive Director for TMDE with full line authority (AR 750-43 defines TMDE in the broadest sense to include system BIT/BITE, ATE, as well as manual ETE.) The resulting management structure is illustrated in Figure 5-1, and includes the following three key players

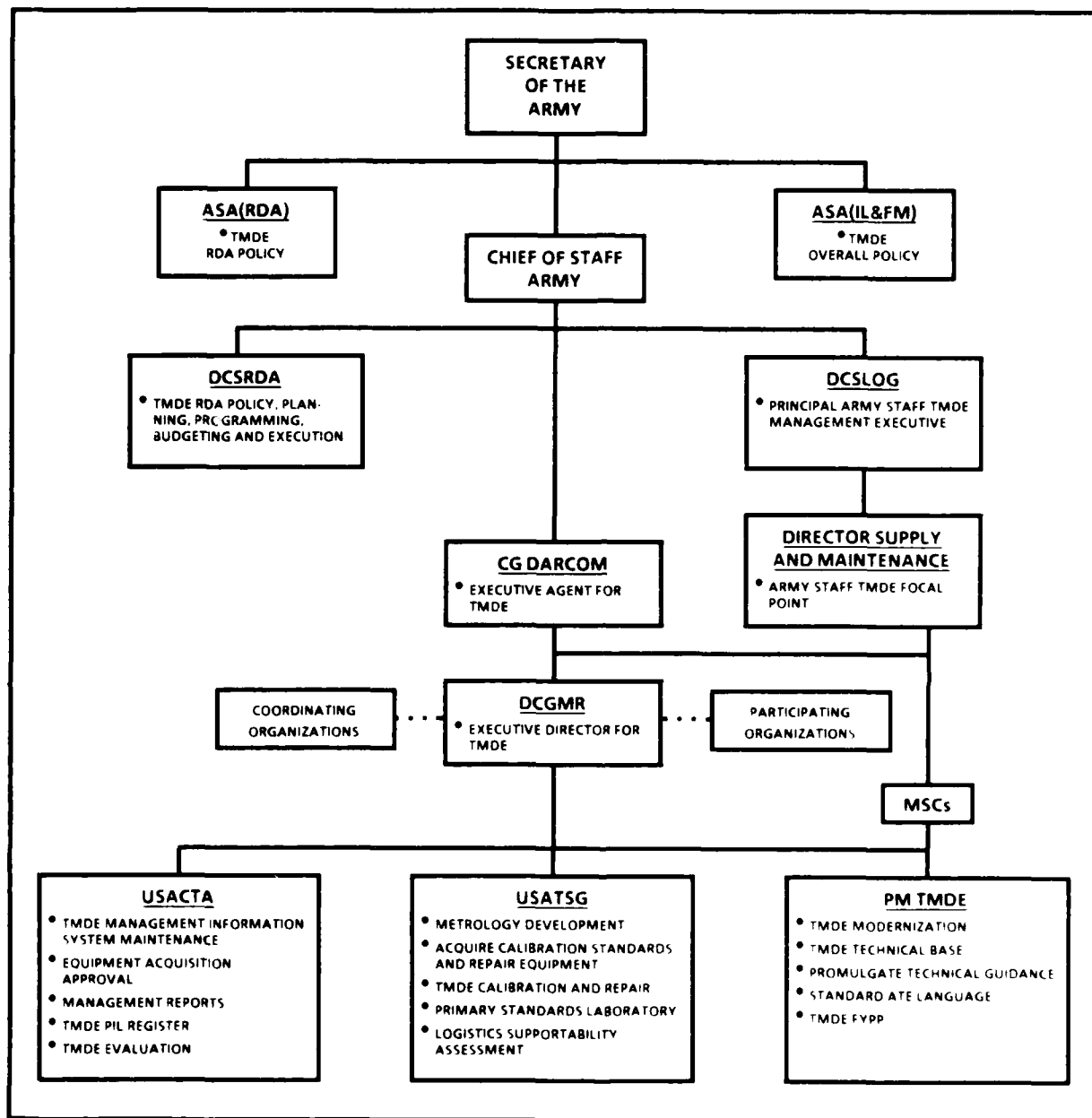
- Centralized TMDE Activity (CTA), Lexington, Kentucky
- U.S. Army TMDE Support Group, Huntsville, Alabama
- Program Manager for TMDE (PM, TMDE), Fort Monmouth, New Jersey.

The responsibilities of each are indicated in Figure 5-1. This centralization of the Army's traditionally dispersed TMDE management structure had been recommended by numerous previous studies

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<sup>3</sup>U.S. Army Signal Center, "Test, Measurement, and Diagnostic Equipment Modernization Fact Sheet" (Fort Gordon, Georgia: U.S. Army Signal Center, May 1981)

FIGURE 5-1. TMDE MANAGEMENT CONCEPT



NOTE: ASA(RDA) = Assistant Secretary of the Army (Research, Development, and Acquisition); ASA(IL&FM) = Assistant Secretary of the Army (Installations, Logistics, and Financial Management); DCSRDA = Deputy Chief of Staff for Research, Development, and Acquisition; DCSLOG = Deputy Chief of Staff for Logistics; CG DARCOM = Commanding General, Department of the Army Materiel and Readiness Command; DCGMR = Deputy Commanding General for Materiel Readiness; MSCs = Major Subordinate Commands; FYPP = Five-Year Program Plan. The Army has subsequently modified this original TMDE management concept to reflect organizational changes.

SOURCE: Headquarters AMC, Executive Director for TMDE, Test, Measurement, and Diagnostic Equipment (TMDE) Implementation Plan (Washington, D.C.: Department of the Army, July 1982).

including one as recent as 1979,<sup>4</sup> and was reiterated by a more recent study conducted by the Department of the Army TMDE Action Team (DATAT), directed by the Deputy Chief of Staff for Logistics at the request of the Assistant Secretary of the Army (Installations, Logistics, and Financial Management).<sup>5</sup> The DATAT report, besides recommending a centralized management structure, made numerous other recommendations for improving the Army's management and support of test equipment.

The Army's fifth initiative was the formal approval of the DATAT report recommendations and institution of a plan to monitor Army-wide implementation. Table 5-1 summarizes the initiatives that have been or are being taken as a result of the DATAT effort. From the numerous initiatives, identified in Table 5-1, several are singled out for further comment.

- **Policy:** The new AR 750-43, April 1984, provides improved procedures for requirements identification, selection, acquisition, and life cycle support for all types of TMDE.
- **Systems Approach:** Traditionally, TMDE has been acquired and fielded on an incremental basis. The TEMOD program is organized similarly, replacing obsolete items with functionally similar ones on a one-for-one basis. The systems approach, in contrast, consists of determining the mission requirements of a maintenance organization and the best mix of TMDE to meet those requirements. A reduction in overall numbers of TMDE is anticipated from this approach. The PM, TMDE is pursuing this approach, starting in fiscal year 1985 with the High Technology Motorized Division
- **TEMOD Program:** The TEMOD program was originally focused on FSC 6625 for which CECOM is the inventory control point. In September 1983, a master plan was completed to extend TEMOD to other FSCs, but TEMOD programmed funding is still limited to Phase I (FSC 6625: 2,543 line items)
- **TMDE Support:** Evaluation of TMDE support, including automatic calibration, was recently completed in a comprehensive study mandated by Congress.<sup>6</sup>
- **Standard ATE Policy:** The Army's Direct Support-Automated Test Support Systems program, renamed the intermediate forward test equipment (IFTE) program, has suffered several delays. Fiscal year 1985 funding for IFTE, the Simplified Test Equipment-Extended (STE X), and the Army Test Technology Laboratory was first eliminated by the

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<sup>4</sup>Lieutenant General Joseph M. Heiser, Jr. (Ret.), Assessment of DA/DARCOM Test, Measurement, and Diagnostic Equipment Program (Washington, D.C.: Department of the Army, September 1979).

<sup>5</sup>Department of the Army Test, Measurement and Diagnostic Equipment Action Team (DATAT) Final Report (Washington, D.C.: Department of the Army, March 1982).

<sup>6</sup>Michael C. Sandusky (Deputy Executive Director for TMDE), Final Comprehensive Report on the U.S. Army Calibration Program (Washington, D.C.: Headquarters AMC, July 1984).

**TABLE 5-1. SUMMARY OF ARMY TMDE MANAGEMENT INITIATIVES**

CATEGORY	DESCRIPTION
<b>Management Structure</b>	Establishment of a centralized TMDE management structure within AMC responsible for all TMDE planning, programming, and budgeting. Establishment of the Executive Director for TMDE as the sole proponent for all TMDE budget actions.
<b>Management Information Systems</b>	<p>Determination of management information needs. Improvements of existing PIL (updating, elimination of obsolete items, and automation) and TMDE register. Development of Army-wide TMDE asset profile. Development of central Test Equipment Management Information System with implementation planned for mid-1985.</p> <p>Development of automatic management information system network intercommand and intra-command transfer and retrieval of TMDE data.</p> <p>Identification of TMDE-related readiness problems by: designating selected TMDE as "pacing items" or equipment readiness code "A" items for unit status reporting purposes; alerting units to emphasize TMDE in readiness assessments; and including TMDE in Sample Data Collection studies.</p>
<b>Policy and Procedures</b>	<p>Revision of policy to strengthen procedures for requirements identification, review and approval, acquisition, and support for all TMDE, including special-purpose TMDE. Development and institution of a "systems approach" for determining TMDE requirements for maintenance organizations.</p> <p>Minimization of TMDE proliferation by authorizing sole-source reprourement and/or multiyear procurements of preferred TMDE (PIL) in accordance with the escape clause in DAR 3-213 ("intent to standardize").</p> <p>Development of source selection criteria for TMDE procurement including life cycle costing and adverse impacts of proprietary rights.</p> <p>Implementation and enforcement of TMDE issue and turn-in procedures.</p> <p>Revision of policy to require separate type classification of all nonexpandable TMDE used by military units, including TMDE components of "sets, kits, and outfits," and to monitor their turn-in for calibration.</p> <p>Development of a TMDE Review Handbook to formalize review procedures/methods for field visits/surveys. Improvements of feedback procedures, including reports on TMDE Activities and Lessons Learned. Revision of policy to improve up-front analysis of support requirements and to require TMDE Support Group's certificate of supportability prior to release of TMDE in order to ensure that fielded TMDE can be supported. Development of provisioning procedures for commercial TMDE to ensure initial fielding is supported with spares and repair parts.</p>
<b>Modernization</b>	Expansion and increased funding support of the TMDE modernization program
<b>Support</b>	Evaluation of TMDE support, including automated calibration, to determine optimum TMDE support structure for Active Army and Reserve Components. Implementation of needed changes in Army National Guard and Reserve support concepts under mobilization conditions. Continuation and completion of consolidation studies under auspices of the JTCG-METCAL.
<b>Automatic Testing</b>	<p>Development of a TPS cost estimating approach and assessment of in-house TPS development capabilities. Assessment of ATLAS compiler for AN/USM-410 and IFTE. Establishment of standard ATE policy, including MSM-105 (i.e., van mounted AN/USM-410) at intermediate (rear), IFTE at intermediate (forward), and STE-X at organizational level in support of combat and tracked vehicles. Publication of an Operational and Organizational Plan for ATE employment.</p> <p>Evaluation of cost-effectiveness and readiness impact of field-level repairs of printed circuit boards.</p> <p>Participation in Air Force and Navy ATE programs through the Army TMDE Technology Team.</p> <p>Establishment of an automatic testing technology research and development program that will meet the Army's needs in the following areas: design for testability, programmable interface electronics, advanced BIT/BITE concepts, nonelectronic equipment measurement and testing, improved methodologies for digital testing programs, and resolution of test problems associated with electro-optics, microwave/millimeter wave equipment, and solid-state microelectronics</p>

SOURCE: Test, Measurement and Diagnostic Equipment (TMDE) Implementation Plan, Department of the Army, July 1982. This plan provides the implementation schedule and milestones for recommendations of the Department of the Army TMDE Action Team (DATAT) Final Report, March 1982, as approved by the Secretary of the Army, April 1982

Senate Armed Services Committee, later approved; IFTE funding was next withheld by the Army Secretariat, pending further justification of need, and finally released in January 1985. The IFTE program entered engineering development with contract award to Grumman Aerospace in September 1985.

A final initiative, with a much broader impact than just TMDE, was the Army's change in maintenance doctrine in 1982. Specifically, the elimination of general support maintenance units from the corps area, as recommended by previous studies,<sup>7</sup> and their replacement by intermediate (rear) units behind the corps rear boundary (i.e., in echelons above corps) has a far-reaching impact on ATE requirements. With less mobility required at echelons above corps, the deployment, operational use, and support of the AN/MSM-105 becomes more viable. At the same time, the doctrine mandates highly mobile ATE for assembly testing and repair by intermediate (forward) maintenance units (formerly direct support) in corps (nondivisional units), division, and forward areas. In this context, it is noteworthy that USAREUR's policy is to screen printed circuit boards (PCBs) if possible, evacuate PCBs that cannot be screened or screened as "no-go" to the 21st Support Command, and repair them at the Pirmasens Communications-Electronics Maintenance Center.<sup>8</sup>

#### NAVY INITIATIVES

The Navy's initiatives to improve management and support of test equipment can be summarized in two main themes. For ETE, the focus has been on ensuring better coordination among the Systems Commands; for ATE, the focus has been on advancing the testing technology used in the Fleet and developing the associated management support tools.

##### Manual Test Equipment

Navy initiatives to control or reduce unnecessary proliferation of general-purpose ETE (GPETE) date back to 1969 when NAVMAT delegated centralized GPETE management

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<sup>7</sup>General John R. Guthrie (Study Director), Army Logistics 1981 Study (Washington, D.C. Department of the Army, August 1981)

<sup>8</sup>Commander in Chief U.S. Army, Europe Message DTG 231059Z Subject: "Theater Repair Policy for Printed Circuit Boards (PCBs)," February 1984. The policy is articulated in more detail in USAREUR Supplement 1 to AR 750-1.

responsibility to the Naval Electronic Systems Command (NAVELEX).<sup>9</sup> Within NAVELEX, that responsibility was centralized in the TMDE Division (ELEX-841), including "research, design, development, evaluation, testing, logistics planning, acquisition, inventory management, maintenance, repair, calibration, budgeting, funding, requirements determination, allocation, allowance, delivery, and follow-on support."<sup>10</sup> In exercising its authority, NAVELEX was unable to obtain agreement on what constitutes GPETE. As a result, Systems Commands, program management offices, field activities, and the Fleet continued with procurement of ETE under the guise of special-purpose ETE (SPETE), beyond NAVELEX control. NAVMAT solved this problem in 1973 by establishing an ETE Board, responsible for determining the classification (i.e., either GPETE or SPETE) of ETE in the inventory as well as new requirements whenever agreement could not be reached by the cognizant Systems Command and NAVELEX.<sup>11</sup> Eventually, NAVMAT established a standard item list [MIL-STD-1364 (Navy), "Standard General Purpose Electronic Test Equipment"], with NAVELEX responsible for keeping the list up to date, and restricting, to the extent practical, new GPETE procurements to items listed in MIL-STD-1364. Specific procedures are prescribed for procurement of "non-standard GPETE" (i.e., items classified as GPETE, but not listed in the latest version of MIL-STD-1364).<sup>12</sup>

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<sup>9</sup>National Material Command, "Naval Material Command Organization Manual," NAVMAT Instruction (NAVMATINST) 5460.2 (Washington, D.C.: Naval Material Command, 20 August 1969).

<sup>10</sup>NAVELEX NOTICE 5430, 2 August 1972.

<sup>11</sup>Naval Material Command, "Electronic Test Equipment: Classification and Assignment," NAVMATINST 5430.52 (Washington, D.C.: Naval Material Command, 10 May 1973); implemented by Naval Electronic Systems Command, "Naval Material Command Electronic Test Equipment Classification Board: Policies and Procedures," NAVELEX Instruction 5420.12 (Washington, D.C.: Naval Electronic Systems Command, 26 October 1973) (Revision A, dated 21 April 1976).

<sup>12</sup>MIL-STD-1387 (Navy), "Procedures for the Acquisition of Non-Standard General Purpose Electronic Test Equipment," first issued in 1974 and cited in NAVMATINST 5430.52, Change 1, 24 July 1975. Specific procedures are set forth in: NAVELEX Instruction 5450.29, "Navy General Purpose Electronic Test Equipment (GPETE): Policies, Procedures, and Responsibilities for," 24 June 1974.

Thus, since the mid-1970's, the Navy has had the policy, organization, and procedures in place for a "single manager" of GPETE. The process appears to be controlling unnecessary proliferation and achieving economies-of-scale in GPETE procurements (subject to procurement regulations that favor competition, making sole-source reprocurement and multiyear procurements difficult). MIL-STD-1364 has been revised every 2 or 3 years (the current version, MIL-STD-1364F, is dated March 1982), with interim quarterly updates (entitled "GPETE Status List with Reference Prices"). Updates consist of additions to, as well as deletions from, the preferred list of GPETE in MIL-STD-1364. The net result is that the number of line items (makes/models) on the preferred list for standard GPETE remains between 300 and 400 items.

In turn, MIL-STD-1364 updates are reflected in the standard item lists maintained by the Naval Sea Systems Command (NAVSEA) (cognizant office: SEA-06C1, Test and Monitoring Systems Division) and Naval Air Systems Command (NAVAIR) (cognizant offices: AIR-552, Support Equipment Division, and Naval Air Engineering Center, Lakehurst, New Jersey) for the purposes of standardization and inventory control.<sup>13</sup> Those lists show the makes/models of ETE (GPETE as well as SPETE) and ancillary items in the actual inventory. They are organized by test equipment type (subcategory code) and show for each type the specific makes/models in the inventory, with the first one listed being the specific make/model (if any) from the MIL-STD-1364 latest update. When new weapons systems are developed, contractors are required to screen MIL-STD-1364 and the standard item list (in that order) to determine whether test equipment requirements can be met with equipment that is already in the inventory. If that is the case, then the contractor's SERD will identify the preferred make/model; if the requirements cannot be met by existing test equipment, then the SERD will identify what is needed. In the latter case, following validation by the Navy (office symbols SEA-06C1 or AIR-552) and revision of the test equipment allowance list for the units

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<sup>13</sup>Naval Sea Systems Command, "Test Equipment Index To Shipboard Portable Electronic Test Equipment Requirements List (SPETERL)," NAVSEA-0967-LP-008-9000, and Naval Air Systems Command, "Avionics Preferred Common Ground Support Equipment Index," NAVAIR-16-1-525 (Washington, D.C.: Department of the Navy, undated).



receiving/supporting the new weapons system, the process eventually updates the standard item list with a new type of GPETE and submits a procurement request to NAVELEX. NAVELEX, supported by the Naval Electronics System Engineering Activity, St. Inigoes, Maryland, again evaluates the need for this nonstandard GPETE, and if it approves the need, it includes the requirement in its budget. The test equipment is actually purchased by the Ships' Parts Control Center, Mechanicsburg, Pennsylvania.

As a result of evolving technology, the number of different test equipment types within the Navy has been growing. For example, NAVSEA currently has approximately 550 subcategory codes, including 140 for standard GPETE and a similar number for nonstandard GPETE. The remaining codes are categorized as both SPETE and ancillary items. The most recent subcategory codes may have 1 or 2 line items in the inventory, while the older subcategory codes may have 10 to 15 different line items. NAVAIR has a similar distribution, with its 150 different types of GPETE.

With respect to the effectiveness of the entire process, NAVELEX may have gone too far with keeping MIL-STD-1364 up to date. The traditional problem with PILs is that they tend to get out of date and thus lose their utility. NAVELEX's quarterly updates, on the other hand, may be too frequent, causing instability in procurement programs and contributing to some proliferation of GPETE. Specifically, NAVAIR notes that the TMDE allowance list for Aircraft Intermediate Maintenance Departments has about doubled over the past 14 years. Part of the growth can be attributed to evolving technology, but part may be attributed to the strict adherence to MIL-STD-1364 and its frequent updates.

Other initiatives by NAVELEX in GPETE management include the establishment of a "GPETE Assets Screening Pool" program, a central registry of Fleet assets in excess of allowance for redistribution. A 1980 GAO report noted that such a capability was lacking in the Navy, with the exception of a NAVSEA program, created in 1977.<sup>14</sup> That program, which is being transferred to the

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<sup>14</sup>U.S. General Accounting Office, "Survey of DoD's Management of Automatic and General Purpose Electronic Test Equipment (LCD-80-106)," Letter Report to the Secretary of Defense, B-199353 (Washington, D.C.: U.S. General Accounting Office, 4 September 1980)

Fleet, has increased the availability of test equipment. More recently, NAVELEX has been installing an automated GPETE data base; the first version, excerpted in mid-1984 from the more comprehensive MEASURE (Metrology Automated System for Uniform Recall and Reporting) data base, is incomplete but will be enhanced to include all GPETE.<sup>15</sup>

In summary, the Navy appears to have an effective management process to control proliferation of GPETE insofar as current procurement regulations permit. GPETE, however, is only part of the manual ETE inventory; SPETE, together with both "limited availability" and "limited demand" GPETE, account for about half of the ETE inventory and escape centralized management. We do not know the extent to which the SPETE category includes items that could or should be classified as GPETE. Furthermore, the Navy has not assigned a high priority for replacement of its test equipment. As a result, a significant portion of today's GPETE inventory (550,000 items valued at \$2 billion) is obsolete, i.e., out of production and not economically supportable. NAVELEX has estimated that 13 percent of its GPETE inventory is obsolete, which implies a funding requirement of about \$250 million for wholesale replacement. While the Navy's annual funding level for GPETE procurement has increased in recent years (from \$7 million per year in the late 1970's to \$60 million for 1985), it is still insufficient to support planned replacements even if there were no new requirements. The average economic life of ETE is commonly estimated at 8 to 10 years, implying an annual funding requirement of \$200 million to \$250 million just to avoid obsolescence.

A recent Navy review of the integrated logistic support (ILS) audits for 28 weapons system acquisition programs shows that the Navy is still experiencing problems with support and test equipment in the acquisition process [see: F. A. Myers, et al., NAVSEA ILS Audits Analyses And

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<sup>15</sup>MEASURE is a Navy-wide management information system in support of the Navy's metrology and calibration program. Its primary functions are to (1) inventory/recall/schedule metrology assets, (2) document calibration actions, and (3) collect engineering data for monitoring effectiveness of calibration and determining calibration intervals. Navy-wide implementation of MEASURE commenced in 1975.

Lessons Learned (Bethesda, Maryland: David W. Taylor Naval Ship Research and Development Center, June 1983)]. That review noted the following significant deficiencies:

- In 7 of 28 programs, the calibration requirements and procedures for ETE had not been established as prescribed by policy. In six cases, calibration requirements had not been addressed at all; in one case, where the ETE did not require calibration, this fact was not indicated in the ILS plan.
- In 4 of 28 programs, the ILS plan was inadequate with respect to test equipment, including: failure to identify needed ETE, failure to include a maintenance plan for the prime equipment, failure to indicate no test equipment is needed because of vendor maintenance of the prime equipment, and failure to indicate that selected GPETE is in critically short supply.
- In 3 of 28 programs, the stated GPETE requirements were not in accord with MIL-STD-1364 and MIL-STD-1387. The selected GPETE either omitted preferred items listed in MIL-STD-1364 or included items not on that list without prior approval having been sought for such nonstandard GPETE per MIL-STD-1387.

#### Automatic Test Equipment

Navy initiatives with regard to automatic testing date back to the 1960's, when NAVAIR adopted the concept of general-purpose ATE for avionics support aboard carriers. A program management office (PMA-238) was established for the development and acquisition of a militarized ATE – the Versatile Avionics Shop Tester (VAST) – which was to be capable of testing the weapon and shop replaceable assemblies of the carrier-based aircraft under development at that time (F-14A, S-3A, and E-2C). The first production contract was awarded in 1968 and the first VAST (nomenclature AN/USM-247) was delivered in 1972. The Navy bought a total of 95 VAST stations at an aggregate acquisition cost of \$1 billion (excluding application software – i.e., TPSs – and support software), with the last station delivered in 1978. They are installed aboard carriers and at Naval Air Stations, Naval Air Rework Facilities, Naval Air Maintenance Training Detachments, and contractor facilities (for TPS development and/or productive work). VAST is the largest ATE in the DoD inventory, comprising ten bays of hardware.

The Navy's experience with the VAST program showed that a single, general-purpose ATE for testing a wide mix of assemblies and modules was not very practical. Because of low throughput, additional VAST stations had to be added aboard carriers (the original plan was two per

carrier), and additional ATE had to be procured to meet the testing workload created by peacetime flying hours. In 1975, in response to widespread problems in the Fleet with ATE and TPSs, the Assistant Secretary of the Navy for Research and Development requested that a quick study be conducted to define the problems and develop solutions. That study was conducted by representatives from NAVMAT, Systems Commands, field activities, the Fleet, and industry consultants. The resulting report, known as the "Marcy Report,"<sup>16</sup> identified the problems and the Navy actions required to solve them (see problem/solution matrix in Figure 5-2). Its recommendations included the following:

- Enforce existing Navy policy in weapons system acquisition regarding supportability.
- Establish a central ATE management group within NAVMAT, reporting directly to the Chief of Naval Material and supported by comparable organizations within the Systems Commands.
- Educate management personnel in the technical and management issues involved in weapons system acquisition, including the practical problems of BIT and off-line ATE hardware/software.
- Provide quick relief to the Fleet by (1) initiating engineering changes (reliability improvements) for high-failure items of prime equipment as well as ATE, (2) establishing "tiger-teams" to respond to ATE problems, (3) developing organic test programming capabilities, and (4) prohibiting deployment of off-line ATE without prior approval.
- Develop a new family of general-purpose ATE and institute policy requiring Chief of Naval Material approval of any off-line ATE acquisition.
- Initiate and support both a short-range and long-term research and development program in automatic testing technology under supervision of the central ATE management office.

To supplement this effort, the Navy also requested input from industry. The Industry Ad Hoc ATE Project, comprising 174 experts from member companies of five sponsoring industry associations, was

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<sup>16</sup>ATE Ad Hoc Working Group, Report on Navy Issues Concerning Automatic Test, Monitoring and Diagnostic Systems and Equipment (Washington, D.C.: Assistant Secretary of the Navy for Research and Development, 13 February 1976)

FIGURE 5-2. NAVY ATE PROBLEM/SOLUTION MATRIX

SOLUTIONS PROBLEMS	SOLUTIONS													
	ATE ACQUISITION	CALIBRATION	TRAINING AND MANPOWER	DOCUMENTATION	TEAMS IMPROVEMENT	COMMAND INFORMATION	END-ITEM REPT ANAL. SUPPORT SYSTEMS	EDUCATION	END-ITEM REL. & SPARE IMPROVEMENT	VAST EQUIPMENT IMPROVEMENT	ADVANCED TESTING TECHNOLOGY -- R&D	CONFIGURATION AND SOFTWARE MANAGEMENT	FAMILY OF ATE	MANAGEMENT
TPS DEFICIENCIES				X			X		X	X	X	X		X
LENGTHY PERIOD OF TEST	X		X				X		X		X	X	X	X
ATE END-ITEM INTERFACE INCOMPATIBILITY							X			X	X		X	X
CONFIGURATION CONTROL	X				X			X				X	X	X
PROLIFERATION	X						X	X	X		X		X	X
SIZE AND COMPLEXITY OF ATE	X						X			X	X		X	X
ATE CAPABILITY/ LIMITATIONS					X					X			X	X
ATE MAINTAINABILITY	X	X	X	X	X		X			X	X	X	X	X
LACK OF RELIABILITY OF ATE	X				X		X			X	X	X	X	X
ATE/HUMAN INTERFACES	X		X	X										X
POOR RESPONSE TO FLEET PROBLEMS														X
SHOP FACILITIES AND MANAGEMENT							X	X	X					X
SPARES	X						X	X	X					X
CALIBRATION	X	X									X			X
DOCUMENTATION	X			X							X	X		X
TRAINING AND MANPOWER			X					X						X
LACK OF EFFECTIVE BIT	X					X	X	X			X			X
LACK OF COMMAND INFORMATION						X	X				X			X
PLANNED MAINTENANCE SYSTEM NOT EFFICIENT		X				X					X			X
ITEMS NOT AMENABLE TO TEST							X		X		X			X

SOURCE: ATE Ad Hoc Working Group, Report on Navy Issues Concerning Automatic Test, Monitoring and Diagnostic Systems and Equipment (Washington, D.C.: Assistant Secretary of the Navy for Research and Development, 13 February 1976).

chartered in November 1975. The project published its final report in April 1977.<sup>17</sup> (See Appendix, Table A-3 for a summary of recommendations.) This effort, in turn, was extended into the Industry/Joint Services Automatic Test Project when it was recognized that the Navy's problems in exploiting automatic testing were common to all Military Departments. As indicated previously, the latter study was completed in June 1980, with most of the recommendations being followed up by joint working groups under the auspices of the JLC Panel on Automatic Testing.

The Navy began implementing many of the "Marcy Report" recommended actions in 1976. A Test and Monitoring Systems (TAMS) Project Office (MAT-04T) was established as the central Navy focal point for all ATE-related matters. The Project Office was assigned responsibility for review of acquisition projects, conduct of a coordinated research and development program in testing technology, development of policies/procedures/tools, establishment of a list of "approved ATE" (with prime equipment program managers required to select from that list, permitting waivers only if justified), and coordination of TAMS offices in the subordinate commands. In the 1980 NAVMAT reorganization, the TAMS Project Office was transferred to NAVELEX and assigned the role of lead Systems Command Project Office in TAMS-related matters (including BIT, off-line ATE, as well as manual ETE and associated support requirements such as metrology and calibration).

The evolution toward an effective management structure in the Navy with associated policies, procedures, and tools has been slow. For example, in 1978 the TAMS Project Office was assigned responsibility for establishing a family of preferred off-line ATE for Navy-wide use (NAVMATINST 3960.4B, "Policy and Responsibility for Automatic Testing, Monitoring and Diagnostic Systems and Equipment," 17 July 1978). It was also assigned responsibility for matching projected test requirements with ATE options, with preference being given to existing ATE (NAVMATINST 3960.9A, "Automatic Testing Guides for Project/Acquisition Managers; Promulgation of,"

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<sup>17</sup>Aerospace Industries Association of America, Inc., et al., Report of Industry Ad Hoc Automatic Test Equipment Project for the Navy, 3 vols. (Washington, D.C.: Aerospace Industries Association of America, Inc., April 1977).

19 September 1979)<sup>18</sup>. However, it took until 1981 to standardize the ATE selection process (NAVMAT P9407, "Support Equipment Selection Analysis Guide," November 1981) and until 1982 to prescribe application of this process and publication of the preferred ATE list (NAVMAT-INST 3960.11, "Selection of Off-line Automatic Test Equipment, Policy for," 11 February 1982). Similarly, while the requirement for a Navy-wide data bank of ATE was firmly established as early as 1974 (NAVMATINST 5230.8, "Data Banks for Automatic Test, Monitoring and Diagnostic Systems and Equipment; Utilization of," 14 November 1974; and NAVMATINST 4440.46, "Inventory of Automatic Test, Monitoring, and Diagnostic Systems and Equipment; Request for," 10 December 1974) and the need confirmed by numerous ATE-related studies, the Navy has still not proceeded beyond a manual ATE inventory survey,<sup>19</sup> although plans are now being made to develop an automated management information system and a consolidated data base.<sup>20</sup> Overall, however, the Navy is tackling the issues. Both the TAMS Program Report (reviewed annually since July 1981) and the Test Technology RDT&E [Research, Development, Test, and Evaluation] Plan (also updated annually) appear to be well managed. Of the recent initiatives, two—one in NAVAIR and one in NAVSEA—are described below.

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<sup>18</sup>This instruction promulgated three of the JLC Guides listed earlier in Figure 4-1: "Automatic Testing Acquisition Planning Guide," "Built-In-Test Design Guide," and "Selection Guide for Digital Test Program Generation Systems."

<sup>19</sup>The most recent data are provided in: Automatic Test Equipment Inventory Survey, TAMS Project Office (NAVELEX 08T), 30 September 1982. This survey lists the testing characteristics of 346 distinct models of ATE. Exact counts of the ATE inventory are unknown; reliability and maintainability characteristics are not included; and data on the performance of self-test diagnostic software are not given.

<sup>20</sup>A consolidated data base is included in the proposed NAVELEX Instruction 3960 4C (draft). The planned system, being developed by the Fleet Analysis Center, is a real-time, menu-based system with terminals throughout the Navy. The preliminary data base design includes 18 data fields relating unit-under-test information (17 data fields) to test equipment identification (1 data field). In contrast, consideration of an ATE management information system, including ATE technical characteristics and utilization, is still in the very early planning stage. see: Technical Report on Test Equipment Data Base Investigation, (Washington, D.C.: Naval Electronic Systems Command, August 1984).

NAVAIR, in assessing the lessons learned from VAST, formulated its ATE plans for the 1980's and beyond, as documented in the "NAVAIR ATE Program Plan" (dated January 1978, approved and promulgated in 1979). That plan focuses on achieving seven goals:

- Integrating ATE program management
- Improving ATE acquisition
- Designing avionics for testability and maintainability
- Minimizing the variety of ATE
- Consolidating and improving ATE software
- Improving the quality of TPSs
- Attaining full and timely organic support capability.

The key element of this plan is minimizing the variety of ATE, with the ultimate objective of developing an ATE inventory with standardized, modular hardware and software elements using a single standard test language. To achieve that goal, the plan establishes a functional family of common ATE to be used in the 1980's and describes a new ATE project, the Consolidated Support System (CSS), for use in the 1990's and beyond. Thus far, however, NAVAIR's instructions on the selection of ground support equipment have not been updated to include the concept of a preferred family of common ATE.<sup>21</sup> The only documents expressing this policy and listing the specific ATE involved are the NAVAIR Support Equipment Selection Guide, (dated June 1981) and a Commander Naval Air Systems Command Memorandum, Subject: "NAVAIR ATE Policy" (first issued on 12 June 1978 and recently reissued). The current family is shown in Table 5-2. For this approach to be successful, however, the Navy will have to enforce its policy to standardize.

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<sup>21</sup>The key instruction, NAVAIR Instruction 5400.72, "Policy and Responsibilities for the Selection, Design, Approval, Ordering, Delivery and Logistics Support of GSE (Ground Support Equipment)," 20 June 1973, is strictly neutral with respect to peculiar versus common support equipment. It is further noteworthy that this instruction does not contain a single reference to pertinent NAVMAT instructions, although NAVAIR's family of ATE is a subset of NAVMAT's preferred ATE list.



However, as indicated by the JLC AGSE study, that standardization will be very difficult because of the many counterincentives in the weapons system acquisition process.<sup>22</sup>

TABLE 5-2. NAVAIR FUNCTIONAL FAMILY OF ATE

YEAR	NAME/NOMENCLATURE	MFG. <sup>1</sup>	TYPE	INITIAL APPLICATION	DATA PACKAGE
1972	VAST (AN/USM-247)	Harris	Digital-Analog-Hybrid	Common	Full
1975	CAT IIID (AN/USM-429 (V))	Grumman	Digital-Analog-Hybrid	F-14A	None
1976	IMUTS II (AN/USM-608 (V))	Litton	Inertial Navigation	F/A-18	None
1979	EOSTS (AN/AAM-60 (V-6))	Boeing	Electro-Optics	S-3A	In Validation
1980	NEWTS (AN/USM-458)	Sanders	Electronic Warfare	ALQ-126B	None
1981	RADCOM (AN/USM-467)	Grumman	Radar	E-2C	None
1983	ATS (AN/USM-470 (V-1))	Harris	Digital-Analog-Hybrid	F/A-18	None
1983	HTS (AN/USM-484)	Harris	Hybrid	Common	None
1984	ATS (AN/USM-470 (V-2))	Harris	Digital-Analog-Hybrid	SH-60	None
198X	AEWTS (AN/USM-487)	Honeywell	Electronic Warfare	ASPJ	None

<sup>1</sup>MFG. = Manufacturer.

SOURCE: Program Manager, Consolidated Support System (CSS), "Navy's ATE Project" (Washington, D.C.: Department of the Navy, 1984 briefing).

The system definition phase of the CSS program started with contract awards to five competing contractor teams in January 1982 and was completed in August 1983. Navy program review was completed in March 1985 with approval to proceed into full-scale engineering development, but with the program broadened in scope to include the intermediate- and depot-level ATE requirements of the other Systems Commands. Renamed the Consolidated Automated Support System, two competitive contracts for full-scale development were awarded to General Electric, Incorporated and Grumman Aerospace Corporation in September 1985. NAVAIR's strategy emphasizes supportability, modularity, technology transparency (i.e., designed for technology updating), rapid reconfigurability, operational evaluation of prototype, and ability to compete the production phase

<sup>22</sup>For example, while the nonradar avionics of the F/A-18 are supported by the Mini-VAST, AN/USM-470(V-1), consisting of VAST building blocks (50 percent), new design test equipment (10 percent), and commercial test instruments (40 percent), the AN/APG-65 radar is supported by a peculiar, contractor-developed radar test station, the design of which does not include any government furnished equipment.

(leader/follower concept), with deliveries starting in 1992. Program costs are estimated at \$5.7 billion (fiscal year 1983 dollars), with development costing \$0.9 billion and production \$4.8 billion. Compared to the current ATE configuration aboard the typical carrier, NAVAIR has projected the following savings from fielding CSS:

- Fewer test equipment types (5 versus 95)
- Fewer maintenance technicians in the intermediate-level maintenance shop (150 versus 250)
- Fewer training courses (5 versus 185)
- Fewer facility space (10,000 versus 15,000 square feet)
- Fewer contractor technicians (5 versus 21)
- Fewer technical publications (45 versus 624 volumes)
- Fewer spares (3,800 versus 30,000 line items).

The resulting life cycle cost savings (compared to the present ATE suite, excluding additional costs for needed ATE additions/replacements to support future weapons systems) have been estimated at \$3 billion.

NAVSEA's initiatives in automatic testing are comprised under a single program, the Support and Test Equipment Engineering Program (STEEP). Initiated in October 1978 under the charter of the Ship Support Improvement Project, STEEP's goal was to improve Fleet support of electronic modules/PCBs. The program entailed a cost effectiveness analysis of utilizing ATE (digital card testers) at organizational- and/or intermediate-maintenance levels for PCB screening and/or repair versus a PCB sparing policy.<sup>23</sup> An evaluation of the pilot intermediate-level installations using commercial digital card testers and TPSs for selected PCBs was conducted from 1979 to 1981. The result was a de facto change in maintenance concept, with the AN/USM-465 selected as standard intermediate-level ATE for testing digital PCBs. In July 1981, NAVSEA fielded the first operational

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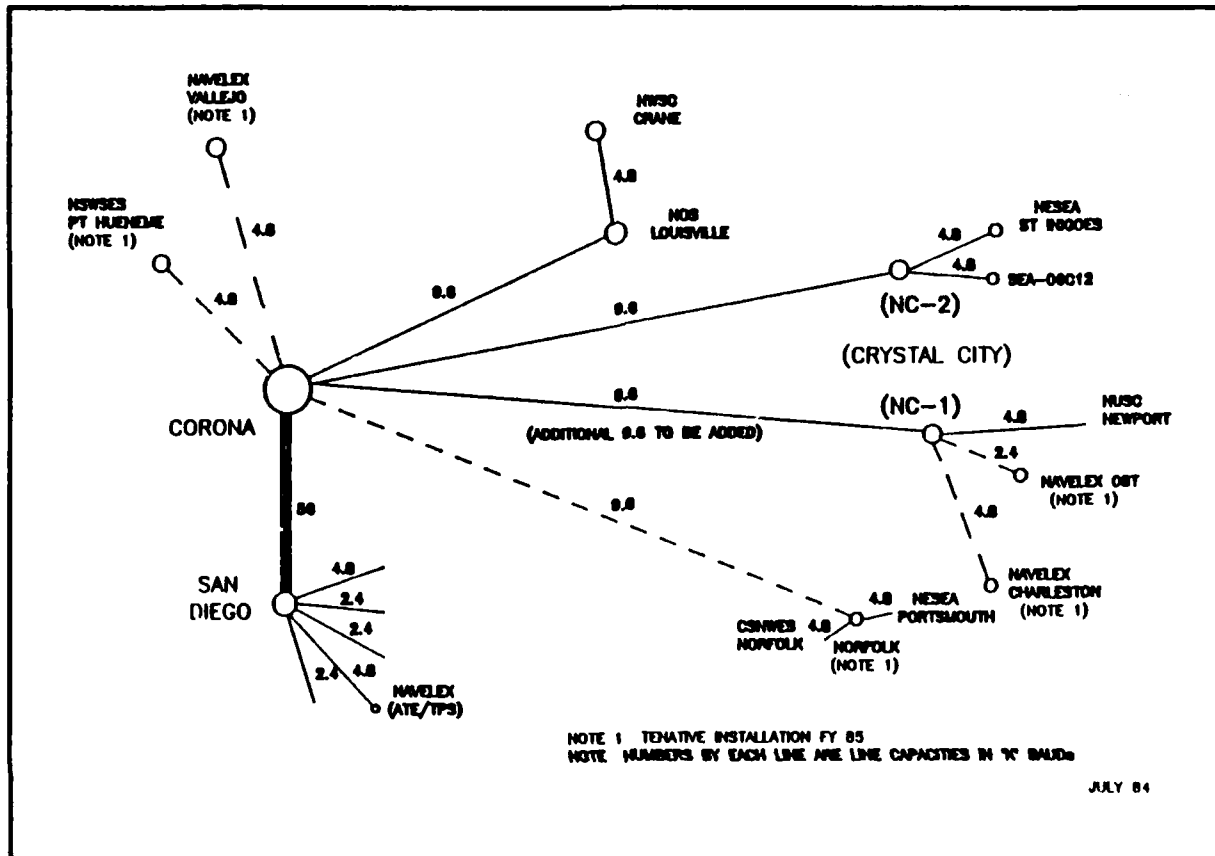
<sup>23</sup>Since 1973, Navy maintenance policy for electronics equipment has consisted of organizational replacement of modules/PCBs, with repairs (if not throwaway) allocated to intermediate or depot level on the basis of level-of-repair analysis. This policy resulted in a two-level maintenance concept, with PCB repairs at depot level.

TPSs for both fault detection and fault isolation at intermediate-level activities. Additionally, the cost effectiveness of testing at the organizational level was evaluated from 1981 to 1983 aboard DD-963 class destroyers, using the same ATE/TPSs planned for the intermediate level. This resulted in the decision to deploy ATE/TPSs aboard selected surface combatants for selected digital PCBs.

Between July 1981 and July 1984, 75 STEEP sites were established (51 shipboard, 24 ashore), with 100 AN/USM-465s procured and deployed and about 430 unique TPSs developed and installed (total density 10,500). In fiscal year 1985, STEEP sites are scheduled to increase to 110, AN/USM-465 inventory to several hundred (by end of fiscal year 1986 a total of 400), and unique TPSs to 1,200 (total density some 20,000), with an annual growth of 300 to 500 unique TPSs projected over the next 5 to 7 years. To manage and support the development and deployment of those TPSs, STEEP established an ATE/TPS Coordination Center to: (1) provide a central point of contact for all TPS users, (2) maintain ATE/TPS configuration and deployment status accounting, (3) duplicate TPSs for deployment, (4) process TPS trouble reports, (5) support TPS development and maintenance programming tools on-line via a communication network to TPS developers, and (6) provide management information. The Center is located at the Fleet Analysis Center, Corona, California, with computer facilities for deployment and configuration information (operational in fiscal year 1982) and for TPS maintenance/development tools (operational in fiscal year 1984). The communications network is illustrated in Figure 5-3. Some of the remote sites shown in that figure will not become operational until late fiscal year 1985.

The Center distributes quarterly to each ship the Catalog of Automatic Testing Capability for Electronic Modules/Printed Circuit Boards, identifying the prime equipment and the specific modules for which TPSs are currently available and the specific test sites involved. It also publishes the Master Test Program Set Index, listing the available TPSs by ATE type and weapons system. [While the AN/USM-465 was selected as the standard ATE for STEEP, other card testers had previously been procured by NAVELEX and NAVSEA in support of selected systems: this index lists TPSs available for four ATEs: AN/USM-465, three Phoenix 530 (3PX530), Bendix Herbie, and AN/USM-422.]

FIGURE 5-3. NAVSEA/NAVELEX ATE/TPS COORDINATION CENTER



SOURCE: NAVSEA/NAVELEX ATE/TPS Coordination Center, "Program Status Briefing" (Corona, California: Combat Systems Assessment Center, July 1984).

One of the TPS development tools that is supported by the Center is the Hierarchical Integrated Test Simulator (HITS), a new digital Automated Test Program Generator (ATPG) that was developed by the Naval Air Engineering Center with contractor support (Grumman Aerospace Corporation). HITS is planned as the standard Navy digital ATPG for the future; it provides more capability than previous ATPGs especially with regard to large- and very-large-scale integrated circuits.

Implementation of STEEP is providing the Fleet with a much needed maintenance capability. Although the program appears to be well planned and managed, initially it suffered from the

lack of coordination between NAVSEA and NAVELEX.<sup>24</sup> That problem was resolved, however, when NAVSEA and NAVELEX signed a 1984 memorandum of agreement, with NAVSEA acting as the consolidated management activity for shipboard ATE and both commands responsible for their own TPSs, using jointly developed standards and procedures. The Fleet still has not become familiar with the revised maintenance procedures of sending PCBs to designated intermediate-level test sites. In 1983, only 20 percent of Fleet units utilized that support for PCBs. Finally, the development and implementation of HITS has been a low-priority, limited-funding effort. According to experts in the testing community, the capabilities of HITS are modest compared to such proprietary ATPG systems as LASAR Version 6 (trademark of Teradyne, Inc.) in which hundreds of staff years have been invested. If the Navy has a justified need for its own ATPG, it will have to increase funding priority for enhancing HITS.

#### AIR FORCE INITIATIVES

The Air Force has undertaken several initiatives to improve management and support of test equipment, including:

- Improving management structure, policies, and procedures
- Establishing the Modular Automatic Test Equipment (MATE) program
- Establishing an ATE management information system
- Modernizing precision measurement equipment laboratory (PMEL) equipment
- Following-up the recently completed Support Equipment Acquisition Review Group Study.

#### Management Policies and Procedures

In the late 1960's, AFLC reorganized its management structure for the support of fielded weapons systems by establishing system manager and item manager functions at its Air Logistics Centers (ALCs). The item manager functions were assigned as follows:

- Warner Robins, Georgia: avionics and electronic warfare

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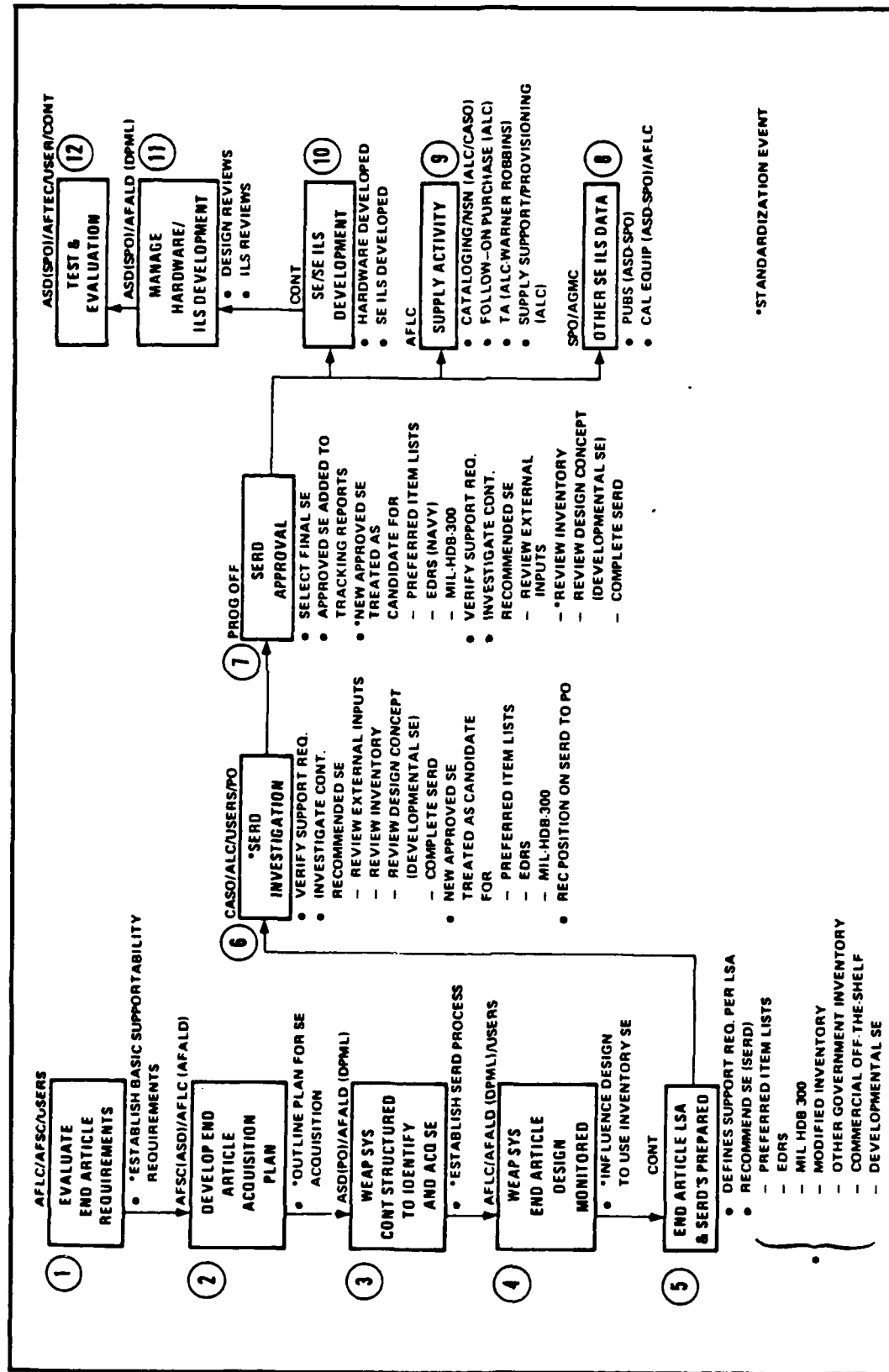
<sup>24</sup>See, for example: Naval Audit Service, Repair of Shipboard Electronics, Audit Report T 10582 (San Diego, California: Naval Audit Service, 17 November 1983) (U.S. Government Only).

- Oklahoma City, Oklahoma: engines
- Ogden, Utah: missile and munitions
- Sacramento, California: communications-electronics
- San Antonio, Texas: test equipment (general purpose)

During the 1970's, the Air Force attempted to improve its management of support equipment, especially ATE, because of problems encountered when program management responsibility for several major weapons systems (particularly, the F-111 and F-15 programs) was transferred from the materiel developer, AFSC, to the command responsible for life cycle support, AFLC. The result of that effort was the establishment, in 1982, of a new Deputy Chief of Staff for Acquisition Logistics, consolidating AFSC's management of acquisition logistics, product assurance, standardization, and computer resources, with the Directorate of Policy and Programs assuming responsibility for support equipment and automatic testing policy. AFLC established the single system manager for automatic test systems at San Antonio ALC (within the Directorate of Materiel Management).

The Air Force's support equipment acquisition process, as it existed in the early 1980's, is illustrated in Figure 5-4. Concurrent with the establishment of a system program office (SPO) by AFSC, AFLC designates the ALC to be the System Manager, and appoints a deputy program manager for logistics within the Air Force Acquisition Logistics Division, a field organization of AFLC, acting as AFLC's arm within AFSC. The deputy program manager for logistics heads the AFLC team working within the SPO. The SPO is also supported by the Support Equipment SPO with its personnel represented within the weapon SPO. The process depicted in Figure 5-4 is the Air Force's implementation of SISMS (see Chapter 4). The process emphasizes the need for contractors to screen MIL-HDBK-300, "Technical Information File of Support Equipment" (latest version 300M, dated 1 October 1982), which is maintained by the AFLC's Cataloging and Standardization Office, Battle Creek, Michigan. SERD review by the Air Force is extensive and involves not only the SPO and System Manager but also the AFLC support equipment managers (normally, San Antonio

FIGURE 5-4. AIR FORCE SUPPORT EQUIPMENT ACQUISITION PROCESS



SOURCE: Joint DARCOM/NMC/AFIC/AFSC Commanders Panel on Standardization of Aviation Ground Support Equipment, Final Report (Washington, D.C.: Joint Logistics Commanders, 28 June 1983).

ALC), the ALC responsible for depot-level repair, the Aerospace Guidance and Metrology Center, and the Cataloging and Standardization Office.

More recently, the Air Force enhanced the role of acquisition logistics and its potential for influencing weapons system design by reorganizing the Air Force Acquisition Logistics Division as a joint AFSC/AFLC organization designated the Air Force Acquisition Logistics Center. As we describe in a later subsection (see "Support Equipment Acquisition Review Group"), the Air Force is in the process of evaluating further improvements in management policies and procedures to improve weapons system support with a minimum of support equipment proliferation and better support.

#### MATE Program

Development and implementation of the MATE program is probably the most important and fundamental initiative undertaken by the Air Force in the area of ATE. Since the program has been well publicized, only the key aspects and the current implementation status are presented.

The MATE program was established in 1976 for the development of a systematic approach to the acquisition of ATE required by future weapons systems. The approach selected was designed to overcome the ATE problems experienced in the past: proliferation of test systems, inadequate fault detection and fault isolation, escalating acquisition costs, shorter life cycles, low system availability, technician experience drain, and a lack of corporate memory of lessons learned. The Concept/Validation phase was conducted from June 1978 to June 1981, with two competing contractors (Sperry Corporation and Westinghouse Corporation) developing a uniform ATE architecture with standard interfaces and "intelligent" (microprocessor-based) stimulus/measurement instruments. The product of this phase, then, was the following set of MATE guides providing the standards, specifications, and procedures for each contractor's concept:

- *Electronic Test Equipment Acquisition Guide*
- *MATE Development Guide*
- *Avionics Testability Design Guide*
- *Production and Operational Support Guide*
- *Test Program Set Acquisition Guide.*



In July 1981, the full-scale engineering development contract (\$55 million) was awarded to Sperry (the selection was primarily based on cost because the two concepts were similar). The contract required refinement of the MATE guides, development of the MATE data base system, and demonstration of MATE in two ways: (1) application of MATE concepts to the development of the intermediate automatic test system (IATS) for the A-10 inertial navigation system, with Sperry responsible for ATE integration; and (2) technical support to the Air Force for the development of the Depot Automatic Test System for Avionics (DATSA), replacing the obsolete general-purpose automatic test system, with the Air Force responsible for ATE integration. The IATS was delivered in August 1983, and a formal evaluation was completed in September 1984. The first DATSA was delivered in May 1984, with evaluation continuing through May 1985.

The IATS met the functional qualification test. The reliability and maintainability test, reportedly, indicated it did not meet the reliability goal (500 hours mean time between failures), but did meet the threshold (200 hours). The Air Force has exercised its option with Sperry to procure 27 IATS stations (nomenclature AN/GSM-294). San Antonio ALC is now developing a depot-level repair capability for IATS tester replaceable units (TRUs) and modules. The Air Force is also acquiring eight DATSA stations under contract with Emerson Electric (with an option for an additional four) for installation at all ALCs for repair of shop-replaceable units from 17 avionics subsystems of the F-111, C-141, F-4, F-105, and F-106 weapons systems.

The MATE program, apart from its importance to the Air Force, had a significant influence on the Army and Navy because it encouraged a more systematic management approach to the acquisition and support of ATE. Major portions of the MATE guides are under review for adoption as Joint Service guides under the JLC Panel on Automatic Testing (see Chapter 4). In fact, over 50 percent of that program's budget spent from 1978 through 1983 was related to MATE.

The Air Force's firm commitment to MATE is demonstrated by its publication of the implementing regulation in early 1984.<sup>25</sup> The regulation "applies to all AFSC and AFLC organizations that acquire, modify, replace, and support Air Force systems that need an automatic test system (ATS) for logistic support," but is not retroactive to programs that have completed contract award of the ATS as of the effective date of the regulation. The regulation includes the policy, organizational structure, waiver process, and authority required to make MATE the standard way of doing business for ATE acquisition. It implements the use of the detailed guides, control and support software, and automated tools (Life Cycle Cost Model, TPS Cost Predictor Model, Software Module Library, MATE Data System, and ATLAS test program evaluation tools) produced by the MATE program. It establishes the functions of the MATE System Policy/Control Office and those of the Technical Control Agents. It spells out responsibilities for updating the MATE System Baseline and the MATE Application Baseline. Finally, it directs the establishment of a MATE Operations Center, installed at San Antonio ALC, to perform MATE qualification testing for hardware and software modules and to provide access to the MATE automated management tools and training system. The Operations Center is also responsible for configuration control, maintenance, and distribution of MATE guides, specifications, standards, and other documentation.

The key factor in the successful implementation of MATE has been the cooperation of the test equipment industry and its interest in meeting MATE qualification standards. The suppliers of commercial test equipment had to commit themselves to very tight requirements in the DATSA program, permitting the Air Force to exercise a level of configuration control such that the commercial test equipment would be supportable over the life cycle of the ATE system. Industry participation in this program appears to demonstrate that a clear and well-reasoned program will receive a positive response from test equipment manufacturers. Some well-known, reputable manufacturers, however, have announced they will not participate in the MATE program because their standard

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<sup>25</sup>Air Force Systems Command and Air Force Logistics Command, "Policy for Modular Automatic Test Equipment (MATE)," AFSC/AFLC Regulation 800-23 (Washington, D.C.: Department of the Air Force, 25 January 1984).

commercial equipment does not meet MATE specifications and would be too costly to modify, given the lack of demand for such specialized equipment from the commercial sector.

The cost benefits of MATE are difficult to express. While the up-front costs, compared to traditional ATE acquisition, will be somewhat higher, life cycle costs have been estimated at 30 percent less. More important is that the availability and effectiveness of ATE can be expected to improve significantly through MATE implementation. On the other hand, the risk to the Air Force will be somewhat higher because it assumes integration responsibility for the test system. Past experiences in this regard have been negative,<sup>26</sup> but may be alleviated by the MATE guides and the new management structure for MATE application. Several of the current weapons systems in development or in major modification programs are not utilizing MATE either because of the high cost (e.g., B-1B program), because the MATE baseline missed the program window (e.g., F-15 and F-111 upgrade programs), or because of commonality (e.g., Peacekeeper).

The maintenance concept for MATE calls for on-station test instrument replacement at the lowest level of indenture, which normally is the entire TRU for commercial instruments, the shop-replaceable-unit level for military specified instruments.<sup>27</sup> The concept also states that commercial, noncore assets are returned to the depot or the manufacturer (commercial core assets are routed via PMEL). One would thus expect that the question of where to repair commercial instruments—depot or manufacturer—would be decided on a case-by-case basis, using traditional level of repair analysis. However, costs were not considered in selecting the Air Force's maintenance plan for the A-10 inertial navigation system IATS. By applying a standard "decision tree analysis" (in

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<sup>26</sup>For example, the Air Force was the integrator for the F-15 Tactical Electronic Warfare System (TEWS) Intermediate Test Equipment, referred to as TITE. The prime contractor developed the ATE, while associate contractors in the TEWS program developed the test requirements. The results were disappointing, with TPS run times for line-replaceable units up to 100 hours, requiring a total rework with the prime contractor as integrator. In contrast, the F-16 program used the prime contractor for development and integration of the F-16 Avionics Intermediate Shop, which was successful.

<sup>27</sup>See: J. Stout, D. Persans, and J. Caporale, "The Air Force Modular Automatic Test Equipment (MATE) Maintenance Concepts," AUTOTESTCON '83 (New York: The Institute of Electrical and Electronics Engineers, Inc., 1983), pp. 345-354.

accordance with AFLC Regulation 66-75), which does not consider any economic aspects, the ATE manager (San Antonio ALC) arrived at the recommendation for organic (depot) repair, and that is the approved maintenance plan today.<sup>28</sup>

#### ATE Management Information System

The Air Force is the only Military Service with an ATE management information system capable of providing information on what ATE is deployed, where it is deployed, and its utilization. (The Army and Navy are working on their information systems but do not plan to include any information on ATE utilization.) A brief description of the Air Force's system and its implementation status follows.

The need for an accurate and comprehensive informational data base was formally identified by AFLC in 1979. The "required system capability" and "data automation requirement" for an ATE management information system were submitted and approved in 1980. Development of the resulting Test Equipment Reporting and Management System was completed in 1981, and implementation began in mid-1982 at five operational air bases. The system consists of a centralized data base (maintained at San Antonio ALC) that is updated on-line from the participating air bases. The input data include ATE utilization records (station data, unit-under-test data, and test-run data); ATE status records (uptime/downtime, reason code, TRU, and shop-replaceable-unit data); station inventory records; and TRU inventory records. The system is designed to portray trends in ATE operational capability, operational time, test activity and results, and similar management-oriented information. The implementation of the system worldwide is awaiting reissuance of Air Force Regulation 65-110, which authorizes/directs operating commands to begin feeding input data to the system. Although AFLC has repeatedly requested that this regulation (or, originally, the planned Air Force Regulation 65-4) be issued, it has been deferred thus far because of reluctance to impose yet another reporting burden on the maintenance work force. However, much of the information needed

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<sup>28</sup>Richard L. Shepherd, "New Start/Decision Tree Analysis (DTA) for the A 10 Intermediate Automatic Test System (IATS)," 23 March 1984 (memorandum and supporting justification with attachments).

for a suitable management information system capability could be collected automatically, utilizing the ATE computer. It would be a straightforward exercise to add a software module to the ATE control software for the purpose of logging all ATE transactions, dumping the data on magnetic tape or disk, and mailing or transmitting the data to a central data bank.

San Antonio ALC is in the process of a phased enhancement of the Test Equipment Reporting and Management System to interface with several other systems, to provide major commands access to the system (currently, only the individual bases have access to it), and to include several software models. A total of \$4 million is programmed for this development effort. Ultimately, the system will evolve into an Air Force-wide reporting system with the installation of the "Core Automated Maintenance System" that is currently under development.

#### PMEL Equipment

The Air Force has 134 PMELs that use 8,000 measurement standards ("base standards") to calibrate some 900,000 items of test equipment of 55,000 different kinds (actually, some 100,000 of these 900,000 items are calibrated by base shops, not PMEL). In turn, the 8,000 base standards are calibrated against 215 Air Force standards maintained at the Air Force's Measurement Standards Laboratory, which is operated by the Aerospace Guidance and Metrology Center (AGMC), Newark, Ohio.<sup>29</sup>

In 1980, AGMC found that the PMELs had problems performing their assigned workload of test equipment calibration and repair and faced increasing backlogs and reliance on contractor support. In 1981, AGMC convened the first worldwide PMEL conference to determine the causes of those shortfalls and the actions required to correct them. It found that the four main problem areas were management, manning, training, and equipment. Following that conference, the Air Staff issued a Program Management Directive to develop solutions to these problems. From 1981 through

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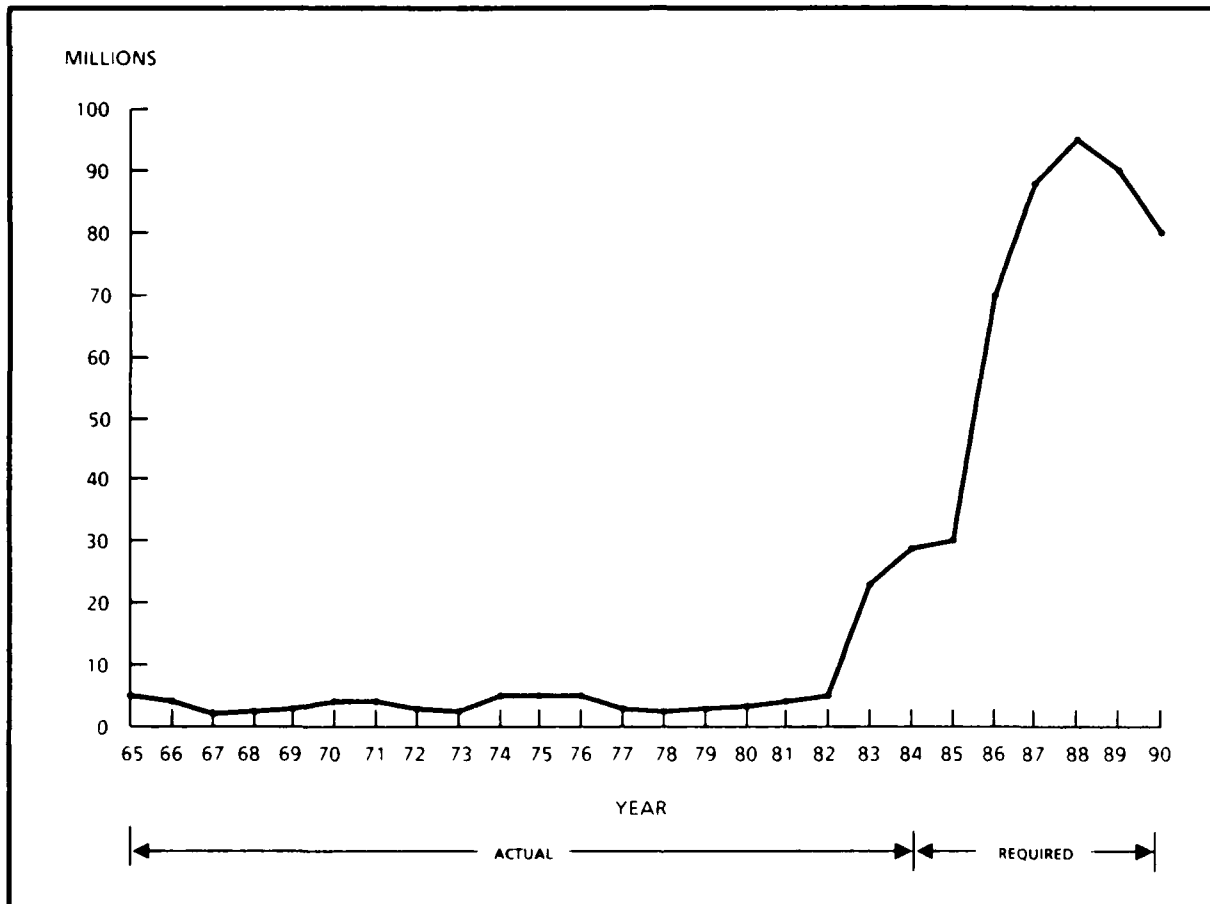
<sup>29</sup>Data from AGMC briefing, "PMEL and Sustainability," to the Deputy Chief of Staff, Logistics and Engineering, early 1984.

1984, several Air Force working groups developed a series of initiatives, most of which have been implemented, including the following:

- **Policies/Plans:** Additions were made to the War and Mobilization Plan, requiring planning for intermediate maintenance support of test equipment (previously, the assumption had been that the nearest PMEL could provide support, not recognizing that all PMELs are different). Base-level instructions were developed to identify PMEL requirements in Operations Plans and Support Agreements. A proposal (still under consideration) was developed to expand unit status reporting to include PMEL shortfalls. The semiannual PMEL report, submitted to the Air Staff, was expanded to include identified PMEL shortfalls by weapons system. Plans were prepared for improving deployed PMEL support through development of a "tactical PMEL," upgrading of transportable field calibration units, and adding PMEL support to the Combat Logistics Support Squadron's mission.
- **Equipment:** Most of the PMEL equipment was found to be obsolete because of inadequate funding in the past. A significant increase in funding for the Metrology and Calibration (METCAL) program was scheduled, including replacements of obsolete base standards, additives for new systems, and some research and development funding. The latter was necessary because the National Bureau of Standards no longer is funded to support DoD research and development requirements. Figure 5-5 illustrates the funding profile.
- **Procedures:** Procedures were developed to improve item management of PMEL standards and to reduce the amount of test equipment fielded without calibration requirements documentation. A PMEL customer complaint process was established. The PMEL Table of Allowance was reviewed (for the first time). AGMC-prepared calibration procedures were reorganized (reducing the PMEL calibration procedure library from 9,000 to 400 procedures) and rewritten (reducing technical order deficiency reports by 35 percent) and the procedure verification process was tightened. The process for distributing technical order corrections was improved (reducing response time from 6 months to 30 days), and plans were developed for the automation of procedure preparation and distribution.
- **Personnel/Training:** Proposals (still under consideration) were developed to improve retention and increase the experience level of PMEL personnel (in the early 1980's, about 63 percent of the PMEL work force had less than 4 years in service). A new PMEL manpower standard was developed and evaluated. An occupational analysis was conducted by the Occupational Measurement Center, and the results were reviewed to determine changes in the existing formal training course. Current plans are to develop a new, career-oriented training approach and to introduce new training technology in the PMEL school at Lowry Air Force Base, Denver, Colorado.

Another initiative, undertaken by AGMC, was the development of a better approach to calibrating ATE. Traditionally, the Air Force calibrated ATE in a similar fashion as ETE, i.e., TRUs were removed from the ATE at specified calibration intervals and sent to the appropriate PMEL for

FIGURE 5-5. AIR FORCE METCAL PROGRAM FUNDING



manual calibration. It was recognized that this "off-site calibration" of ATE has many disadvantages, including:

- ATE downtime is significant. The ATE is down anytime a TRU is removed; because the TRUs have their own calibration intervals and due dates, the ATE is seldom completely assembled.
- Programmable features cannot be exercised in calibration. As a result, timing and time-related problems are either masked or ignored, so that functional TRUs on the test bench may not work in the ATE.
- System performance is not checked. No compensation or allowance for cabling, loading, switching, or other sources of signal degradation between the TRU and the unit under test is possible. The result, again, is that functional TRUs on the test bench may not work in the ATE and vice versa.

- The TRUs are subject to damage in transit between ATE site and PMEL; frequent removal also causes unnecessary wear or damage of connectors.
- Calibration effort is wasted on unused features of the TRUs. Very few ATE applications use every feature of a commercial unit and even fewer use a feature to its full rated specification (accuracy) limits. For the same reason, unnecessary repair actions may be conducted on features not used by the ATE, increasing the turn-around time of TRUs.
- High levels of integration in modern ATE make off-site calibration difficult or impossible. Many measurement/stimulus functions previously performed by individual TRUs are now often implemented at the card level. Removal and calibration of those functions in the PMEL is difficult.
- The TRUs are not calibrated in their operational, physical, and electrical environment. The validity of off-site calibration is thus in doubt.

To overcome these shortcomings, AGMC developed an on-site calibration concept, the Portable Automatic Test Equipment Calibrator (PATEC), with the following features.

- Portable calibration standards are brought in protective cases to the ATE site.
- The ATE is calibrated as a total system, addressing only the required functions to required accuracies.
- Calibration is performed as close to the unit-under-test interface as possible.
- The calibration process is controlled by a program on the embedded computer in the ATE.
- Only a single calibration interval applies to the entire ATE station.
- A calibration interface test adapter is used when necessary to provide appropriate signal conditioning, but it does not contain active devices.
- PMEL personnel perform the ATE calibration with user (ATE operators) assistance and participation.
- Most PATEC standards are programmable, providing as totally automated a calibration procedure as possible.

The calibration interface test adapter, calibration program, and associated technical documentation are referred to as a calibration test program set (CTPS).

From 1976 through 1984, a total of 210 PATECs were bought (\$9 million for hardware), with about 180 installed or to be installed at PMELs and the remainder to be used for CTPS development by contractors for selected ATE. The new MATE stations (A-10 IATS and DATSA) are



among the ATE for which CTPSs are being developed. AGMC has developed briefings for ATE contractors and guidelines/Data Item Descriptions for the implementation of PATEC for new ATE. The benefits of PATEC, in removing the above-specified shortfalls of off-site calibration, are enormous. Neither the Army nor the Navy has adopted this concept.<sup>30</sup>

#### Support Equipment Acquisition Review Group

The Support Equipment Acquisition Review Group was established at the request of the Assistant Secretary of the Air Force (Research, Development, and Logistics) and formally chartered by the AFSC and AFLC Commanders in March 1984 to perform a study of the entire support equipment acquisition process. The study group was chaired by Major General Smith, Commander, Air Force Acquisition Logistics Center, with participants drawn from all major Air Force commands. The study was completed in June 1984 with briefings to the Air Force Secretariat; the final report was published in July 1984. That report identified 19 major problems in support equipment acquisition and made 107 recommendations to solve them (see Appendix, Table A-4 for summary). In assessing the operational impacts of the problems, it concluded that shortages in support equipment (estimated at a cumulative value of \$1.5 billion) do not impact peacetime mission accomplishment because of extensive work-around procedures. However, those shortages could potentially have

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<sup>30</sup>The Army's EQUATE is calibrated by replacing the built-in standards at specified intervals by calibrated spares on site, with the replaced standards calibrated off site. In the early 1970's, the Navy developed a modular, automated calibration concept for ETE, known as MECCA (Modularly Equipped and Configured Calibrators and Analyzers). It was designed as a portable and programmable calibration system to handle 80 percent of the general ETE calibration workload. It is now being adopted also for on-site calibration of new ATE. The fundamental distinction with PATEC is that MECCA has its own built-in microcomputer; PATEC has not, but uses the ATE computer.

mission impacts "if we are stressed, and particularly if we are stressed in more than one direction at the same time."<sup>31</sup>

Among the many recommendations offered by the study group, the five most important ones, according to a separate Air Force planning document,<sup>32</sup> are the following:

- Develop and maintain a master plan for support equipment
- Create a central support equipment broker/advocate
- Treat support equipment as any prime equipment program
- Include support equipment considerations in early program planning and trade studies
- Program the funding for common support equipment in the same way as for peculiar support equipment.

The study recommendations have been approved, in principle, by the Air Force Secretariat, and the Air Staff has instituted a tracking system to monitor their implementation. Some of the recommendations, such as the creation of a central support equipment "broker," have reportedly been deferred. Other recommendations, including the establishment of a separate program element for common support equipment and the development of an ATE replacement/modification roadmap (as a subset of the support equipment master plan), have already been implemented. Furthermore, a new policy for more effective management of fielded ATE is in final coordination (AFLC Regulation 66-37, "Management of Automated Test Systems").

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<sup>31</sup>Quoted from: Air Force Systems Command and Air Force Logistics Command, Support Equipment Acquisition Review Group: Final Report, July 1984. Note that the report defines support equipment as comprising two categories: TMDE and AGSE. TMDE is defined as comprising precision measurement equipment, ATS (ATE hardware, ATE software, TPSs), and special test equipment. It reports the support equipment inventory to consist of 65,614 line items (NSNs), over 2 million pieces of equipment, with a total cost of \$9 billion. This is, however, the centrally procured inventory, excluding another 20,000 line items locally procured (unknown cost, unknown counts). While the report does not provide a breakout between TMDE and AGSE, approximately 80 percent of cost and line items pertain to TMDE, and the quoted cost figures refer to hardware, not software such as TPSs.

<sup>32</sup>See: Thomas E. Wenzel, Avionics Master Plan, ASD-TR-85-5001 (Wright-Patterson Air Force Base, Ohio: Aeronautical Systems Division, December 1984). The 1985 edition of this annual planning document, prepared in accordance with Air Force Regulation 800-28 ("Air Force Policy On Avionics Acquisition and Support"), addresses for the first time such issues as standardization and avionics support equipment.

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MANAGEMENT OF ELECTRONIC TEST EQUIPMENT VOLUME 2  
PREVIOUS STUDIES AND INITIATIVES(U) LOGISTICS  
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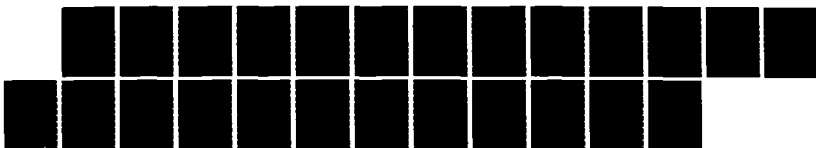
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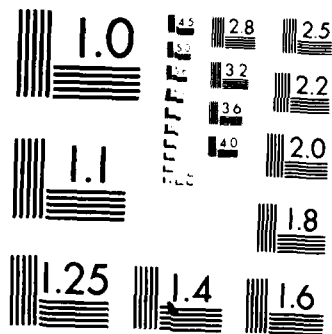
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APPENDIX  
SUMMARIES OF SELECTED STUDIES

This appendix summarizes the following reports in tabular format:

- Industry/Joint Services Automatic Test Project, Final Report, June 1980 (Table A-1).
- JLC [Joint Logistics Commanders] Panel On Automatic Testing, Subtask Descriptions, 30 September 1982 (Table A-2).
- Report of Industry Ad Hoc Automatic Test Equipment Project for the Navy, April 1977 (Table A-3).
- Major General Monroe T. Smith, Study Chairman, Support Equipment Acquisition Review Group Final Report, July 1984 (Table A-4).

The table entries are paraphrased from the originals, not verbatim quotes. Furthermore, the table entries are largely limited to those topics germane to test equipment management and support. A glossary of the terms used may be found at the end of the Appendix.

**TABLE A-1. SELECTED RECOMMENDATIONS FROM THE INDUSTRY/JOINT SERVICES  
AUTOMATIC TEST PROJECT**

AREA	ISSUE	RECOMMENDATION
Organizations/ People/Funding	<p>No single focal point is responsible for testability requirements and evaluation during weapons system acquisition, thus precluding effective implementation of testability.</p> <p>Lack of funding at the start of weapons system development for purposes of ATE research and development precludes system planning and tradeoffs for cost-effective systems support.</p> <p>Lack of development of advance metrology standards has caused universal problems with respect to traceability and repeatability that continue for years after a new technology is introduced.</p>	<p>Establish a central point of responsibility in each Military Service for testability achievement in weapons system acquisition.</p> <p>Provide ATE funding at the start of weapons system development.</p> <p>Encourage the Military Services' Metrology and Calibration Centers, in concert with the National Bureau of Standards, to provide leadership in support of emerging technologies.</p>
Equipment Design	<p>A serious communications problem exists with respect to testability because of the absence of universally accepted terminology.</p> <p>The proliferation of ATE, excessive support cost, and high ATE development and TPS costs can be traced to poor management of the ATE acquisition process without consideration for multiweapons system support.</p> <p>The use of commercial test equipment is increased by Government directives but cost-effective application of this equipment is contingent upon adequate technical documentation, configuration management, and environmental specifications.</p>	<p>Develop a military standard on definition of testability terms.</p> <p>Promulgate a Joint Service ATE Acquisition Guide that embodies specific changes in the ATE acquisition process as identified in the Addendum (see page A-11).</p> <p>Make specific provisions for supportability when using commercial equipment</p>
Specifications/ Directives	<p>Current ATE procurement practices recognize the existence of an industry ATE/Instrument Interface Specification, but the frequent use of alternative or additional control and data interfaces adds to the proliferation of both hardware and software associated with similar ATE requirements within the DoD.</p> <p>Current design approaches for ATE switching systems tend to be customized to a particular application such that modularity is more the result of packaging considerations than the intentional outcome of standard functional modularity</p> <p>CDRL data items supportive of MIL-STD-1388 are redundant and duplicative between items and between the Military Services.</p> <p>No true TRD standard exists. Each UUT contract imposes some tailored version of MIL-STD-1519 so uniquely applicable to one contract that, in fact, a new specification is written for every contract.</p>	<p>Adopt a DoD-wide ATE/Instrument Interface Specification for future procurements, modeled on the current IEEE Standard 488, but updated to reflect the collective input from the DoD ATE community.</p> <p>Adopt a DoD-wide Interface and Path Switching Modularity Specification incorporating those elements deemed necessary based on a DoD-funded study.</p> <p>Standardize CDRL data items across the Military Services to be compatible with the MIL-STD-1388 engineering process.</p> <p>Develop a common, Joint Service standard for the TRD.</p>



TABLE A-1. SELECTED RECOMMENDATIONS FROM THE INDUSTRY/JOINT SERVICES  
AUTOMATIC TEST PROJECT (CONTINUED)

AREA	ISSUE	RECOMMENDATION
<p>Specifications / Directives (Continued)</p>	<p>No uniform methodology is employed in the acquisition of ATE software incident to the acquisition of ATE. Application of various existing standards regarding performance requirements, quality assurance, and configuration management is largely judgmental.</p> <p>Repeated formal updates of ATE data items, including TRDs and TPSs, to maintain compatibility with UUT configurations, generate significant costs.</p> <p>The marginal quality of technical publications creates problems at all intermediate-level shops.</p> <p>Most ATE application software exhibits serious shortcomings: (1) TPSs do not fault-isolate to a single SRU, take too long to run, and do not distinguish between UUT, ID, and ATE failures; (2) ATE self-test is incomplete, unreliable, and takes too long to run; (3) IDs are subject to failure and cannot be checked; (4) too many different languages are in use, including 71 different versions of ATLAS, with few usable on other ATE; and (5) the program test philosophy lacks consistency.</p>	<p>Develop a military standard defining the elements of ATE software and establishing documentation guidelines to support requirements definition, quality assurance, configuration management, and user operation and maintenance.</p> <p>Defer ATE data item delivery until weapons system design has matured and stabilized.</p> <p>Improve content and format of technical publications for the ATE operator, UUT troubleshooter, diagnostician, and ATE repairman through additional schematics, detailed troubleshooting information, and better formats. Many of today's ATE shortcomings could be overcome by on-site users if they were given adequate information.</p> <p>Procure test software with specific fault-isolation requirements and verification provisions prior to fielding. Provide ATE with the capability to fault-isolate to the UUT, ID, or ATE. Provide intermediate-level shops with capabilities to write/modify TPSs subject to local supervision and nonalterable Master Programs. Standardize on one ATE language and impose it on all future procurements.</p>
<p>TPS Development and Management</p>	<p>In the absence of accurate mathematical models of analog devices, analog ATPGs will remain infeasible or inadequate.</p> <p>Experience with digital ATPGs has shown that cost-effective operation depends on certain features that have not been available in the past.</p> <p>Adequate data on analog faults are not being collected, leading to a fruitless debate over the necessity of detecting/isolating soft faults and disregard of soft faults in developing analog ATPGs. Soft faults are frequently the cause of hard failures of the next level of assembly.</p> <p>With increasing IC density, the complexity of circuit cards will outstrip the capability of gate-level ATPG simulators and the cost of test generation will become prohibitive.</p>	<p>Fund the development and demonstration of several analog ATPG systems using concepts that have shown promise in theoretical studies.</p> <p>Adopt ATPG guidelines specifying that: (1) the ATPG system employ a dedicated general-purpose computer, (2) the ATPG system be interactive, (3) the simulator be under control of the operator, (4) logic UUT diagrams be an optional output, and (5) a combination of fault-dictionary and guided-probe methods for fault-isolation be available.</p> <p>Collect statistical data on hard and soft faults in analog equipment. Ensure that analog ATPGs are designed to detect/isolate hard faults in the presence of soft faults.</p> <p>Adopt digital ATPG simulators that utilize both functional and gate-level models to extend their capability for economical test generation to LSI and VLSI assemblies.</p>

TABLE A-1. SELECTED RECOMMENDATIONS FROM THE INDUSTRY/JOINT SERVICES  
AUTOMATIC TEST PROJECT (CONTINUED)

AREA	ISSUE	RECOMMENDATION
<p>TPS Development and Management (Continued)</p>	<p>TPSs have not lived up to expectations, often as a result of discovering what can be afforded at a late point in the total system development effort. Both TPS development and maintenance costs have been underestimated.</p> <p>Many TPSs, although they perform adequately in the laboratory, do not work in the user environment because of poor quality.</p> <p>The definition of what constitutes a TPS varies among designers, suppliers, buyers, and users. As a result, the TPS invariably lacks the support and maintenance data necessary to allow the user to make necessary TPS modifications.</p> <p>The lack of proper standards have resulted in a high risk being associated with TPS contracts so that contractors pad their bids. Another cause of excessive cost is the lack of an orderly planned approach to TPS development building on past experience or results.</p>	<p>Establish TPS definition, development requirements, schedule, required funding, and life cycle cost during the Concept Formulation phase of weapons system development.</p> <p>Issue a Joint Service TPS Style/Design Guide addressing TPS quality aspects in the user environment (information flow to operator, non-UT failures, multiple-failure conditions, etc.)</p> <p>Issue a Joint Service standard defining what constitutes a TPS. It should encompass: object code media; interface device; test program instruction; and supporting data including UUT/interface signal identification, source program listing, program flowchart, program description, and UUT schematics.</p> <p>Issue the Joint Service TPS Development Planning Guide, emphasizing a phased task approach with timely design reviews, quality assurance provisions during development, and configuration management aspects during development and fielding</p>
<p>ATE</p>	<p>The lack of a coordinated family of ATE for use on multiple weapons systems results in proliferation of specialized equipment. Without standardizing software and architecture, ATE technology will be moving in many different directions, precluding "technology transparency" of future ATE</p> <p>Current ATE systems lack uniformity in language, control, display arrangements, operator messages, and procedures as a result of inadequate hardware/software guidelines</p> <p>Current ATE systems accomplish one task at a time, with the control computer and its peripherals idle most of the time. Design for multioperational functions would increase ATE cost effectiveness</p> <p>No industry standards exist to guide the suppliers of ATE interfaces in the design and use of a programmable interface pin (i.e., a UUT interface pin capable of being switched, under program control, to more than one stimulus signal or measurement input)</p>	<p>Fund the existing military programs aimed at establishing standard families of ATE (MATE, IFTE, and CSS) but ensure that these programs are coordinated and that interface and software issues are emphasized.</p> <p>Determine common user information, display, and control requirements, and develop hardware/software guidelines to facilitate standardized ATE control and display arrangements</p> <p>Develop ATE hardware/software design guidelines necessary for multioperational interfaces using distributed processing systems architectures</p> <p>Conduct a DoD funded trade study to determine applicability of inherent features of a universal interface pin to the different maintenance levels</p>



TABLE A-1. SELECTED RECOMMENDATIONS FROM THE INDUSTRY/JOINT SERVICES  
AUTOMATIC TEST PROJECT (CONTINUED)

AREA	ISSUE	RECOMMENDATION
ATE (Continued)	<p>Much confusion exists on subjects related to measurements, calibration, and metrology. The problem is common to industry and Government, is of domestic and international scope, and is the cause of misdirection, fragmented responsibilities, ineffective use of measurement resources, and general inefficiency in metrology and calibration for ATE.</p>	<p>Support the NBS in development of a series of common industry/Government guides for measurement and calibration: (1) terms and definitions, (2) specification criteria for generic types of test equipment, and (3) other areas.</p>
New Technology	<p>No centralized technology forecasting and assessment activity oriented to DoD needs presently exists. Consequently, industry does not know which technologies will be most important to the DoD, when they will be needed, or what impacts they will have. As a result, costly "shotgun" approaches are used in developing new technologies and their applications.</p> <p>Techniques and facilities used to test, align, and handle weapons systems and their components are usually not operationally suitable at field-maintenance levels. Technology trends point toward higher maintenance skill level requirements, less maintainable systems except in laboratory environments, more equipment damage in the field, and more personnel injuries.</p> <p>New technologies can solve current problems as well as cause future problems. Barriers between technological fields are inhibiting effective applications of new technology to ATE. ATE implementers are generally not technology innovators, but rather appliers of available technology.</p> <p>Inadequate interface techniques and test instrumentation limit the performance, reliability, and testability aspects of new technology implementations.</p> <p>IEEE Standard 488 (1975) represents an excellent basis for a DoD ATE/Instrument Interface specification, but current trends toward distributed systems raise fundamental questions regarding data rate and data word size.</p>	<p>Establish a centralized Technology Forecasting and Assessment Activity for research and development.</p> <p>Sponsor research and development programs to develop effective techniques and facilities that satisfy the sensor alignment, handling, and test requirements resulting from new technology. Program objectives are to produce fieldable test and alignment equipment; to develop better design approaches for protecting equipment and personnel; and to improve operational availability through better testability and BIT design.</p> <p>Establish a DoD/Industry ATE Technology Advisory Group to coordinate ATE testing technology projects and to promote implementation of innovative ATE technology (in analogy to the DoD/Industry Manufacturing Technology Advisory Group).</p> <p>Undertake a research and development program to develop system interface and instrumentation techniques for exploiting new technology applications.</p> <p>Initiate study program to determine need for an update to IEEE Standard 488, as applied to DoD ATE/instrument interfaces.</p>
System Software	<p>ATE system software development is complex and requires other management and technical approaches than used for other DoD software. Attempts to reduce ATE software costs fail to deal with the underlying causal factors</p>	<p>Adopt a clear, formal, and rigorous definition of the ATE system software life cycle.</p>

TABLE A-1. SELECTED RECOMMENDATIONS FROM THE INDUSTRY/JOINT SERVICES  
AUTOMATIC TEST PROJECT (CONTINUED)

AREA	ISSUE	RECOMMENDATION
<p>System Software (Continued)</p>	<p>ATE system software development, control, and maintenance has been, and will continue to be, a labor-intensive process. Automated support tools are technically feasible, but development of rehostable tools has been inhibited by the lack of universally acceptable system programming languages.</p> <p>ATE system software is currently provided in many different languages, reducing the opportunity for rehostability and increasing the maintenance demands on the eventual system user. The application of standard high-order languages to ATE system software is far behind that in the EDP environment.</p> <p>There is no consistent set of software quality assurance objectives, policies, or procedures available today. MIL-S-52779, "Software QA Program Requirements," is not generally applied to ATE software.</p> <p>Certain components of ATE system software and tools for software development could be standardized as Government-furnished software to reduce costs without stifling creativity, but the tradeoffs are unknown. Widely used tools, such as ATPGs, are promising candidates for Government-furnished software.</p> <p>There are no tools or guidelines for measuring or projecting ATE system software development and application costs, which precludes effective program planning.</p> <p>Lack of a DoD-approved industry-managed standard test language has resulted in a Military Service disagreement about course of action and precluded industry investment pending clear DoD direction. The uncontrolled language proliferation has caused user hardship and unnecessary cost escalation.</p> <p>Standardization of ATE system and support software should be in terms of interfaces, not products, as the latter results in proliferation, lack of competition, and technological obsolescence. If the Military Services continue to "standardize" (formally or de facto) on products, this would effectively compromise the entire language standardization effort.</p> <p>ATLAS has been developed as a voluntary industry standard over the past 12 years. Rapid advancements in prime equipment technology, the normal lag in support</p>	<p>Reexamine DoD software acquisition policies with respect to both the formal process and the use of standard high-order languages. Promulgate guidelines for development, configuration management, and maintenance of ATE system software.</p> <p>Limit the choices for high-order languages used to implement ATE system software.</p> <p>Develop and apply guidelines and standards for ATE system software quality assurance and quality management.</p> <p>Define and establish a basis on which to evaluate the cost-effectiveness of Government-funded development of potentially large-use ATE system software tools or components.</p> <p>Develop tools and guidelines for ATE system software cost measurement and prediction.</p> <p>Adopt IEEE ATLAS as the standard DoD-wide test language, with evolutionary development of the standard managed by a formal industry standards organization (not the DoD), and optional use of specific subsets of the standard for specific areas of testing.</p> <p>The DoD should not adopt a standard test language compiler but focus its standardization efforts on interfaces, with the highest payoff estimated to be in standardizing commands, protocol, and system messages related to the operator/ATE interface.</p> <p>Participate in the correction of known deficiencies in the existing ATLAS standard documentation (IEEE 416). Continue to support research and development in test</p>

**TABLE A-1. SELECTED RECOMMENDATIONS FROM THE INDUSTRY/JOINT SERVICES  
AUTOMATIC TEST PROJECT (CONTINUED)**

AREA	ISSUE	RECOMMENDATION
System Software (Continued)	technology, and the voluntary nature of the ATLAS standard group have created a gap between what is needed and what currently exists.	languages to explore new testing areas, to improve the test programming features of ATLAS, and to track ongoing technical innovations.
Metrology and Calibration	<p>Calibration of analog test equipment is a time-consuming process requiring highly skilled personnel. Application of automatic microprocessor control can reduce the time and skill requirements.</p> <p>Very few ATE systems have been specified as a composite unit with capabilities defined at a common reference point, accounting for derating due to unit response/settling time or for enhancement created by arbitrary accuracy compensation software correction factors. Standard criteria and discipline do not exist. Significant problems exist with specification criteria for time-dependent parameters, measurement techniques, and measurement standards to support needed measurement accuracies.</p> <p>One element to be defined early in ILS planning is the calibration concept/plan for organizational-, intermediate-, and depot-level test equipment, including the calibration of the calibration standards themselves for the life cycle of the system. This element of ILS has frequently been ignored resulting in (1) continued support problems relative to calibration requirements at all maintenance levels, (2) mismatches in technology applications, and (3) support tasks for which no funds have been programmed.</p> <p>Industry and Government do not have a system for effecting coordinated efforts in support of measurement technology in a timely, efficient, and inclusive fashion. NBS attention has been diverted to consumer and safety affairs and away from metrology over the past 10 years. NBS commitment is necessary to recover and restore the situation to what it should be.</p>	<p>Explore expanded use of microprocessors in calibration of test equipment, including analog sensors, and develop a design guide for automatic calibration.</p> <p>Assess existing and develop new universal criteria and discipline to ensure that ATE testing capability be defined by a system performance specification at the UUT interface connectors and be characterized dynamically as a function of time, including the contribution of software to capability enhancement. Support NBS in the development of measurement standards and techniques as required for improved accuracies.</p> <p>Authorize and require the Metrology and Calibration Centers to participate in the LSA process during early ATE definition and support planning.</p> <p>Accelerate support to the NBS in taking a more active leadership role in the measurement technology field to be responsible for:</p> <ul style="list-style-type: none"> <li>• Technical assessment and standardization of METCAL terminology, definitions, specification criteria, and verification techniques for generic types of test equipment</li> <li>• Establishment and documentation of the highest</li> <li>• Attainable measurement capabilities in NBS for every measurement parameter</li> <li>• Identification and development of required measurement capabilities exceeding the existing ones.</li> </ul>

TABLE A-1 SELECTED RECOMMENDATIONS FROM THE INDUSTRY/JOINT SERVICES  
AUTOMATIC TEST PROJECT (CONTINUED)

AREA	ISSUE	RECOMMENDATION
<p>Metrology and Calibration (Continued)</p>	<p>The traditional measurement policy stipulates achievement of a minimum accuracy ratio (typically, 4:1) between each step in the chain from prime product measurement to the highest order standard in combination with worst-case tolerancing at each step to establish a high confidence factor of measurement integrity. A higher accuracy ratio generally implies a higher equipment cost for an assumed but unquantified gain in measurement integrity. This traditional policy has no technical basis. If an adequate and predictable confidence factor could be achieved with lower accuracy ratios (i.e., cheaper equipment), immediate benefits would result in supporting existing and in planning for new equipment.</p>	<p>Conduct a coordinated study with NBS, industry, and Government participants to assess the fundamental measurement criteria of tolerancing and accuracy ratio techniques, including alternatives to existing policy such as "statistical tolerancing and accuracy ratio budgeting," relative to establishing realistic prime equipment specifications, supporting ATE capability requirements, and the resulting calibration specifications. Promulgate study results in the form of guides for use by industry and Government to assure proper application of the most cost-effective calibration approach.</p>
<p>Maintenance Shop Productivity</p>	<p>A common support problem, when different test equipments are used at the different maintenance levels, is the prevalence of test inconsistencies. This leads to prolonged back-and-forth movement of prime assemblies through maintenance pipelines, increased costs for additional prime equipment spares, and reduced weapons system availability. Resolving the problem frequently requires the fielding of duplicate factory test equipment at intermediate shops. A better solution is the concept of vertical commonality that provides for common test equipment, software, and procedures at intermediate, depot, and factory levels to ensure test consistency.</p> <p>The highest-rated problem in field surveys is the inadequate skill levels of ATE operators and maintenance personnel due to inadequate training, inadequate selection, higher turnover, motivational problems, and very low retention.</p> <p>Management control in the ATE shop is hindered by the lack of real time status, priority, production, manning, inventory, performance measurement, and other data needed for efficient operation of the shop. Various management control systems are in use, but they are manual, causing excessive</p>	<p>Revise DoD policy documents and standards relative to maintenance planning and ATE acquisition to include the concept of vertical commonality in weapons system support across all maintenance echelons as a recommended approach.</p> <p>Institute a proper personnel and training system for ATE personnel, including selection on the basis of ATE-related aptitudes; training in accordance with present ATE capabilities, maintenance philosophy, and task requirements; controlling their assignments to ATE organizations; reducing non-ATE related job diversions; providing retention incentives such as professional pay and assignment preferences; and ensuring career-level training for ATE supervisors.</p> <p>Develop and implement a standardized real-time management information system for all large ATE shops. The system should collect UUT and ATE status tracking data, using the available ATE computer peripherals, and generate the following management information: throughput, backlog, NORS</p>

TABLE A-1. SELECTED RECOMMENDATIONS FROM THE INDUSTRY/JOINT SERVICES  
AUTOMATIC TEST PROJECT (CONTINUED)

AREA	ISSUE	RECOMMENDATION
<p>Maintenance Shop Productivity (Continued)</p>	<p>paperwork associated with status tracking. There are no consistent measures of ATE shop performance.</p> <p>Facilities (both ships and buildings) that house ATE systems are often undersized because of poor planning causing inefficient operations. Another problem in most installations surveyed is a lack of adequate, properly regulated and filtered electric power, exclusively available to the ATE. These conditions result in loss of maintenance time, inaccurate test results, and sometimes equipment damage.</p> <p>Maintenance performance in ATE shops is highly inefficient. The causes include: (1) insufficient quantities of spares are provided for prime equipment and for the ATE itself; (2) spare modules and piece parts received through the supply system frequently are not equivalent in form-fit-function to original parts; (3) responsibility for supply support is not controlled or managed by the ATE shop manager causing delays in obtaining replacement parts; and (4) storage of spare parts for prime equipment and ATE is often remote from the repair work center causing loss of repair time.</p> <p>Existing ATE has too many shortcomings including the following: (1) too much ATE proliferation, often in the form of large, single-ported stations; (2) too many IDs that are too complex, take too long to connect, are not people proof, are subject to hookup errors, and come with bulky cables and fixtures that often prevent access to ID or UUT adjustment; (3) station calibration is a nightmare, taking much longer than planned, frequently resulting in building blocks that will not work when reinserted after off-station calibration, and degrading shop throughput capability; (4) ATE is too dependent on a controlled environment and stable power inconsistent with the operational environment; and (5) ATE is too noisy, requiring the use of noise muffs or acoustic curtains and frequently resulting in premature fatigue, nausea, and decreased efficiency of ATE personnel.</p>	<p>and NORM rates of supported systems, productivity, ATE availability, and ATE utilization rate.</p> <p>Facilities planning for ATE should include space requirements for all ATE system components, and a source of dedicated power of good quality.</p> <p>Establish a single manager for both the end item and the spares/piece parts to support it, including those for the supporting ATE.</p> <p>Encourage procuring agencies to allow maximum use of COTS parts for ATE. Place intermediate-level supply support for ATE under the authority of the intermediate-level ATE manager. Colocate repair parts for ATE and for weapons system LRUs/WRA's in the same physical area close to the repair work center.</p> <p>Control types and features of ATE hardware, starting with the procurement of a family of small, generic ATE (digital, RF, servo, etc.), and impose compatibility requirements on future weapons system acquisitions. Standardize the physical ATE interface to the ID, standardize UUT connector families, and include minimization of the numbers and complexity of IDs as formal evaluation criteria in acquisition.</p> <p>Insist that future ATE be self-calibrating, except for primary standards; with respect to existing ATE, provide more spares for calibrating components and calibration in place, where possible. Require that ATE operate on normal line power and be impervious to damage by voltage transients and spikes; and that operating temperatures be consistent with intermediate-level environmental conditions without external support (cooling).</p> <p>Consider noise abatement when procuring ATE by including maximum allowable acoustic noise in procurement specifications.</p>

## ADDENDUM TO TABLE A-1

### SPECIFIC CHANGES IN THE ATE ACQUISITION PROCESS TO BE IMPLEMENTED VIA A JOINT SERVICE ATE ACQUISITION GUIDE

The next-generation family of ATE needs to be defined via a well-managed acquisition process and not driven by ATE technology alone as has happened in the past. Specifically, the Military Services need to implement a formal process for ATE acquisition, with checkpoints and measures to ensure that the process has been followed. The following six major areas have an impact on the ATE acquisition process and the associated suggestions are offered for implementation through a *Joint Service Acquisition Guide for Automatic Test Equipment*.

#### DATA REQUIREMENTS/TECHNOLOGY CENTERS

The data requirements that are essential to successful acquisition fall into two categories: data required from the prime system designer and historical data required to exercise the tradeoff tools used by management in the decision process. The following documented results of Logistic Support Analysis (LSA) and Test Requirements Analysis (TRA) should be provided by the prime contractor:

- Test objectives and test functions
- Level of repair: on-line and off-line (BIT tradeoffs)
- Maintenance sites and site-workload calculations from reliability data
- Source documentation suitable for programming (TRD)

Historical data are required to support the tradeoff tools used in the acquisition process. These data should be stored in technology centers on a Joint Service basis, making maximum use of existing data systems. The data systems should be broken into ATE characteristics, logistic data, and advanced testing technology data, with appropriate linkage between the three.

Application software will become a major military asset and should be integrated by the Military Services at "software centers," with configuration management and control as well as test program generation functions included.

### UTILIZATION OF EXISTING STATE-OF-THE-ART CAPABILITY

The acquisition process should call out as a recommended approach the evaluation of inventory test systems and subsystems prior to procurement of new or modified systems. The test system inventory should include commercial systems for those applications for which militarized capability is not required at the site in question. As new systems and subsystems are developed, they should be added to the inventory and their characteristics entered into the data bank to encourage multiweapons system as well as Joint Service utilization of this capability. The test equipment inventory that has been initiated by the Military Services should be extended to include inventory of test program sets.

### IMPLEMENTATION OF SELECTED STANDARDS

Any new or modified test systems needed must be procured with a "standard subset of specifications" determined by the Government. This process will promote lower life cycle ATE cost while not impairing technical progress. (The ATLAS standard language is the first such specification agreed to by DoD components.) Other possible future specifications may include standard computer/instrument bus interfaces, and standard stimuli or measurement devices for such stable technology areas as power sources, standard input/output controls, and displays.

### SITE WORKLOAD ANALYSIS REQUIREMENT

This process requires that no ATE system be procured without a level of repair analysis pointing out the maintenance level and site at which the ATE will be utilized. Further, for each site for which ATE is proposed for a particular weapons system and/or equipment, a "site workload analysis" must be performed. In addition, wherever a site supports multiple weapons systems and/or equipment, the workload analysis should include all workload at that site and utilization of existing ATE at that site. To enhance throughput, the use of large systems for simple tasks should be avoided whenever possible.

The complexity of the test system is directly related to the diversity of the units to be tested; therefore, partitioning workload to minimize test system complexity and maximize throughput should be a goal of the workload analysis. As an additional requirement of site workload analysis, a

phaseout plan for obsolete equipment should be developed, including test program set translation, redevelopment, or discard.

#### TESTABILITY AND ATE TECHNOLOGY DEFICIENCY DOCUMENTATION AND FEEDBACK

It should also be required that, as a result of the above analyses, two specific deficiency reports be generated. The first should be addressed to testability problems in the prime system design and the second should point out technology deficiencies in state-of-the-art ATE. The technology deficiencies will provide inputs to advanced testing technology programs so that all ATE procured for production programs is limited to off-the-shelf technology.

#### ATE SUPPORT PLANNING REQUIREMENT

Finally, the process should require that, a complete ILS plan for the proposed ATE be developed. The ATE/ILS plan should consider the specific resource constraints (e.g., supply, personnel, space) at each site and be emphasized in all procurements and tailored to that application. ATE self-test should be emphasized in all procurements. Wherever practical, self-test should include extended versions suitable for calibration analysis.



**TABLE A-2. SUMMARY TASK DESCRIPTION OF JLC PANEL ON AUTOMATIC TESTING  
(MANAGEMENT AND ACQUISITION SUPPORT AREAS)**

TITLE	DESCRIPTION	SCHEDULE <sup>1</sup>
<b><u>MANAGEMENT</u></b>		
Document Review	Review of existing directives, instructions, regulations, and standards and development of recommended changes for a single DoD document package for automatic testing (AT) considerations in weapons system acquisition.	2Q81C
Document Changes	Military Service review and implementation of needed changes on the basis of the document review, including coordination via DMSSO	2Q82C
Warranty Incentives	Evaluation of incentives or warranties in AT acquisition and development of associated policies/procedures for incorporation in the DoD document package.	3Q80C
Fly Before-Buy/Fly-Off	Development of policies/procedures for implementing "fly-before-buy" and "fly-off" concepts in AT acquisition and incorporation of recommended process in the Joint AT Acquisition Guide.	2Q81C
ATE Workload Management	Development of computer-based ATE shop management procedures.	2Q85
DID List	Compilation and publication of essential documentation requirements to be procured with AT systems.	3Q84
DID List	Development and publication of DID Guide for AT acquisition.	4Q84
Corporate Memory	Identification of individual Military Service organizations responsible for "corporate memory" in AT and development of Military Service agreements for exchange of information.	3Q81C
Corporate Memory	Evaluation of current Military Service approaches to the development, maintenance, and utilization of "corporate memory" and identification of possible improvements.	2Q83
Computer Acquisition Interfaces	Development of a coordinated ATE computer acquisition policy, resolving the conflicting regulations regarding weapons system/ATE/ADPE computers, and coordination of recommendations with the Joint Technical Coordinating Group on Computer Resources Management.	4Q80C

<sup>1</sup>Actual ("C") or scheduled task completion; "+" if continuing task.



TABLE A-2. SUMMARY TASK DESCRIPTION OF JLC PANEL ON AUTOMATIC TESTING (MANAGEMENT AND ACQUISITION SUPPORT AREAS) (CONTINUED)

TITLE	DESCRIPTION	SCHEDULE <sup>1</sup>
AT Coordination	Coordination between the JLC AT Program and the NSIA AT Project.	4Q85
Program Benefits	Assessment of benefits/effectiveness of the JLC AT Program.	4Q82
<b><u>ACQUISITION SUPPORT</u></b>		
Terminology	Compilation and revision of Joint Service terminology standard, MIL-STD-1309C.	4Q83
AT Information Exchange	Examination of existing ATE information systems and publication of Reference Guide, including Military Service Focal Points, DID Listing (see above), and Corporate Memory Structure listing (see above).	4Q83
AT Newsletter	Publication of AT Newsletter to improve communication among the AT community	Quarterly
BIT Design Guide	Development and publication of a Joint Service BIT Design Guide, using the Navy's updated guide as a baseline.	3Q82C
Testability Guide (Electronic)	Development and periodic updating of a Joint Service Electronic Systems Testability Guide, using the MATE Testability Design Guide and the RADC Testability Notebook as baseline documents.	2Q85
Testability Guide (Nonelectronic)	Development and publication of a Joint Service Nonelectronic Systems Testability Guide	3Q86
Testability Specification	Development and publication of a MILSPEC describing numerical testability parameters and interfaces required in electronic system design.	2Q84
Testability Design Review	Development of a design review checklist permitting a technical audit of compliance with testability requirements and incorporation of checklist/procedures in MIL-STD-1521A	4Q87
BIT Improvement	Development of improved procedures for specification and evaluation of BIT for weapons systems. Revision of MIL-STD-471B for demonstrating testability attributes. Publication of military handbook addressing Testability Analysis.	4Q84

<sup>1</sup>Actual ("C") or scheduled task completion; " + " if continuing task.

TABLE A-2. SUMMARY TASK DESCRIPTION OF JLC PANEL ON AUTOMATIC TESTING  
(MANAGEMENT AND ACQUISITION SUPPORT AREAS) (CONTINUED)

TITLE	DESCRIPTION	SCHEDULE <sup>1</sup>
MIL-STD-1388	Coordination of JLC AT Panel comments on the revised LSA standard.	4Q82C
LCC Models	Development of a complete set of tools and models needed to produce optimum AT support, using the MATE Guides as a point of departure and focusing on Standard Joint Service Life Cycle Cost models.	1Q86
TPS Design Handbook	Development and Publication of a Joint Service TPS Design Handbook	3Q85
ATG Selection Guide	Review, completion, and publication of the Navy-prepared Digital ATG Selection Guide as a Joint Service guide.	4Q80C
TPS Acquisition Guide	Development, coordination, and publication of a TPS Acquisition Guide, using the MATE Guide as a baseline.	2Q85
TPS V&V Guide	Development, coordination, and publication of a TPS Validation and Verification Guide, using the MATE Guide as a baseline.	1Q85
MIL-STD-881	Revision of the current work breakdown structure for defense material items (MIL-STD-881) to include TPSs and computer software items.	1Q83
ATLAS Source Code	Development and implementation of procedures for control and verification of ATLAS TPS source code by means of an automatic syntax analyzer. Creation and maintenance of a library of ATLAS Syntax Comparator versions, indexed to the systems/programs using each version.	4Q84 +
Hardware Interface	Development of specifications for standardizing hardware interface adapters between the UUT and ATE, starting with MATE specifications and examining feasibility of a Joint Service specification.	2Q83
Sensors	Review of the state-of-the-art of sensors, updating of the Sensor Handbook, and identification of R&D needs for new and improved sensors.	4Q84 +
Training Courses	Development and presentation of AT related training courses	4Q85 +

<sup>1</sup>Actual ("C") or scheduled task completion; "+" if continuing task

**TABLE A-2. SUMMARY TASK DESCRIPTION OF JLC PANEL ON AUTOMATIC TESTING  
(MANAGEMENT AND ACQUISITION SUPPORT AREAS) (CONTINUED)**

TITLE	DESCRIPTION	SCHEDULE <sup>1</sup>
TRD/TPS Standard	Analysis of existing documentation requirements, MIL-STD-1519 (USAF), MIL-STD-1345B (Navy), MIL-STD-2076 (AS), MIL-STD-2077 (AS), for the purpose of combining all into a single, Joint Service standard.	1Q84
ATE Selection Methodology	Development of ATE selection methodology as part of the MATE program; Military Service review of methodology; and publication as a Joint Service guide.	4Q85
Commercial Test Equipment	Survey of acquisition and life cycle support of ATE built with commercial test equipment (CTE); development of recommended changes in policies/procedures that will rectify any problems identified; and preparation of a program of action and milestones to implement recommended changes.	3Q83

<sup>1</sup>Actual ("C") or scheduled task completion; "+" if continuing task.

**TABLE A-3. SUMMARY OF HIGH-PRIORITY RESEARCH AND DEVELOPMENT  
RECOMMENDATIONS BY THE INDUSTRY AD HOC ATE PROJECT  
FOR THE NAVY**

TOPIC	ISSUE	RECOMMENDATION
Software	<p>ATE software is a major contributor to the life cycle cost of prime weapons systems.</p> <p>ATE software management is inadequate, with particular problems in configuration management, quality control, and feedback of TPS deficiencies.</p>	<p>Identify the cost drivers and control their effect on TPS development and maintenance. Improve TPS quality by improving the acquisition process for test requirements data.</p> <p>Improve ATE software management and control methods. Improve feedback methods. Standardize ATE software tools, techniques, and interfaces. Improve operational aspects of ATE software to reduce run time of operating software as well as TPSs.</p>
Automatic Test Generators (ATGs)	<p>The trend toward LSI is out distancing the capabilities of digital ATGs to generate quality test programs.</p> <p>Because of wide variety of analog equipment that will never be replaced by digital electronics, there is a need for analog ATGs.</p>	<p>Initiate R&amp;D program to advance the state of the art in digital ATGs.</p> <p>Sponsor R&amp;D program for analog ATGs.</p>
Design for Testability	<p>Traditional design methods and acquisition procedures do not result in supportable systems at affordable costs. A new methodology is needed to achieve testability.</p>	<p>Sponsor a continuous R&amp;D program to develop new BIT techniques and the means for implementing these at the system level. Develop testability specifications, along with the means for quantitatively measuring this parameter. Develop LCC model methodology as a tool for assessing cost-effectiveness of testability. Improve acquisition management by motivating contractors, enforcing LSA, and instituting testability audits/reviews.</p>
Nonelectronic Equipment Monitoring	<p>Shipboard machinery maintenance is a costly burden, is time-consuming, adversely affects crew morale, is unreliable, and frequently causes damage.</p>	<p>Develop prototype monitoring and diagnostic systems for evaluation at sea. Evaluate adequacy of existing commercial sensors, modify Navy specifications, establish QPLs for families of machinery-monitoring sensors, and identify R&amp;D needs. Develop guidelines and standards to ensure compatibility between monitoring systems and Ships Data Multiplexing System. Expedite test and evaluation of the LM-2500 and FT-9 engine condition monitoring systems. Develop and evaluate prototype diesel engine condition monitoring system for the LST 1179 Class.</p>
New Technology	<p>In the past, weapons system acquisition decisions have been based on potential performance effectiveness and initial costs, ignoring the fact that life cycle costs are dominated by operational and maintenance costs. Introduction of new technology can worsen life cycle costs, if risks have not been adequately assessed.</p>	<p>Develop objective methodologies to assess new technologies and guide their implementation, including identification of risks, R&amp;D needs, available alternatives, ILS requirements, and state of associated manufacturing technology. Establish test standards and methodologies for microprocessors and mass memory devices. Develop advanced BIT capabilities for lasers, fiber optics, and solid-state imaging devices to preclude complex alignment problems. Initiate R&amp;D for the application of microprocessors to enhancing</p>

**TABLE A-3. SUMMARY OF HIGH-PRIORITY RESEARCH AND DEVELOPMENT  
RECOMMENDATIONS BY THE INDUSTRY AD HOC PROJECT  
FOR THE NAVY (CONTINUED)**

TOPIC	ISSUE	RECOMMENDATION
New Technology (Continued)		BIT in future systems. Sponsor R&D program on automated test techniques related to RF and microwave technology.
Education, Training, and Management	There is a serious void in the training of decisionmakers within Navy and industry. Navy acquisition managers have a limited understanding of the technical capabilities and limitations of automatic testing. Navy ILS planners have a limited understanding of the relationships between ATE and maintenance concepts. Contractor ATE developers have a limited understanding of the skill levels of Navy technicians operating/maintaining ATE and the way ATE is utilized in the Navy.	Develop courses suitable for indoctrinating Navy and contractor personnel in ATE design, procurement, and use. Develop and implement a training program for the weapons system acquisition community (naval officers and civilians), matching personnel classifications to the spectrum of courses developed. Develop selection criteria for new instructional media and training aids, and apply new training technology in training ATE operators/maintainers.
Advanced ATE Concepts	The Navy has yet to optimize its exploitation of ATE technology and can learn valuable lessons from industry. The Navy's dilemma between low throughput of the expensive general-purpose supertester versus proliferation of peculiar test equipment usurping available space must be resolved through adopting a new approach.	Sponsor R&D program to define and develop the next generation or family of ATE. Sponsor studies to examine the optimum use of ATLAS and OPAL test languages and the potential of graphic programming. Develop and standardize eight families of ATE building blocks (power supplies, switching modules, microwave signal synthesizers, scan converters, mass memory testers/logic analyzers, high-power test stations, ruggedized key commercial instruments, and operator control/display stations). Sponsor a long-range continuing R&D program to develop advanced test techniques for BIT and ATE application. Sponsor a 5-year R&D program to examine and improve the ATE man-machine interaction. Establish an ATE technology center to assimilate the wealth of technical data, coordinate R&D, and assess impacts.

TABLE A-4. SUMMARY OF AIR FORCE TMDE MANAGEMENT INITIATIVES

ISSUE	RECOMMENDED ACTION
<p>"Lack of SE planning results in proliferation, increased costs, and deployment constraints."</p>	<p>Develop SE Master Plan, including action plan to achieve standardization for each SE category, updated annually. Revise AFR 800-12 to standardize SE definitions and to require all major commands support the Master Plan. Establish separate program element for common SE to fund common SE development.</p>
<p>"Organizational structure for managing SE is fragmented, with no clear lines of responsibility."</p>	<p>Create SE broker/advocate function, responsible for SE planning, MIL-HDBK-300 support, and improving SE procedures; assign function to Air Force Acquisition Logistics Center (AFALC) Revise AFSCR/AFLCR 800-5.</p>
<p>"Planning of SE acquisition strategies is not always effective."</p>	<p>Revise policy to improve scrutiny of SE in the acquisition process (AFR 800-2, AFR 800-5, AFSCR 70-2, AFSCR 70-7, AFLCR 65-5, AFSC/AFLCP 800-34). Increase use of FAR 15 213, with delegation of authority below Secretarial level, and multiyear contracts for TMDE. Adopt AFMAG<sup>1</sup> recommendations pertaining to technical data acquisition.</p>
<p>"SE is not adequately emphasized in program management documents, especially Program Management Directives (PMDs)."</p>	<p>Revise USAF HOI 800-2 and AFR 800-2.</p>
<p>"MIL-HDBK 300 does not adequately support USAF requirements for collecting and distributing SE information required by Program Managers and Air Force contractors."</p>	<p>Transfer management responsibility for MIL-HDBK-300 from CASO<sup>2</sup> to SE broker/advocate, AFALC. Implement JLC Panel on AGSE recommendations to improve MIL-HDBK-300 and develop automated screening process.</p>
<p>"SE is frequently late for unit conversions and unit or depot activations."</p>	<p>Revise budgeting procedures (AFLCR 57-2, AFLCR 57-11), use interim release procedures (AFLC/AFSCP 800-34), retain SE of deactivating units (AFLCR 57-2), plan depot maintenance earlier (AFSC/AFLCR 800-32), identify shortfalls in decision tree analysis process (AFLCR 66-75), and satisfy early data requirements by LSAR data sheets (AFSC/AFLCR 800-30)</p>
<p>"Guidance and planning for calibration is inadequate."</p>	<p>Revise AFR 800-12 and AFSC/AFLCP 800-34. Direct AGMC to promulgate guidance on calibration concepts. Revise directives to ensure TMDE is supportable (AFR 400-37, AFR 74-2, AFSCR 67-8, AFSCR 67-6).</p>
<p>"Failure to integrate SE design and development into the systems engineering process contributes to SE proliferation and increases long-term support costs."</p>	<p>Revise AFR 800-12 and AFSC/AFLCR 800 5 to require SE considerations be part of early system-level trade studies, with emphasis on reducing or eliminating SE. Revise MIL-STD 1521A, AFLC/AFSCR 800-24, and AFLC/AFSCP 800-34</p>
<p>"Current LSA and SERD guidelines and procedures are not effective in identifying and reporting SE requirements."</p>	<p>Immediately develop a modern ADP capability to process LSA data, interfaced with an automated MIL-HDBK 300 and an automated engineering drawing retrieval system. Revise AFR 800-8 to legitimize use of LSAR "E" sheet as an alternative to SERD, eliminating redundant data bases and reporting requirements, but modify "E" sheet to include narrative text and references to engineering drawings/lists defining proposed SE. Require LSA programs to include SE for SE other than tools and plant equipment. Develop a common SERD tracking system for use by all SE requisition agents. Simplify SERD review process.</p>
<p>"Improper SE design and specification practices impact performance, increase costs, and reduce competition."</p>	<p>Emphasize all programs on the design, specification, and configuration management of SE, including DT&amp;E, OT&amp;E, and technical order validation and verification. Develop standardized CDRL for acquisition of engineering data to be used in procurement</p>

<sup>1</sup>The AFMAG study of spare parts problems, conducted in 1983, attributed many problems to SE acquisition problems.

<sup>2</sup>CASO is an AFLC activity located in Battle Creek, Michigan. The Logistics Management Institute's review of programming data indicates that CASO has been spending less than one-half man-year annually on keeping MIL-HDBK 300 updated.

TABLE A-4. SUMMARY OF AIR FORCE TMDE MANAGEMENT INITIATIVES (CONTINUED)

ISSUE	RECOMMENDED ACTION
<p>"Support for SE is expensive and frequently late."</p>	<p>Revise AFR 800-12 and AFSC/AFLCR 800-5 to require support considerations for SE, including application of ILS (AFR 800-8) and LSA (MIL-STD-1388) to SE acquisition.</p>
<p>"Funding for common SE is frequently late and inadequate, and lacks visibility."</p>	<p>Continue emphasis on program "baselining" (Acquisition Improvement Initiative #30). Establish a new program element for development of common SE. Program funds for common SE through the POM cycle based on forecasted requirements just as peculiar SE funds are programmed. Implement regulatory changes requiring weapons system SPOs to program common SE funds for initial acquisition, rather than AFLC and the ALCs (AFR 800-12, AFM 172-1).</p>
<p>"Technical Orders for SE are frequently late and inadequate."</p>	<p>Enforce AFR 8-2 and TO 00-51, requiring delivery of the TOs for SE at the same time the equipment is delivered.</p>
<p>"SE acquisition methodology needs to be improved to properly incentivize contractors."</p>	<p>Require each program manager to plan for SE incentives. Establish requirement in PMD and acquisition plan.</p>
<p>"SE is frequently acquired by personnel who have not received appropriate training."</p>	<p>Direct AFIT to expand coverage of SE in its program management and logistics courses. Develop an SE Acquisition Handbook to replace the outdated Aeronautical Systems Division Pamphlet 800-19. Ensure that personnel involved in SE acquisition receive requisite training.</p>
<p>"The estimated price for SE often greatly exceeds the intrinsic value of the item itself."</p>	<p>(Report lists 17 recommendations that are beyond scope of our study.)</p>
<p>"Lack of visibility of small dollar, sole source procurement prices increases probability of overpricing on SE."</p>	<p>(Beyond scope of our study.)</p>
<p>"There is no standard management information and control system to aid SE managers in the acquisition of SE."</p>	<p>Develop an interactive, real-time data system for use by Air Force and contractors to pass and track SE data.</p>
<p>"The information systems used to acquire and control common SE are outdated and inaccurate, degrading the Air Force's ability to effectively manage these assets."</p>	<p>Continue current efforts to improve C013 (Support Equipment Acquisition and Control System) and the interfaces among the hodgepodge of computer systems constituting the AFEMS. Initiate actions to develop, test, and implement an on-line real-time replacement for AFEMS. Revise the AFLC AFEMS management structure to bring all AFEMS programmers and managers under control of a single manager.</p>



## GLOSSARY OF TERMS USED IN APPENDIX

ADP	automatic data processing
ADPE	automatic data processing equipment
AFALC	Air Force Acquisition Logistics Center
AFEMS	Air Force Equipment Management System
AFIT	Air Force Institute of Technology
AFLC/AFSCP	Air Force Logistics Command/Air Force Systems Command Pamphlet
AFLCR	Air Force Logistics Command Regulation
AFMAG	Air Force Management Analysis Group
AFR	Air Force Regulation
AFSCR	Air Force Systems Command Regulation
AGMC	Aerospace Guidance and Metrology Center
AGSE	aviation ground support equipment
ALC	Air Logistic Center
AT	automatic testing
ATE	automatic test equipment
ATG	automatic test generator
ATLAS	Abbreviated Test Language for All Systems
ATPG	automatic test program generator
BIT	built-in test
CASO	Cataloging and Standardization Office
CDRL	contract data requirements list
COTS	commercial off-the-shelf
CSS	Consolidated Support System
CTE	commercial test equipment
DID	Data Item Description
DMSSO	Defense Materiel Specifications and Standards Office
DoD	Department of Defense
DT&E	Development Test and Evaluation
EDP	electronic data processing
FAR	Federal Acquisition Regulation
HOI	headquarters operation instruction
IC	integrated circuit
ID	interface device
IEEE	Institute of Electrical and Electronics Engineers
IFTE	Intermediate Forward Test Equipment
ILS	integrated logistic support
JLC	Joint Logistics Commanders
LCC	life cycle cost
LRU	line replaceable unit
LSA	logistics support analysis
LSAR	Logistics Support Analysis Record
LSI	large-scale integration
MATE	Modular Automatic Test Equipment
METCAL	metrology and calibration
MIL-HDBK	Military Handbook
MILSPEC	Military Specification
MIL-STD	Military Standard

NBS	National Bureau of Standards
NORM	not operationally ready due to maintenance
NORS	not operationally ready due to supply
NSIA	National Security Industrial Association
OPAL	Operational Procedures Analysis Language
OT&E	Operational Test and Evaluation
PMD	Program Management Directive
POM	Program Objective Memorandum
QA	quality assurance
QPL	qualified products list
RADC	Rome Air Development Center
R&D	research and development
RF	radio frequency
SE	support equipment
SERD	support equipment recommendation data
SPO	system program office
TMDE	test, measurement, and diagnostic equipment
TO	Technical Order
TPS	test program set
TRA	test requirements analysis
TRD	test requirements document
USAF	U.S. Air Force
UT	unit under test
VLSI	very-large-scale integration
V&V	validation and verification
WRA	weapon replaceable assembly

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

## REPORT DOCUMENTATION PAGE

a REPORT SECURITY CLASSIFICATION Unclassified		1b RESTRICTIVE MARKINGS	
a SECURITY CLASSIFICATION AUTHORITY		3. DISTRIBUTION / AVAILABILITY OF REPORT "A" Approved for Public Release; distribution unlimited.	
b DECLASSIFICATION / DOWNGRADING SCHEDULE			
4. PERFORMING ORGANIZATION REPORT NUMBER(S) LMI Task ML504		5. MONITORING ORGANIZATION REPORT NUMBER(S)	
a NAME OF PERFORMING ORGANIZATION Logistics Management Institute	6b OFFICE SYMBOL (if applicable)	7a NAME OF MONITORING ORGANIZATION	
6c ADDRESS (City, State, and ZIP Code) 6400 Goldsboro Road Bethesda, Maryland 20817-5886		7b ADDRESS (City, State, and ZIP Code)	
a NAME OF FUNDING / SPONSORING ORGANIZATION ASD(A&L)	8b OFFICE SYMBOL (if applicable)	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER MDA903-85-C-0139	
6c ADDRESS (City, State, and ZIP Code)		10. SOURCE OF FUNDING NUMBERS	
		PROGRAM ELEMENT NO	PROJECT NO
		TASK NO	WORK UNIT ACCESSION NO
11 TITLE (Include Security Classification) Management of Electronic Test Equipment Volume II: Previous Studies and Initiatives			
12 PERSONAL AUTHOR(S) Frans Nauta			
13a TYPE OF REPORT Final	13b TIME COVERED FROM _____ TO _____	14 DATE OF REPORT (Year, Month, Day) July 1986	15 PAGE COUNT 123
16 SUPPLEMENTARY NOTATION			
17 COSATI CODES		18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number) Test Equipment, Electronic Test Equipment, Automatic Test Equipment, Test Program Sets, Management and Support of Test Equipment	
FIELD	GROUP SUB-GROUP		
19 ABSTRACT (Continue on reverse if necessary and identify by block number) <p>Since the early 1970's, the Office of the Secretary of Defense, the Military Departments, and industry have sponsored numerous studies of test equipment, formed several joint panels to investigate selected technical issues, and initiated a variety of programs to correct identified problems. Despite such attention, the Department of Defense still faces many significant problems with fielded test equipment.</p> <p>In a previous report, <i>Test Equipment Management</i>, January 1985, we summarized the nature and extent of those problems and recommended the Assistant Secretary of Defense (Manpower Installations, and Logistics), ASD(MI&amp;L), take the lead in effecting needed improvements in test equipment management and support. The ASD(MI&amp;L) concurred with that recommendation and established, via an action memorandum for the Under Secretaries of the Military Departments, dated 26 June 1985, a "DoD Test Equipment Management Improvement Program" under the overall guidance of his Maintenance Directorate.</p> <p>Since the issuance of that action memorandum, the Maintenance Directorate has been coordinating DoD-wide efforts to implement the DoD Test Equipment Management Improvement Program. This report, which is published in four volumes, bolsters the Maintenance Directorate's initiative. Volume I lays out a specific program of action for the Assistant Secretary of Defense (Acquisition and Logistics) to serve as a cornerstone for the DoD Test Equipment Management Improvement Program; Volume II reviews previous studies and initiatives pertaining to test equipment management and support; Volume III describes how the Military Departments are organized to carry out that management and support; and Volume IV reviews and assesses the adequacy of DoD policy.</p>			
20 DISTRIBUTION / AVAILABILITY OF ABSTRACT <input type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT <input type="checkbox"/> DTIC USERS		21 ABSTRACT SECURITY CLASSIFICATION	
22a NAME OF RESPONSIBLE INDIVIDUAL		22b TELEPHONE (Include Area Code)	22c OFFICE SYMBOL

FORM 1473, 84 MAR

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