AD-A061 756 ARINC RESEARCH CORP ANNAPOLIS MD F/G 15/5
THE ARMY TASK FORCE REPORT ON AUTOMATIC TEST SUPPORT SYSTEMS (A--ETC(U)
MAY 78 R S KALE, L J GRAHAM, A L SIMMONS DAEA18-72-A-0005

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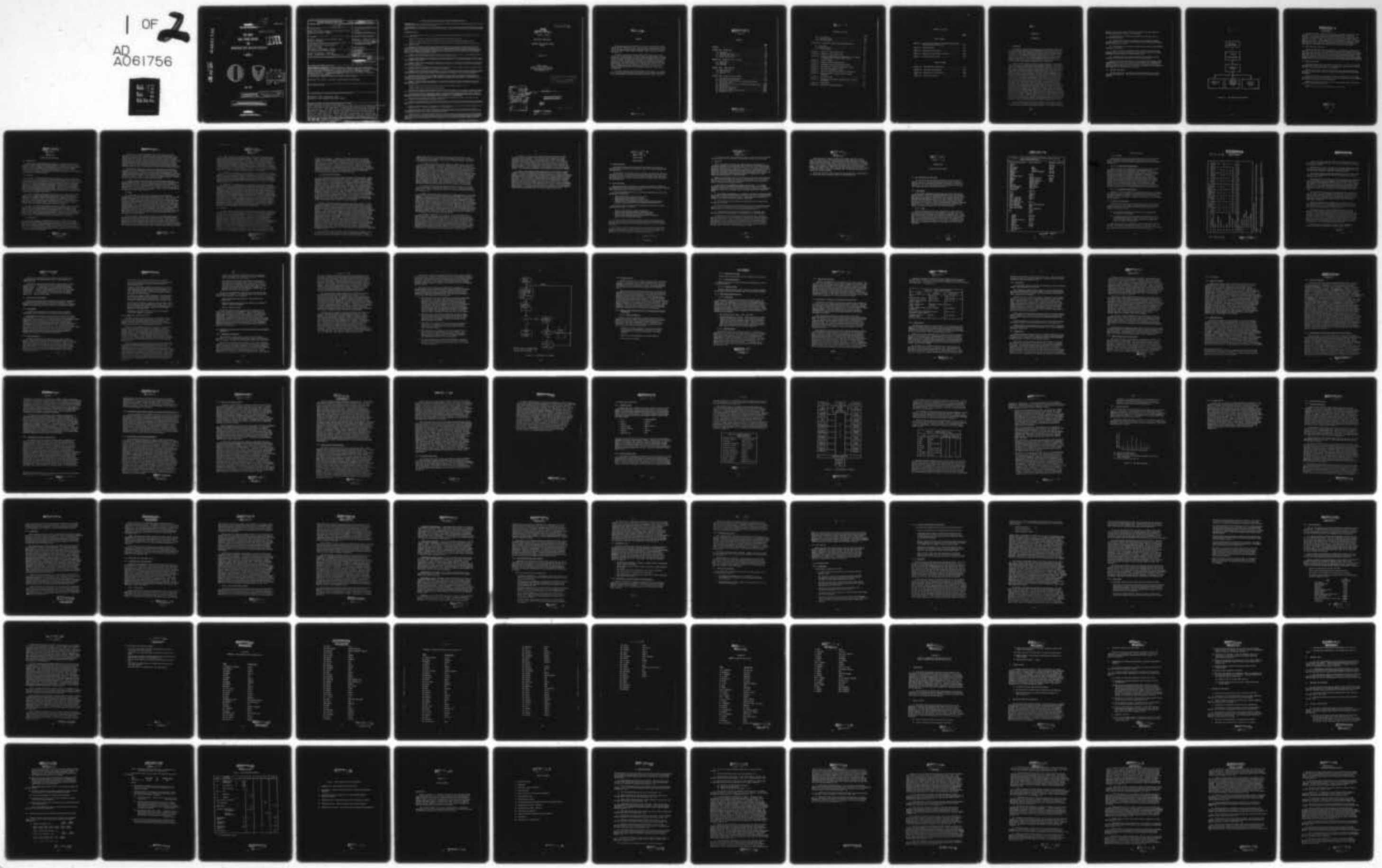

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THE ARMY
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—ATSS—

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

(12) 190p.

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)

(6) The Army Task Force Report On Automatic Test Support Systems (ATSS).

5. TYPE OF REPORT & PERIOD COVERED

(1) FINAL rept.

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)

Product Manager For Automatic Test Support Systems

8. CONTRACT OR GRANT NUMBER(s)

Contract: DAEA 18-72-A -005 MQD #9 ARINC Research CORP

9. PERFORMING ORGANIZATION NAME AND ADDRESS

ARINC Research Corporation
2551 Riva Road
Annapolis, Maryland 21401

class E016067

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

(16) 1X263748AJ29

11. CONTROLLING OFFICE NAME AND ADDRESS

Product Manager, CORADCOM
ATTN: DRCPM-ATSS Ft. Monmouth, NJ 07703

12. REPORT DATE

(11) May 1978

13. NUMBER OF PAGES

~~265~~ (183-Sanitized)

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

(15) DAEA18-72-A-0005

15. SECURITY CLASS. (of this report)

[redacted] UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

~~CONFIDENTIAL VERSION: Distribution limited to US Govt agencies only; Test and Evaluation; 21 Aug 78. Other requests for this documents must be referred to Product Manager for Automatic Test Support Sys~~tems. SANITIZED VERSION: Approved for Public release, distribution unlimited.'

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Approved for public release; distribution unlimited

(10) R.S./Kole, Jr. / Graham
A.L. / Simmons

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Automatic Test Equipment (ATE)
Automatic Test Support Systems (ATSS)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Under general guidance from DARCOM, the Army task force assesses the current Army, ATE posture and develops an optimum ATE acquisition strategy for the future. The Task Force investigated the technical feasibility, employment concepts, and operational desirability of developing a family of Automatic Test Support Systems to be used for the maintenance of Army material. This included formulation of interim and long-range ATE approaches for major subordinate commands and program managers and a plan for future ATE development and acquisition.

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TASK FORCE FINAL REPORT

AUTOMATIC TEST SUPPORT SYSTEMS
(ATSS)

August 1977

Product Manager
Automatic Test Support Systems
U.S. Army Electronics Command
Fort Monmouth, N.J.

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FOREWORD

This report presents the findings of the U. S. Army's Automatic Test Support Systems (ATSS) Task Force. The Task Force, established by TRADOC and DARCOM, was convened at Fort Monmouth on 10 January 1977 with representatives of TRADOC, DARCOM Commodity Commands, depots, and other services and agencies.

To provide guidance for the Task Force effort and a review of the results of the investigation, a steering group was established; its members were general officers representing DA, TRADOC, and DARCOM; representatives of DoD, Air Force and Navy; and consultants. The steering group, chaired by MG H. Griffith, DARCOM Director of RDE, held two meetings at DARCOM Headquarters. The first meeting, on 10 February 1977, reviewed the study plans and objectives of the Task Force. The second meeting, on 24 March 1977, reviewed the Task Force progress and findings. A list of the Steering Group attendees at the two meetings is included in this report as Appendix A.

This report has been compiled and edited by R. S. Kole, L. J. Graham, and A. L. Simmons, ARINC Research Corporation, under Task 7D, Modification #9 to Contract DAEA 18-72-A-0005, Delivery Order 0007, dated 6 May 1976.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

The dramatic advances in technology and their subsequent applications to Army Systems has resulted in the fielding of billions of dollars worth of electronic and highly sophisticated computer-controlled weapon systems. In excess of 11,000,000 sophisticated electronic and non-electronic units under test require support (block boxes, power supplies, printed circuit boards, etc.). The trend is towards fielding even more complex and more sophisticated systems. The new systems perform more functions via increasingly complex circuits in denser packages, and they require skills and more sophisticated support systems for their maintenance.

Because of the complexity of these systems, Automatic Test Equipment (ATE) from built-in-test to large general purpose machines is required to insure adequate cost effective levels of materiel readiness. If, as in the past, special ATE were developed to support individual systems, the cost of development, procurement, personnel requirements, and training would be prohibitive and achievement of the required operational readiness of the system would be, at best, doubtful. The Army, through establishment of the Office of Product Manager, Automatic Test Support Systems (PM ATSS) has embarked on development of standards for ATE hardware and software and to enable development and readiness weapon systems managers and other users, e.g., Depots, to optimize their ATE expenditures and increase readiness. This standardization may be effected vertically for a particular weapon system by using the same ATE at several levels of maintenance, and/or horizontally by supporting a number of different weapon systems with the same ATE. The use of common ATE at general support, depot, and factory levels (vertical standardization) has particular appeal since it allows the same set of test programs to be employed at all three levels with significant savings in developing test program sets. (Test program sets consist of functional test and diagnostic programs, adapters providing an interface between the Unit Under Test (UUT) and the ATE, and supporting documentation). The use of one family of general purpose ATE within GS and depot shops also has appeal as a means of reducing spare parts and training requirements and increasing ATE availability. TRADOC has recommended that the Army adopt only one type of general purpose tester or family of ATE components for use at missile, avionics, and communications-electronics general support shops.

At the present time, most commodity commands and numerous PM's have made significant commitments or are in the process of committing themselves to existing ATE systems and programming languages. For example, SIGINT/EW systems, improved Hawk, AAH, and TSQ-73 are preparing ILS plans based on ATE and have begun the writing of test programs.

The implementation of an ATE standardization policy gives rise to the following questions:

a. Should standardization be established at the commodity command or Army-wide level; i.e., should the Army employ two or more types of general purpose testers or only one?

b. At what points in time should standard testers and the Army standard language be introduced?

c. Who will manage the development and configuration control of the standard machine(s) and test language? At what level of detail will central management end and commodity and PM management begin?

d. How quickly can small suitcase testers be introduced to improve readiness in the division and reduce the need for large GS ATE.

The need for prompt decisions on these and other issues related to ATE standardization resulted in a directive issued December 1976 by DARCOM Headquarters establishing a TRADOC/DARCOM Automatic Test Support Systems Task Force (see LOA in Appendix C) which convened on 10 January 1977 and terminated on 24 March 1977 at Fort Monmouth, New Jersey.

1.2 THE ATSS TASK FORCE

The ATSS Task Force, consisted of representatives of most U.S. Army commands (see Appendix B). The organization of the Task Force is shown in Figure 1-1.

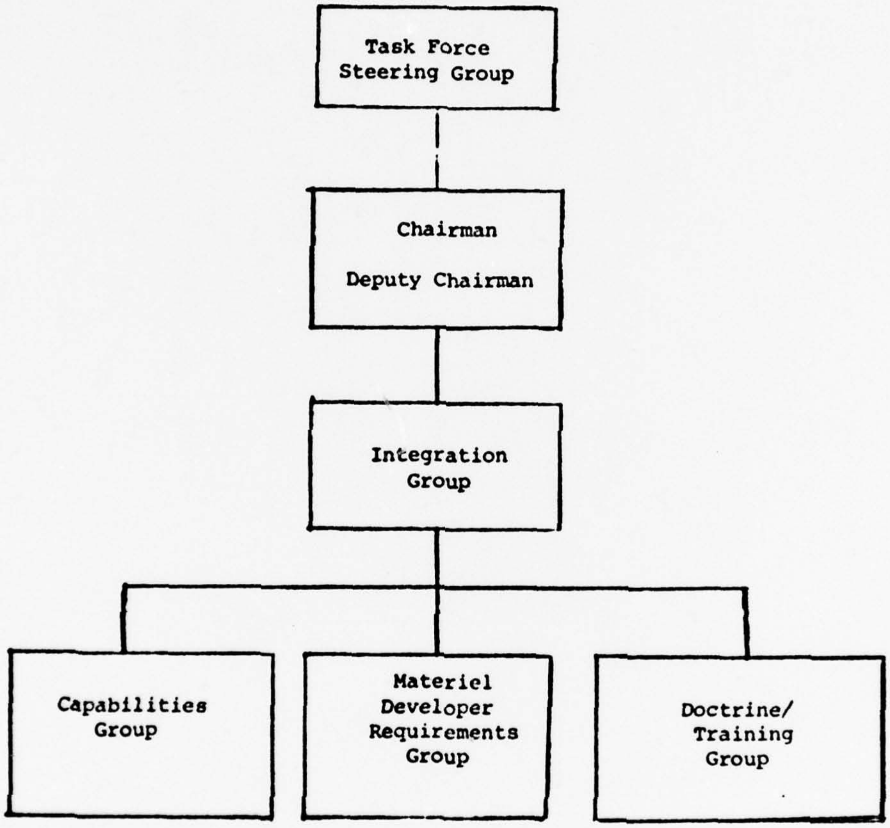

Figure 1-1. ATSS TASK FORCE ORGANIZATION

The Task Force was divided into four groups, concerned, respectively, with Integration, Capabilities, Materiel Developer Requirements, and Doctrine/Training. These groups defined and outlined the "key issues" assigned to them, accumulated and analyzed data, and summarized the results in reports, charts, matrices, and tables. These summaries were exchanged between groups for further analysis and comment. The Integration Group (representatives of TRADOC, DARCOM, MSC's and PM's, and AMSAA) then synthesized the results of the analyses and formulated the conclusions and recommendations presented in this report.

1.3 ATSS TASK FORCE OBJECTIVES

General guidance was provided by DARCOM for assessment of the current Army ATE posture and development of an optimum ATE acquisition strategy for the future. Specifically the Task Force was organized to investigate the technical feasibility, employment concepts, and operational desirability of developing a family of Automatic Test Support Systems to be used for the maintenance of Army materiel. This included formulation of interim and long-range ATE approaches for major subordinate commands and program managers and a plan for future ATE development and acquisition.

1.4 REPORT ORGANIZATION

This report consists of five chapters presenting the activities of the Task Force and its findings and conclusions. The background, Task Force organization, and objectives have been presented in this chapter.

Chapter Two presents a brief discussion of the more important ATE systems employed in the Army today, offering a historical perspective of the Army's ATE development.

Chapter Three outlines the approaches taken by the Task Force in its study of the problem, the methodologies used to evaluate and reduce raw data and summarize its findings, conclusions, and recommendations.

Chapter Four discusses the major issues in considerable detail and presents the bulk of the Task Force efforts.

Chapter Five presents the conclusions of the Task Force.

CHAPTER TWO

STATUS OF ATE IN THE ARMY

2.1 INTRODUCTION

This section is intended to provide readers a familiarity with existing Army ATE and place each in a historical perspective. Also provided is a short summary of efforts leading to the development of each ATE and the present status of each. While this section is not intended to duplicate a later appendix titled "Lessons Learned", some earlier ATE mistakes are mentioned. This section does not cover all Army ATE but does address those ATE systems considered of historical or technical interest.

2.2 DEPOT ATE

A. DIMATE. One of the first major Army initiatives into the utilization of ATE was started in the early 60's, when a program was approved to design and install comprehensive (by standards of that period) automatic test equipment at the three CONUS electronic depots. This system, named Depot Installed Multi-Purpose Automatic Test Equipment (DIMATE) was designed to perform end-to-end checkout and diagnostic testing of electronic equipment. DIMATE was first installed in 1964 at Tobyhanna Army Depot, with other DIMATEs later installed at Sacramento Army Depot and Lexington Blue Grass Army Depot. These systems are still operational, but are considered technically obsolete, and some recent efforts have been initiated toward replacing the DIMATEs.

B. GATE. DIMATE was followed by another effort to utilize automatic test equipment at two CONUS depots with the installation of the General Purpose Automatic Test Equipment (GATE) configured around a commercial HP 9500 system. This system, installed in 1970, was designed to test and diagnose the anti-intrusion electronic sensors (antilog) developed by the US Army Mobility Equipment Research & Development Center. These systems are presently in use at Tobyhanna Army Depot (TOAD) and Sacramento Army Depot (SAAD).

C. DACT. In 1970 a system called the Digital Automatic Card Tester (DACT) was installed at two (TOAD and SAAD) of the CONUS electronic depots. These digital card testers were installed to provide support to the AUTODIN cards. While the GATE at TOAD is used to support AUTODIN cards in a production mode, the backup GATE at SAAD was subsequently programmed to support some of the DIMATE cards. These General Dynamics-designed units were configured around an HP 9500 base and consist primarily of off-the-shelf commercial test equipment.

D. DEPOT MAIDS

(1) Another automatic test equipment installed in a CONUS depot was the Depot Multi-Purpose Automatic Inspection and Diagnostic system (Depot MAIDS). This system, installed at Letterkenny Army Depot (LEAD) in 1971, was intended to provide pre-teardown inspection, diagnostic evaluations, and final run-in for the select tank automotive engines. This system consisted of computer-controlled dynamometer test stands and was programmed to test the AVDS 1790 series engine and some automotive transmissions.

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(2) While the concept of Depot MAIDS was never technically refuted, implementation was partially defeated by certain Army depot decisions (i.e., LEAD was not selected for a major tank rebuild program). A major tank rebuild program would have resulted in Depot MAIDS being used more for pre-overhaul testing, where the greatest potential savings would have resulted. Instead, LEAD received engines that were removed from vehicles and returned to the depot. These engines often had been cannibalized without the resulting holes being plugged. Rainwater entry into these engines insured that overhaul, whether originally needed or not, was required by the time the engine reached the depot.

(3) While Depot MAIDS did not fulfill its potential as a pre-overhaul diagnostic tool, its performance in a role as a final checkout station proved valuable, and a follow-on program to the Depot MAIDS has been proposed. This program includes the installation of computer-controlled dynamometer test stands at Anniston Army Depot (ANAD). These planned test stations are scheduled to be installed in October 77 but will not include pre-teardown diagnostics. Approval for this follow-on program is presently pending in HQDA.

E. ADADS. Another Depot ATE is the Army Depot Automatic Diagnostic System (ADADS) designed to test Laser Range Finders (LRF) and the M60A1/A3 Add-On Stabilization systems. Frankford Arsenal proposed to design and build a LRF system in FY 74, with contractual efforts initiated early in FY 75. In 1975, Frankford Arsenal also proposed to modify this system to accomplish testing of the M60 series Add-On Stabilization subsystems. Both systems were scheduled for installation in CONUS depots during CY 77.

F. MATE

(1) During 1974 the US Army Missile Command experienced problems replenishing the circuit cards for the Improved Hawk (IH). These cards had been designated throwaway, consistent with the maintenance (MS+) concept of that period. Problems resulted partially because Army logistic planners made assumptions about support parameters that they could not control. In this case, an assumption was made that the circuit card throwaway rate would be equivalent to the card failure rate. This turned out to be inaccurate because in most cases, the IH diagnostic procedures only fault-isolated to a group of cards. Another assumption made was that an infinite number of cards could be procured from the contractor for the life cycle of the IH system. This was also incorrect since contractors have little incentive to supply circuit cards after production and certainly will not jeopardize current production line operations to be responsive to a fielded system.

(2) As a result of these and other problems, the IH office contracted for the system contractor to test and return good (incorrectly diagnosed) boards and to rebuild bad boards rather than manufacture new ones. The expense of this alternative, while less than throwaway, led to the US Army Missile Command's obtaining three excess automatic test equipments from the SPRINT program in 1975. These systems, since renamed Missile Automatic Test Equipment (MATE), are basically HP systems with some Martin Marietta-peculiar instruments and interface circuitry.

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G. TRMF. Another Depot level ATE that is used with the Improved Hawk is called the Theatre Readiness Monitoring Facility (TRMF). There are presently three of these systems, one installed in Europe, a second at Red River Army Depot (RRAD), and the third in Korea. These systems are large, fixed-location facilities used to automatically test and recertify the IH missile rounds. This IH missile recertification is performed on a periodic sampled basis. Missile rounds found to be inoperative by this method are also rebuilt by this facility. These facilities are considered Quality Assurance test facilities and are managed by the Directorate for Quality Assurance, HQ DARCOM. These systems were initiated about 1970, and the last unit was installed in Korea in January 77.

H. ST-25/ST-51. In addition to the Army-developed/designed ATE, the Army supports (i.e., is a major customer of) the National Security Agency (NSA) program, which is presently developing the ST-51, a hybrid ATE designed to support Tri-Service communication security (COMSEC) materiel. This system is a successor to the ST-25, which was developed by NSA in 1971. The ST-25 is strictly a digital depot ATE installed at Lexington Blue Grass Army Depot and supports only digital printed circuit cards.

I. TOW/COBRA. In 1975, while the US Army Missile Command was processing and renovating the three excess MATES, the TOW/COBRA Project Office was in the process of selecting an ATE system. The US Army Missile Command was requested to standardize its ATE or adopt an existing other major ATE system already in development or in the Army inventory. The eventual decision made was to develop a special TOW/COBRA ATE called Fully Automatic Diagnostic Equipment (FADE) configured around a HP 9500-based system. Special ATE capabilities, in addition to those required for TOW/COBRA, were also contracted for. These features included a computer-generated stimuli subsystem and a sampled measurement subsystem. The reason provided for adding the additional capabilities was to develop a state-of-the-art ATE system to satisfy other MICOM ATE requirements and be consistent with the ATSS Program. The TOW/COBRA Project Office also decided to develop a government-owned ATLAS compiler for their ATE system. The decision to contract for this ATE system in lieu of adopting an existing system was based on the extremely tight developmental schedule for the TOW/COBRA.

2.3 FIELD ATE

A. LCSS. Only a relatively small number of ATE systems have been developed for use in the field Army environment. The largest field Army ATE investment is represented by the Land Combat Support System (LCCS). The system was initiated in 1964, with fielding beginning in 1967. The U. S. Army Missile Command decided to develop a single ATE system to support four separate land combat missile systems. Systems supported by the LCSS are the SHILLELAGH, TOW, LANCE, and DRAGON. The LCSS was attacked by skeptics during its development and critized afterward by users because of numerous technical, supply, and training problems. While some of the criticism of LCSS was justifiable, other LCSS criticism actually reflected shortcomings of the planning efforts. For example, a shortage of the MOS 27B personnel required to operate the LCSS impacted the overall efficiency of this system. Problems keeping repair parts also caused low availability for the LCSS. Both examples demonstrate pitfalls inherent in assuming optimistic values for support parameters beyond the control of the concept planner. Irrespective of problems experienced by the LCSS program, it did demonstrate that general purpose ATE could be developed to support several systems and that the ATE could operate in a field environment. Presently, there are 44 LCSS in the Army inventory and there are no plans to field additional systems. Several product improvement programs (PIPs) have been proposed to LCSS to upgrade these aging systems. These PIPs range from component replacement to reconfiguration of LCSS into a single van. In addition to proposed improvements to LCSS, the Army Missile Command in 1976 proposed to replace the LCSS by the MATE. This proposal was one of the many factors precipitating the establishment of the ATSS Task Force.

B. SATE/EQUATE/CATE/AUTOCAL

(1) The Electronics Quality Assurance Automatic Test Equipment, AN/USM-410 effort dates back to the early 1960s, when the US Army Electronics Command (ECOM) proposed and received approval to develop a "standard" automatic test equipment to use as factory production line special acceptance and inspection equipment (SAIE) for electronic materiel. Subsequent to this effort, a proposal was made to develop a field version of this equipment, and a proposed Qualitative Materiel Requirements (QMR) document for computer-controlled automatic test equipment (CATE) was prepared in 1966. In 1969 due to problems encountered during manufacturing testing of several radios (AN/VRC12, AN/PRC77 and the AN/ARC114, 115, and 116), at the request of DARCOM a Manufacturing Method and Technology Program was initiated at ECOM to develop an array of test equipment to facilitate factory testing and acceptance. As a result of ECOM investigations, it was determined that production lot sampling was inadequate and a Special Acceptance Test Equipment (SATE) was defined and five units were procured and shipped to the contractors as Government Furnished Equipment for 100% testing of the radios prior to their acceptance by the Government.

(2) While a multitude of factors prevented the formal approval of a CATE requirements document, the US Army Electronics Command continued their EQUATE contractual efforts and produced their first EQUATE in 1973. During this time period the US Army Metrology & Calibration Center (USAMCC) began a development program to investigate the practicality of fielding a mobile automatic calibration facility. A draft requirements document for this automatic calibration system, known as AUTOCAL, was staffed to HQDA for approval and reached HQDA during the same period in which the CATE requirements document was being processed. HQDA raised questions about the necessity of two similar systems and returned the requirements documents to HQ TRADOC. To answer DA questions, an Ad Hoc Working Level Committee with a DARCOM Steering Group was established in 1973 to work with TRADOC to resolve these problems. The problem could not be resolved for a multitude of reasons, and in 1975 TRADOC and DARCOM signed the present ATSS-LOA. Funds for the ATSS investigations were reduced by HQ DARCOM from a conservative 30 million dollar estimate to less than 5 million, below the major program threshold (at that time). After the ATSS-LOA was approved, Frankford Arsenal informally obtained proponency in 1975, and proponency was subsequently transferred to PM ATSS in 1976.

(3) In the same period, 1975-1976, USAMCC continued their AUTOCAL effort, also without a requirements document. In 1974, USAMCC contracted for two prototype (commercial) van-mounted, automatic calibration systems. Delivery of

these systems was made in July 1975 and technical evaluations began. All AUTOCAL efforts were directed to be halted by HQDA in March 1976. In February 1977, HQDA authorized USAMCC to complete their AUTOCAL feasibility evaluations in coordination with PM ATSS.

(4) Several program offices have adopted the EQUATE system. The largest customer to commit projects to support by EQUATE in the US Army Intelligence Security Command (INSCOM). Soon after the commitment was made, it became evident that the ATSS program was not as well defined or funded as has been perceived and INSCOM requested assurances from HQ DARCOM that they would receive the full support promised. In 1975, HQ DARCOM made a compromise decision to utilize a large segment of the EQUATE as a "core" configuration to satisfy immediate INSCOM requirements and that this ATE "core" specification would include the essential features required of an ATE "core" system. HQ DARCOM, in late CY 75, directed the utilization of the EQUATE for field support of the AN/TSQ-73. The TSQ-73 has a large degree of printed circuit board commonality with TACFIRE, which was to be supported by EQUATE. This commonality was a major factor in the forced standardization between these two support systems. Since that time, additional EQUATEs have been procured (total 14) to support various systems.

(5) In late CY 76, the US Army Training & Doctrine Command, which represents the Army user, recommended the EQUATE system as an interim standard ATE for the Army. TRADOC stressed their desire for a single ATE system for interim field application.

C. MATE. In January 76, the US Army Missile Command appointed an Ad Hoc ATE Study Group to look into the MICOM ATE problems and recommend near- and long-term solutions. This group concluded in May 1976 that MATE should be selected as a MICOM interim standard ATE and that while the MICOM ATE program should be consistent with the ATSS family concept, it should be a separate "commodity oriented" program and converge at some future date with the ATSS program. At the conclusion of the study effort, USAMICOM directed that the TOW COBRA depot ATE program (FADE) be terminated (after the remainder of the committed funds were spent) and that the TOW office direct their contractor to use MATE. USAMICOM estimates that this redirection would save three million dollars and shorten the TOW COBRA ATE development time by seven months. The FADE effort was actually never terminated by the contractor, however, because the US Navy was procuring FADE units to furnish to the Government of Iran to support their TOW system.

D. US ROLAND. From late CY 74 to early CY 76, the US ROLAND Program had planned to utilize European test equipment. It eventually became evident that the European test equipment design was not as mature as had been believed by the US Army. In addition, the Europeans, in 1975, began considering changing their field maintenance test set (FMTS). This action would have made the US Army the only user of the original European ROLAND field test equipment. After the requirement to select other test equipment became known, requests were made to the ROLAND Project Office to consider adapting one of the existing ATE systems. Schedule constraints prevented this, however, and the ROLAND PM contracted for development of a Hughes-designed HP 9500-based system in October 1967.

E. ATE/ICE. A small special purpose ATE under development intended to provide field ATE support is the Automatic Test Equipment for Internal Combustion Engines (ATE/ICE). A Qualitative Materiel Requirements (QMR) was approved in 1969 and contractual efforts began in 1971. Initial efforts centered on providing an organizational level test equipment for automotive materiel. Many technical problems were encountered in trying to develop this small ATE system. In 1975, the success of the simplified test equipment for internal combustion engines (STE/ICE) program prompted a review of the ATE/ICE program. The requirement for ATE/ICE is now undergoing reevaluation by TRADOC.

F. AIDAPS. The Automatic Inspection Diagnostics and Prognostics System (AIDAPS) was conceived because of the identification of a need for a system capable of automatically diagnosing mechanical malfunctions, warning of impending mechanical failure, and designating replacement of aircraft components on condition rather than on schedule. A QMR was approved in September 1967 to initiate the AIDAPS. The initial effort consisted of a Test Bed Program and a Concept Formulation Program, both of which were completed in December 1971. DA then approved a three-phase development program in January 1972. Phase I, currently being completed, consisted of development and test of prototype AIDAPS components, identification of functioning and malfunctioning signatures, and verification of faulty implants. Performance and reliability of the AIDAPS, as well as continuation of the program beyond Phase I, are questionable at this time.

CHAPTER THREE

STUDY APPROACH

3.1 GENERAL APPROACH

The general study approach consisted of three steps; data collection, data reduction and analysis, and formulation of the Task Force conclusions and recommendations.

To accomplish this, the Task Force was divided into three major groups: a Requirements Group, a Capabilities Group, and a Doctrine/Training Group. Later, an Integration Group consisting of the Task Force chairman and his assistants and group leaders was formed to guide the effort and develop final conclusions and recommendations.

3.2 DATA COLLECTION

The initial effort of the Task Force was directed toward the collection of background data and the definition of critical issues to be resolved. Specific tasks undertaken as part of this effort were:

A. User requirements data were solicited from program managers by sending questionnaires requesting:

- Lists and descriptions of UUTs to be tested
- Quantities of these items to be fielded
- ATE characteristics required to test each UUT
- Schedule dates for developing, testing, and fielding prime systems
- Results of program manager studies establishing needs for ATE

B. A survey of the Army's present ATE capabilities and general industry capabilities was made; it included:

- Visits to RCA and Martin Marietta Corporation
- Presentations given by a number of ATE manufacturers
- Review of ATE manufacturers' technical documentation
- Review of ATE trends and projected capabilities necessary to meet the future systems requirements

C. Doctrine for using ATE at the general support level was developed. This work was aimed at the generation of operational mode summary and mission profiles indicating mobility and environment requirements for ATE employed at this level.

D. "Lessons learned" information was collected from presentations and documentation provided by the Navy, Air Force, and industry regarding their experience in applying ATE and their plans for using it in the future. The results of these investigations are summarized in Appendix D.

E. Key problem areas were identified, together with the decisions necessary for determining a course of action for developing, procuring, and using ATE.

3.3 ANALYSIS

After compilation of UUT test requirements data and ATE capabilities, an information subcommittee of Requirements and Capabilities Group members was then set up to analyze the data, and perform comparison of the range of stimuli and measurement capabilities and requirements. To resolve questions dealing with the feasibility, desirability, and degree of standardization, subcommittees were established to examine language standardization, procurement risks, R&D and life cycle costs, management and coordination problems, and experience in using commercial-grade equipment in a GS environment.

Within the Integration Group a list of major decision issues was compiled on the basis of DARCOM guidance and judgments made by members of the Task Force. The determination of answers to these questions became the major objective of study. A list of these questions follows:

A. What degree of standardization should the Army seek; i.e., should one machine or family of machines become Army-wide standards or should each commodity command establish its own standard machine or machines? Alternatively, should each program buy or develop special or general purpose ATE suiting his needs?

B. If Army-wide standardization is undertaken, what family of hardware should be selected? Should the ATE selected be a Government-developed, Government-owned design or off-the-shelf commercial hardware? What degree of ruggedization is required to meet mobility and environmental requirements?

C. At what points in time should Army standard ATE and the standard test language be introduced?

D. What is the appropriate mix of ATE types for each type of general support shop; i.e., what types of more specialized testers should be included in the standard family to supplement the large general purpose machine?

E. How should ATE development and standardization be managed? What should be the relationships between concerned Activities in this process?

In consideration of the breadth of the assigned tasks and the limited time available, the decision was made by the Task Force to limit its two-month effort to issues A, B, C, and E, leaving the question of ATE mix for future investigation. Other problem areas, excluded from intensive examination for the same reasons, were the applications of ATE at direct support and organizational levels and the cost-effectiveness of the current doctrine requiring printed circuit card repair at the general support shops.

These decisions, in effect, limited the two-month effort of the Task Force to consideration of large general purpose testers employed at general support and depot operations. The assumption was made that there is sufficient need for the general purpose tester to justify at least one machine of this type in each of the missile, communications electronics, and avionics general support shops. This assumption is supported by the selection of a general purpose machine by a number of PMs and by the fact that expected shop work loads contain a sufficient number of complex, low-density UUTs to establish an area of usefulness for the large machine.

Final consideration of these factors and the preparation of recommendations and conclusions were accomplished within the Integration Group.

CHAPTER FOUR

DISCUSSION OF KEY ISSUES

4.1 ATE COMMITMENTS AND NEED DATES

Two sets of data were compiled in determining the ATSS requirements for the Army. One set, presented in this section, consists of the data related to ATE support requirements (quantities and dates of deployment). The other set represents the user technical requirements (test parameters) and is presented in Section 4.2.

4.1.1 Methodology

An ATE support requirements questionnaire was sent to the PMs and Commands listed in Table 4-1, requesting technical stimuli and measurement requirements, geographic ATE deployment localities, deployment dates, and numerical requirements. Because of an early response date and the fact that many PMs simply did not have the data available, the quantity of data received was limited. Where data inputs were missing, values were assumed, as in the case of Special Acceptance and Inspection Equipment (SAIE) (see 4.1.1.1 below), one ATE system was allocated per tactical system, or estimated as specified in the following sections.

4.1.1.1 SAIE

SAIE would normally be the first requirement for ATE to support a system and would be provided to the contractor for in-plant use. This goes hand-in-hand with ATE for Test Program Set (TPS) generation in that test programs must be generated for production acceptance testing and the SAIE. It is anticipated that these initial stages will evolve into the Depot and, with further evolution, into the field. ATE requirements for applications software (TPS) generation are outlined in Appendix D; they were used for estimating the quantity of ATE required for TPS software generation.

[redacted]

Table 4-1. LIST OF PROJECT MANAGERS AND COMMANDS SURVEYED FOR ATE SUPPORT REQUIREMENTS DATA

MICOM/MISSILE COMMUNITY

- STINGER
- GSRS
- 2.75 ROCKET
- CHAPARRAL
- VIPER
- PERSHING II
- PATRIOT
- ROLAND
- HIGH ENERGY LASER
- LANCE
- TARGETS
- DRAGON
- HAWK
- TOW
- HELLFIRE
- LASER DESIGNATOR
- TSQ 73 (ECOM)
- COPPERHEAD

ARMCOM

- ARGADS
- VADS
- VVS-1 (LASER RF)
- VVG-1 (LASER RF)
- VVG-2 (LASER RF)
- M-60 STABILIZED SYS
- XM-19 COMPUTER
- XM-21 COMPUTER
- XM-35 FUZE SETTER
- MAIDS (ENG TESTER)

ECOM

- SINGARS
- ARTADS
- ATACS
- FIREFINDER (MALOR)
- NAVCON
- REMBASS
- MSCS
- SIGINT/EW
- TRI-TAC
- DCS (ARMY)/CSA
- SATCOM

ECOM (continued)

- R&D
- MAINT
- MAT MGT
- PRODUCT ASSURANCE

INSCOM

- ULR-17
- TACELIS (MLQ-112)
- TACJAM (MLQ-34)
- AGTELIS (TSQ-109)
- CEFLY LANCER
- MULTEWS (AIR)
- QUICK FIX
- TRAIL BLAZER
- MSQ-103

TARADCOM

- ATE/ICE
- STE/ICE
- MICV
- M60A/E3
- XM-1

AAVSCOM

- AAH - (LESS HELLFIRE)
- UTTAS
- UH-1
- AH-1 (TOW/COBRA)
- OH-58
- CH-47
- OV-1

TOBYHANNA

- TACFIRE
- PRC-77
- TSQ-73
- RT-524
- RT-246
- R-442

TOBYHANNA (continued)

- ARC-114
- ARC-115
- ARC-116
- ARN-89
- GRC-103
- GRC-106

MERADCOM

- SLUFAE
- PADS
- TSIID

[redacted]

4.1.1.2 DT/OT

Development and Operational Testing (DT/OT) with System ATE refers to the ATE required for participation in DT/OT testing of a tactical system. This also includes the support requirements for test preparation and training.

4.1.1.3 Field and Depot Requirements

There was little or no methodology for determining field and depot requirements for ATE other than simply estimating workload for quantities of systems to be deployed at each location. Insufficient data were available on the machine time required for simple or complex printed circuit boards and electronic black boxes. Therefore, a technique was developed in Appendix E, which provides a method of estimating early ATE requirements for purposes of funding forecasts. Following this estimate, the data must be reevaluated so that funding and AMP projections can be updated. Once the PM provides the system configuration, by estimating the number of Line Replaceable Units (LRUs), the system design failure rates, and the estimated system deployment density, the estimated failures per year for the ATE can be computed and translated into estimated machine-years required for ATE.

4.1.1.4 Miscellaneous Requirements

Miscellaneous ATE requirements were estimated as follows: 10 percent for Maintenance Float, 5 percent for War Reserve, and 5 percent for school training and other miscellaneous. Adding this 20 percent to the total estimated requirement provides a reasonable starting point for ATE requirements estimating.

4.1.2 Results and Discussion

The amassed data were tabulated by fiscal years; they are presented in Table 4-2 for the total Army. Requirements in Table 4-2 are of two types. This appears to be an upper limit on number of machines and is subject to downward revision.

A. A requirement satisfied by the delivery of an ATE suitable for SAIE of TPS development.

B. A requirement that can be met only by the delivery of a fully configured ATE complete with all necessary test program sets properly mounted, programs loaded, and ready to support UUTs (e.g., for DT/OT, GS, and Depot).

Where delivery meets the requirement, it is assumed that contractor delivery can be made in the same year as delivery to the user, i.e., (A), (B), and (F) Table 4-2; however, for (C), (D), and (F), it is assumed that contractor delivery will be required during the prior year.

Table 4-2. ATE REQUIREMENTS ***

Application	1977	1978	1979	1980	1981	1982	1983	1984	Total
(A) SAIE	1	6	3	3	5	3	0	0	21
(B) TPS Preparation	6	19	16	11	6	1	1	-	60
(C) DT/OT Test	0	5	(3)	(5)	(2)	(0)	(1)	(5)	5
(D) GS	1	4	11	11	25	37	26	47	162
(E) Depot	3	4	3	3	7	9	6	8	43
(F) 20 Percent Depot/GS	1	2	3	3	7	9	7	11	43
(G) Distribution*	8/4	27/13	22/14	17/14	18/32	13/46	8/32	11/55	-
(H) Delivery**	25	42	36	49	64	45	63	11	334

20 percent includes training, maintenance float, war reserve float, other = 20 percent × (GS + depot).

Does not include:

- 29 units for radios
- 20 units for calibration
- 8 units for ACC
- 0 to 15 new systems

*Distribution line reflects A+B+F/C+D+E.

**Delivery numbers for a year is the sum of (A+B+F) of that year plus (C+D+E) of the following year.

***NOTE. These data undergo constant requirements. Until accurate field data on machine thru put are available, quantities should be used for planning purposes only.

[redacted]

It must be further noted that funding for machines must occur one year prior to contractor delivery; i.e., the 49 ATE machines in 1980 must be contracted in 1979.

DT/OT machines in line C of Table 4-2 are shown in parentheses after 1978 and are not included in the totals, under the assumption that five machines will be managed to support all DT/OT requirements.

As previously stated, one ATE was allocated for each tactical system for SAIE. Other requirements for SAIE will be added when developers determine their needs.

ATE quantities for Test Program Set (TPS) preparation were calculated by the methodology outlined in Appendix J and are shown in Table 4-2. ATEs shown as TPS Requirements (Table 4-2) in 1977, 1978, 1979, and 1980 are utilized in each following year through 1980. For example, one ATE required in 1977 and 1978, respectively, represents seven machine-years through 1980. After 1980, these units will be available for TPS work, yet to be identified, for redistribution or for TPS maintenance by the prime.

The total DT/OT ATE requirement is estimated to be five units in FY 1978. These same units would be used to meet all subsequent DT/OT requirements by rescheduling them from one tactical system to the next with the addition of necessary TPSs. This procedure would optimize the utility of DT/OT ATE units through FY 1981, while minimizing procurement requirements.

Depot ATE requirements are combined since depots have not yet been designated for most of the systems listed in Table 4-1. Plans for geographic dispersion to actual depots must be accomplished later, as each system being supported is assigned a depot.

Field requirements were not calculated for actual locations, because complete geographic breakouts were not received from many developers. Very few developers provided inputs for reserve component requirements; therefore, estimates of actual reserve requirements were not made. However, since the methodology used considered total force workload, redistribution of requirements could be made from the other allocation to reserve allocation, or from any GS location as required. ATSS requirements planners must attempt to relate all system support requirements to a specific ATE by geographic location.

Miscellaneous ATE requirements include schools, maintenance floats, war reserves, and any other requirements not covered.

Nonelectronic requirements were considered, but were not used in calculating total requirements because little is known about how to compute workload.

The total estimate of ATE units required (Table 4-2) for FY 77-84 should not be considered precise because of the many approximations made in projecting the quantities. The total could be even further reduced by judicious workload planning for testing of like UUTs, use of dedicated UUT testers, increased employment of BITE, and elimination of the necessity to verify repair of a UUT on the ATE. The total, even if inaccurate, is indicative of the substantial ATE investment required to satisfy the Army's needs.

4.2 USER TECHNICAL REQUIREMENTS

This section presents the data collected on the users' requirements in terms of the types and range of stimuli and measurements. Prime attention was focused on obtaining requirements for support of electronic systems, but requirements were also compiled for nonelectronic systems.

4.2.1 Methodology

To establish a representative cross-section of Army technical requirements, data were gathered on the systems listed in Table 4-1.

Measurement and stimuli data were collected in the form of a matrix (see Appendixes F and G) for each candidate system. Then the data were reduced from several systems to a composite matrix for the commodity-oriented organization. These data sheets were then reviewed by the group and refined to eliminate redundancies and overlaps and to form an Army composite matrix. The total composite matrix was reviewed to assure that all commodity requirements were satisfied. Next, the composite matrix was used to determine how many of the UUTs in the commodity requirements would utilize each of the stimuli and measurement requirements specified. Finally, the group met and totaled, for all the systems studied, the number of UUTs that needed each stimuli and measurement capability delineated on each line of the Army composite matrix.

4.2.2 Data Limitations

This data collection was an intensive effort. The resultant matrices reflect the stimuli and measurement requirements for a large number of Army systems. However, due to limitations of time and resources, the results should not be considered as all-inclusive. That is, the data do not include all Army systems, nor do they represent the total time and resources (e.g., one Project Manager estimated that 12 months and $200,000 would be required to determine adequately his technical requirements for ATE). Use of the results should be tempered by the following considerations:

- The results of few in-depth UUT analyses were available.
- Most of the data gathered was gleaned from system, LRU module and PCB specifications, drawings, and other available descriptive material.
- A number of the systems studied have already been fielded and therefore already have approved test support equipment. As such, they may not be prime candidates for ATE; however, they were included because their stimuli and measurement requirements were firm and available.
- A number of the systems studied had meager or no firm requirements because they are still in development. These systems may be prime candidates for ATE support, but at present their requirements range from tentative to sparse, to nonexistent.
- During the data collection, compaction, and refinement, some of the raw data may have been abraded or distorted. Also, there may be instances where several narrow, but reasonable, requirements were combined to produce a single broad requirement bordering on the impractical.
- Occasionally, when the raw data had gaps or was ambiguous "engineering judgment" was applied.

4.2.3 Results (See Appendixes F and G)

The results of this survey are presented in Appendixes F and G on electronic and nonelectronic requirements, respectively. For the systems investigated, the total density of electronic UUTs to be supported is over 9,200,000 items, not including spares; assuming 15% spares, the total increases to approximately 11,000,000.

The formats for Appendixes F and G are similar. In most cases a single page is devoted to each parameter, for example: DC Power Sources. Each vertical column specifies a particular aspect of the parameter such as: nominal voltage, voltage tolerance, current, etc. Each horizontal line represents a specific stimuli or measurement capability requirement. In some cases more than one capability is required simultaneously; this is indicated in the left-hand column by 1a, 1b, 1c, etc. Thus, as shown on pages 1 and 2 of the Power Supplies, there are some UUTs which required 1a through 1n (14) power supplies simultaneously.

The column headed "Quantities" indicates the number of UUTs (for the systems examined) which require the capability on that line. This is an attempt to indicate the frequency of use or utility of the capability on that line. If an ATE were constructed with all of the capabilities listed in Appendix F, that ATE should be capable of testing every electronic UUT in each of the Army systems studied. However, such an ATE might not be technically or economically feasible; a more justifiable ATE would be one that satisfied those capabilities required by a large population of UUTs. The "Quantities" column on the matrices was provided to indicate which capabilities might be most heavily utilized. Use of the data in the "Quantities" column must be governed by the following:

- The data in the matrices represents only the Army systems studied (see Table 4-1); it does not represent requirements for all the UUTs in all Army systems.

- Some UUTs have simultaneous requirements for both heavily and lightly utilized capabilities. This is illustrated on the first page of Appendix F. Power Supplies 1a, 1b, and 1j are required by a large number of UUTs, while Power Supplies 1g and 1h are required for very few UUTs. However, as explained above, there are some UUTs which require all Power Supplies 1a through 1n simultaneously.

The stimuli and measurement requirements for nonelectronic UUTs are tabulated in Appendix G. The types and sources for the raw data used to compile Appendix G are as follows:

- Aircraft Subsystems and Components - Corpus Christi Army Depot (CCAD)

- Vehicle Internal Combustion Engines, Hydraulic and Pneumatic Systems - ARMCOM and TARADCOM

- Optics - ARMCOM and MICOM

As with the electronic requirements listed in Appendix F, the data listed in Appendix G were gathered from a limited number of systems, both fielded and developmental. However, the nonelectronic requirements are considered to be representative of the Army's test requirements. It should be noted that nonelectronic UUTs cannot utilize ATE techniques except through the use of transducers to convert nonelectronic parameters to electrical form. With suitable transducers, nonelectronic UUTs can readily be tested automatically; this has been demonstrated conclusively by the MAIDS facility at LEAD, TARADCOM's ATE/ICE and STE/ICE Projects, and the automated aircraft engine test stand at Corpus Christi.

4.3 OPERATIONAL CHARACTERISTICS AND EMPLOYMENT CONCEPTS FOR THE GENERAL SUPPORT ATE

4.3.1 Operational Mode Summary

The maintenance support concept envisions the use of ATE at all levels. It is an evolution of maintenance support which spans the gamut of automatic testing from organizational through depot maintenance.

At the organizational and direct support levels, higher equipment availability will be achieved by expedited fault isolation, coupled with rapid accessibility, and module replacement. The replacement decision will not be determined by the operator, but by a built-in test capability such as BITE, supplemented by simple highly portable ATE. Fault indications that cannot be, or perhaps should not be built into the supported system, should have test points brought out to a test connector.

The suitcase tester would be used to give the fault information to the repairman. Accordingly, skill requirements and unnecessary repairs at these levels will be reduced. The direct support role will be primarily oriented toward supply, validation and reduction of high module replacement rates that adversely impact operational readiness status, plus maintenance team support, and retrograde of defective modules to general support. General support units will affect rapid piece part repair of modules. This will be accomplished through a concentration of skills and the best possible automatic test equipment. The Depot will back up the GS unit by absorbing overloads, performing time-consuming repairs and making major hardware and software modifications.

ATE is envisioned as special equipment to be allocated to general support maintenance units in the friendly corps area(s). It is envisioned that various ATE test stations will reflect configurations that utilized a common core, a standard language, and minimum essential commodity-peculiar hardware and software. Consideration must be given to multiple test station capability. The ATE will be capable of automatic total system self-test. The ATE must also be capable of diagnosing itself to the LRU level (board module or instrument). Furthermore, the equipment will verify and diagnose failures in UUTs, i.e., LRUs, cards, and modules, in order to enable returning to service items from such complex and sophisticated commodities as missile, aviation, communications-electronics, wheel vehicle, armament, vehicle, and combat vehicle systems.

The ATE should be capable of being transported by road, rail, air, and water modes to and within active theaters of operations. When mounted, it should be able to withstand movement without any adverse effects on its operational capability. Further, it should be able to be transported over main and secondary roads at speeds commensurate with existing road and traffic conditions up to 55 MPH. Consideration must be given to winter road conditions (e.g., rutted ice, pot holes, etc.). Additionally, it should be able to withstand movement over unimproved roads or off roads at speeds from 2-1/2 to 5 mph for distances sufficient for entering into tactical posture. The term "when mounted" does not imply any specific type military van, vehicle, or trailer. To the extent possible, the ATE will utilize commercial off-the-shelf components. The protection required for the transport facility (e.g., trailer, van, etc.), should be appropriately designed.

The ATE must be capable of being able to be operated, stored, or transported in climatic categories 1 through 6 (AR 70-38). Environmental protection for the ATE configuration(s) can be provided by the ATE van, packaging, trailer, or facility. Cold weather kits, etc., are acceptable to assist in meeting climatic 6 requirements. The ATE must also be adequately protected against vibration, shock, condensation, humidity, fungus, salt, and sand in accordance with MIL-T-28800B.

The system will be manned up to 24 hours/day (7 days/week) in peacetime and in wartime. No more than one hour per day will be allocated to PM (Preventive Maintenance). The mode of operation planned for the various configurations is verification and diagnostic testing of UUT's arriving for repair from supported systems. The sequence of operations for a typical UUT diagnostic task is as follows:

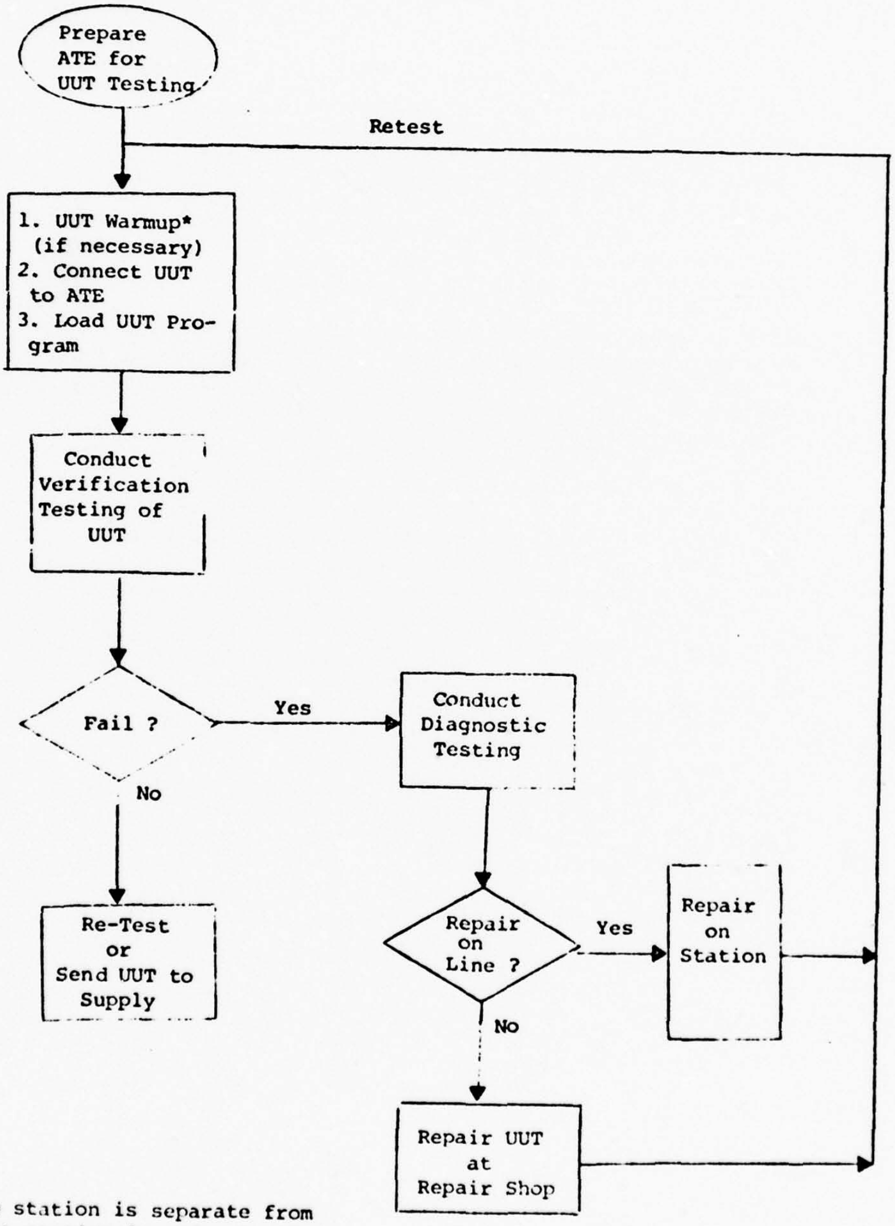
A. After the ATE is set up for operation, at the location designated by the corps, a self-test of ATE is performed and testing of UUTs will begin. Figure 4-1 shows, in flow chart form, the sequence of operations narrated in the following paragraphs. When received, the UUT is scheduled for time on a test station(s). When the UUT comes up for testing, the software application program for that particular UUT must be present in the system. It is envisioned that these programs will be stored on magnetic tape cartridges and/or contained on a disc pack. A card may require a special interface box between it and the test station.

B. After the UUT is connected and the appropriate program loaded, the verification test is run to verify that the UUT has failed. If the test results show the UUT failed and the item is a GS repairable item, the diagnostic program is run either on the same or another test station.

C. Failed UUT's are tested for failure verification and diagnosis to the discrete component level at the ATE test station(s). Those UUT's not repairable at the general support level are sent to depot for repair.

D. After the failure is isolated to a discrete component on the UUT, the UUT is disconnected from the system, tagged, and sent to the repair area, where the malfunction is corrected. The normal mode of operation will be to diagnose the fault and subsequently repair it in the same facility.

E. The same connection and program loading procedure is followed in validating the repair of the UUT as was used in verification testing. If the card passes the verification test, it is placed in supply for direct.



* Warm up station is separate from ATE test station in order to tie up the ATE unnecessarily.

Figure 4-1. FLOW CHART OF UUT TESTING

4.3.2 Mission Profile

The ATE will be a part of a General Support Facility consisting of other test equipment, repair shops, and supply shops. When in movement, this facility will move 80% of the time on various types of roads in the area of operations. Movement to area of operation on unimproved roads or off road will account for the remaining 20%.

When not in movement or set up/tear down mode, the ATE will be operated for diagnostic testing up to 23 hours per day during peacetime and wartime, performing diagnostic and verification testing in support of tactical systems maintenance. It will operate in a tactical environment approximately 60-120 km from the Forward Edge of the Battle Area (FEBA) in the corps area. The mission of ATE will be to provide automatic self testing and to fault-isolate failures in Line Replaceable Units (LRUs), circuit cards, and modules. ATE is subject to movement on an infrequent basis as dictated by the tactical situation. Tear down and/or set-up time for/or to relocation will normally not exceed twenty-four hours (this includes all unpacking/packaging, uncrating/crating, and preparation for movement).

4.3.3 Failure Definition/Scoring Criteria (Including Both Hardware and Software

4.3.3.1 Mission Reliability

To assess mission reliability, a failure is defined as any malfunction, occurring within the approved operational environments, which the operator/crew cannot remedy by adjustment/repair or replacement action during scheduled preventive maintenance using the controls, OEM tools, and available parts, and which causes or may cause one or more of the following:

- Inability to commence operation, cessation of operation, or degradation of performance to the extent that self-test and diagnostic test of selected UUTs is no longer possible.

- Damage to systems/subsystems by continued operation

- Personnel safety hazards

4.3.3.2 Related Malfunctions

Simultaneous related malfunctions are considered as one failure.

4.3.3.3 Mission Performance

Malfunctions which do not affect mission performance will not be considered failures.

4.3.3.4 Scoring Criteria

Scoring criteria for the specific items will be jointly prepared by the combat and materiel developers and will be specified in the DP.

4.3.4 RAM Category/Methodology Used

4.3.4.1 Reliability

The details of the concept of tactical maintenance support for missile, avionics, communications-electronics, wheel/armament, and combat vehicle test equipment is not finalized, particularly regarding the optimum use of ATE. Logistics modeling is expected to be accomplished to develop the optimum concept and provide quantitative analysis for decision making. Information needed to substantiate or change the RAM values stated in the ROC will result from this modeling. These numbers will be validated/refined as additional data are available. The MTBFs are as follows:

- Best Operating Value (BOV): MTBF = 500 hours.
- Minimum Acceptable Value (MAV): MTBF = 250 hours in any mode (based on a failure of any part). These values include the restoration of support equipment essential for ATSS operation such as generators and air-conditioners. Redundancy of air-conditioners and power generators may be used to meet stated MTBF. The equipment will be designed to maintain the BOV and MAV during the first five years of ATSS employment.

4.3.4.2 Maintainability

The ATE MTTR requirement is MTTR = 2-1/2 hours. This value is considered to be realistic and attainable within the concept of system design and logistic support. The system will be designed with self-test features to quickly fault-isolate to a line replaceable unit. Replacement of the LRU(s) and running a go/no-go diagnostic to verify operation will restore the system to an operational state. The float level (number of spare LRUs for the ATE) will be sufficient to support repair times for the selected LRUs. In addition, priority can be given to fault-isolating the replaced LRUs for quick repair and return to stock.

4.3.5 Special Considerations

Currently the TRADOC plan is to expand the use of LCSS at Direct Support Level and discontinue its use of General Support (GS) and depot. The LCSS is used to provide maintenance support (automatic testing) for major assemblies and subassemblies of the ground guidance systems of Shillelagh, Dragon, and TOW (anti-tank missiles plus ground and airborne guidance and control systems) and LANCE plus selected associated test equipment. The LCSS and its Operational Mode Summary and Mission Profile (OMS/MP) are already in existence. If the LCSS is eventually replaced by a standard ATE DS maintenance, then the LCSS OMS/MP will have to be updated and will apply to that ATE configuration in this special application mode.

4.4 ENVIRONMENTAL, MOBILITY, AND RUGGEDIZATION CAPABILITIES

Van mounting of commercial off-the-shelf automatic test equipment is a critical issue that reaches beyond the peacetime environment. The issue is to determine whether commercial grade ATE can be packaged and handled in such a way as to make its use practical in a corps level General Support Shop environment. The results obtained by the Task Force reflect experience gained by users of commercial grade, computer-controlled instrumentation and data processing systems employed in a mobile or semi-mobile environment.

The findings were obtained in a short period of time (three weeks) by use of the most expeditious media and available study documentation. The findings do not, in any sense, present a complete picture, and it must be stressed that a complete in-depth study is recommended as a follow-on effort. The findings do, however, indicate that there are a considerable number of users scattered throughout the military services and other governmental agencies who have been successful in obtaining satisfactory service from commercial computerized equipment in fairly rugged environments.

The experience gained from van-mounted commercial equipment indicates a strong possibility that Army ATE can also function when configured in vans. Though off-the-shelf commercial equipments are not as rugged as MIL-spec designed hardware, they can be made performance-reliable when proper precautions are taken. It appears that commercial equipments do not perform satisfactorily in environments that differ from those normally encountered in the commercial world. (This may be a governing factor, restricting ATE usage to a controlled environment.) Further, commercial equipments are not designed to operate when subject to extreme temperatures, humidity, and vibrations. Since the present trend is to utilize off-the-shelf equipment, every effort should be made to ensure that the environment of the van-mounted ATE continually meets the commercial requirements.

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Appendix H contains the results of a survey conducted by the Task Force of seven users (see Table 4-3) of off-the-shelf equipment used in mobile or semi-mobile vans. On the basis of this survey a number of trends and conclusions are appropriate, as discussed below.

Table 4-3. WEAPON SYSTEMS SURVEYED

System	Location	Installation
CS3	Worldwide	Van, 35' STD
ECM Waveform Analysis	White Sands	Semi-Trailer 10' × 50'
Transp. Auto. EMC Meas. Syst. (TAEMS)	Fort Huachuca	Van, 8' × 20'
Res. Aircraft Meas. Syst. (RAMS)	Florida, California, Colorado	Aircraft
Comm. Satellite Monitor AN/TSQ-11B	Fort Monmouth	S-280 Shelter
Data Acquisition Ranging Telemetry System (DARTS)	White Sands	Van, 8' × 40'
Tactical Auto Dig. Switch (TADS)	Europe	Van, M29 1A2

4.4.1 Rack Mounting

Rack mounted equipments in vans equipped with air suspension systems seem to be adequately protected against shock and vibration resulting from transport over improved roads at normal highway speeds and short distances (100 meters) over rough terrain at 3 to 5 mph with either no shock mounting or only a minimum amount of shock mounting within the racks.

Present off-the-shelf equipment is not designed to withstand abnormal vibration, shock, bounce, etc. Component parts such as plug-in circuit boards are not usually provisioned with lock bars to prevent dislodgement. Further, there are no special heavy duty mountings to secure heavy motors, power transformers, floating suspension devices (e.g., disk memories), etc. In general, commercial equipment is designed for minimal stress and not "shake, rattle, and roll" abuse.

As a minimum, the van should be equipped with a combination of air bags and air suspension system to cushion the ride. This would suffice for transporting the ATE over paved roads at normal highway speeds. Also, this would be sufficient to transport the van from paved roads to an operating site located short distances (100 meters) from the paved road; speed should not exceed 5 mph, and discretion must be used. Additional cushioning measures could be employed to extend the slow-speed distance by shock mounting the ATS mounts within the van.

4.4.2 Van/Shelter

The van/shelter should be designed and configured to house the ATE and support self-maintainability of the ATE.

The van/shelter housing the ATE should be as large as possible and should be human-engineered to provide sufficient room for the maintenance man to work and to prevent him from sustaining personal injuries due to tight spacing and low overhangs.

The ATE within the van/shelter should be designed for easy movement in order to accomplish preventive maintenance (cleaning, tightening nuts/bolts, replacing parts, etc.). Modular subassemblies (digital volt meters, individual power supplies, etc.) should be enclosed in movable racks, where each rack can be moved for servicing from all sides. Each modular subassembly should be on slides within movable racks to allow individual servicing. The racks, subassemblies, or major units should be fully operational when moved to a maintenance position; all cables (signal and power) must be connectable so that technical analyses can be made while the system is operational.

Interconnecting cables should be designed and laid to prevent rubbing, binding, looping, etc., which would cause abnormal friction and wear due to the periodic movement of the equipment to a maintenance position for servicing.

A track or appropriate system should be used to guide heavy equipment and modular equipment racks to maintenance positions away from walls.

Measures should be incorporated to prevent dust and dirt accumulation, e.g., by installing rugs, air filtration systems, outer air lock chambers (inflatable rubber), etc.

4.4.3 Temperature

Commercial computers generally require an ambient temperature in the range of 60° to 85°F with humidity controls for overall quality operations. It appears that the majority of the problems related to van-mounted commercial equipment are tied to climate control equipment.

Every effort must be directed toward a climatic control system that will maintain an environment in which off-the-shelf commercial equipment will operate continuously without failure due to extremes of temperature or humidity. The average operating range specified by the majority of commercial manufacturers is from 50°F to 104°F, with 8 to 80 percent relative humidity. Experience has shown that the most effective operating range for continuous use is from 65°F to 75°F with 45 percent to 50 percent relative humidity. The nonoperating (storage) environment must be within -40°F to 167°F with 0 percent to 95 percent relative humidity (noncondensing).

Generally, when room temperatures exceed 85°F, solid-state devices tend to become erratic due to molecular run-away. This condition may be sufficient to promote hardware failures. Momentary failures are often sufficient to cause the loss of a program, which results in system downtime in order to reload programs and to restore/restart the system. Temperatures below 45°F will also contribute to erratic conditions. However, operating temperatures below 45°F are not recommended, in order to ensure an effective environment for operator and maintenance personnel. Extra clothing and cool temperatures can have a negative effect with respect to the efficiency of those personnel who are exposed to these conditions for long periods. In consideration of the mission and high dollar value of the ATE, human-engineered efforts must be considered.

The climatic control system should contain air conditioning, heating, humidifying, and dehumidifying equipment sufficient to maintain the environment in which the off-the-shelf ATE will operate without failure due to climatic causes. Experience with off-the-shelf ADPE (CS, IBM-360/361) mounted in vans indicates (in some cases dependent on location) that standard air conditioning (4 18K-BUT systems in each CS 3) was not adequate to maintain the required operating temperatures when external van temperature exceeded 95°F. Operation in these areas (Fort Hood and Fort Carson) also revealed that some of the standard humidifiers could not compensate for low humidity, which caused high levels of static electricity. It is believed that many bit errors (mostly parity errors within the computer memory) were caused by these static charges.

All air ducts should be designed to force conditioned air into the equipment fan input. This is essential to obtain the maximum efficiency of the climatic system. There is a great loss of air conditioner effectiveness when cooled air is not forced into the equipment. Further, air ducts should be installed to custom-fit individual subassemblies (DVMs, power supplies, etc.) with conditioned air up through the movable equipment rack.

A stable climatic system will prevent computer failure and will control rust and corrosion of unprotected metals found in commercial equipment. Off-the-shelf equipment is not provisioned to function in an uncontrolled climatic environment. High humidity will cause system failures as condensation lowers the designed resistive path and alters circuit configuration.

4.4.4 Power Generation and Air Filtration

When commercial power is unavailable, gasoline/diesel generators will have to be used as organic power. "Precise" generators should be used rather than "utility" grade ones. The precise generators have an overall tolerance of ±10 percent. Erratic load changes due to off/on operation of high-power-consuming users (air conditioner, heaters, etc.) will be transmitted to the ATE as erratic voltage/cycle changes. This can cause computer interrupt. Dust and dirt can cause damage to magnetic disc and tape memory systems. However, air filtration and moderate attention to "good housekeeping" seem to provide adequate protection against this hazard.

4.5 ATE LANGUAGES

4.5.1 Types of Languages

Languages are the means for programming test procedures to be run on Automatic Test Equipment (ATE), i.e., the means by which the test designer instructs the ATE to perform the required tests. These languages also may serve as a means for precise documentation of the required test procedures independent of the use of ATE. Languages range from low-level "machine" languages which are close to what the specific ATE actually does (i.e., they are in a detailed coded form related to the specific ATE) to high-order languages which are more English-like and closer to what a man would like to say. (Examples of non-ATE high-order languages are COBOL, FORTRAN, TACPOL, and JOVIAL). Programs written in a machine language are oriented to specific ATE; i.e., they are "machine dependent" in the sense that they would have to be completely redeveloped in order to switch to the use of a different ATE. Also, the highly codified form makes them difficult to understand. Consequently, redevelopment of such programs must be based on a return to the original machine language programs themselves. High-order language programs, on the other hand, tend to be machine-dependent, but they are less so. The transition of high-order language programs to a different ATE may not require a full redevelopment of the program if the new ATE employs the "same" language.* If the new ATE does not employ the "same" language, then program transition will usually require a major redevelopment of the software.

4.5.2 Software Problems

The level and quality of an ATE language and the way the language is used can affect software development costs. In fact, the high cost and poor performance of computer software have become problems of major concern in the DoD (reference recent DoD Directive 5000.29, "Management of Computer Resources in Major Defense Systems"). DoD software now costs in excess of $3.5 billion annually and, all too often, is also late and full of errors. Furthermore, software costs are now rising very rapidly in relation to hardware costs. Failure of the software to meet requirements is common. Software, rather than facilitating system growth and evolutionary improvement (its intended purpose), has been inflexible with respect to desired changes in software function or in hardware. It is now widely recognized that the present methods of software development are not sufficient to produce reliable software at an affordable cost. These methods include techniques and software tools for (1) software specification and design, (2) the synthesis of such specifications and designs into programs in the ATE programming language, and (3) the testing and validation of these programs against the original intent. The ATE language is a key element in this process.

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*In the absence of tight control of a language, many dialects can evolve. For example, the committee was informed that the Air Force uses more than fifty (50) versions of ATLAS. Such dialects impede understanding and the transition of the programs to different ATE.

4.5.3 Goals for Languages

There are several goals for programming languages which, if met, can reduce life-cycle costs and schedules. These goals are discussed below: (1) Transportability. A language, to the maximum extent practicable, should be transportable; i.e., the effort required to transfer a program to a different ATE should be minimal. (2) Reliability. A language, by its nature/structure should promote the development of error-free, i.e., reliable, programs. (3) Testability. Programs developed using the language should be easy to test (errors should not go undetected) and correct (if the software doesn't run correctly, the cause should be readily eliminated). (4) Modifiability. The language should facilitate later modification/enhancement of the programs. (5) Training. The language should be easily and quickly learned. (6) Specification. The specification of the language, i.e., what you can say in the language (syntax) and the action evoked in the ATE (semantics), should be clear, complete, and unambiguous. (7) Readability. Early programming languages had relatively simple structures and were oriented toward "writability." For example, many abbreviations, special terms, and numerical codes were used. Through this approach, individual programs tended to be generated rather rapidly by experienced programmers; however, when systems of a larger scale were attempted, software errors became excessively numerous and very costly to correct. Part of the problem (which still exists today) lies in the programming language and the way that it is used. The lack of structure caused the program sequence to branch every which way. This, coupled with an emphasis on conciseness, made programs appear to be much more complex than they really were and, consequently, much more difficult to correct or modify later. Today, the emphasis is on achieving "readability" (at the expense of writability if necessary) since it is now recognized that the cost of the original software development may be from one-half to one-tenth of its total life-cycle cost. Readability can be achieved through the elimination of abbreviations and codes and the use of language structures that permit the software to be divided into smaller more manageable pieces and that simplify sequence control and reduce the need for excessive branching (such structures keep the control flow "visible").

4.5.4 The Importance of Translators (Compilers and Interpreters)

When a program to test a UUT is developed in a high-order language, a translator program is required to act on the UUT program in order to convert it to an equivalent program in the machine language of the ATE. The UUT program in the high-order language is usually referred to as the "source program" and the machine language program (which is the program that actually "drives" the ATE during the testing process) as the "object program." Depending on its type, the translator program may be called a "compiler" or an "interpreter." The compiler (generally) must translate the entire source program into an object program before testing can begin. In the interpretive approach, the normal sequence is to translate one source statement into machine language and then to execute the test or action called for. OPAL and ATLAS are compiler-oriented languages (although some interpretation is possible). MOTEL is an interpreted language. There are advantages and disadvantages with each approach, which will not be explored here. In any case, the UUT test program that is expressed in the high-order language cannot be executed on the UUT by the ATE until the translator does its job. Translators are themselves very complex and expensive software programs. The development of a high-quality compiler or interpreter is a significant engineering effort typically involving development times from 15 to 30 months and R&D costs from $750,000 to $3 million depending upon the complexity of the language, the capacity of the computer it is to run on, the desired quality of the compiler (e.g., how much aid it provides the UUT programmer in the detection and location of a software error, its own modular structure, its efficiency, etc.), and the software tools available to aid compiler/interpreter development.

The translator is the embodiment of the language specification. If sufficient care is not taken, two translators of the same language may produce different/inconsistent results for the same UUT program.* This may occur if the language specification is vague, ambiguous, or incomplete, or if the compiler contains errors. Unfortunately, all of these are very common problems and occur more often than not. The combination of an ill-specified language and an immature compiler is a "formula for disaster" with respect to UUT software development. Compilers too often (1) accept bad language statements and do not advise the UUT programmer of the error, (2) reject the program even though the program meets the language specification, (3) reject a bad program but do not adequately aid the programmer (via error messages) in determination of the location of the bad statements, or (4) accept a good program but produce ATE actions that were not intended.

4.5.5 The Importance of the Run-Time System

The compiler's job is to produce a correct object program which is then run (executed) under the supervision of another large and complex program variously called the "operating system," the "executive", or the "run-time system." Some errors made by the programmer in the use of the language are not detectable at the time of compilation (by the computer) but can only be detected when the object program is being executed in the process of testing the UUT (i.e., at "run-time"). As with compilers, experience has shown that problems associated with run-time systems are legion, and statements similar to those made above with respect to the compiler can also be made with respect to the run-time system. To illustrate this, consider the case of a program being executed by a run-time system. After a while, the program (test) may stop running and the run-time system may print "ERROR, SRQ 1197." Upon looking this up in a book of error messages, one may find: (1) that SRQ 1197 is not listed; or (2) there exists an entry for SRQ 1197, but neither the programmer nor his associates, and frequently not even the developer of the run-time system, find it to be any clearer than "ERROR SRQ 1197." When considering a compiler, it must be understood that the compiler goes hand-in-hand with a run-time system. If a new compiler is

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*This is apart from any difference that might result from the use of different ATE resources -- e.g., timing differences.

being developed, then either a new run-time system must be developed simultaneously with it or the existing run-time system must be modified significantly. The compiler and the run-time system are very important parts of the ATE system. If poorly developed, then, on detection of a problem during UUT testing, it may not be possible to determine which of the following is faulty: (1) the UUT, (2) the JUT program, (3) the compiler, (4) the run-time system, or (5) the ATE.

4.5.6 Development and Control of Languages, Compilers, and Run-Time Systems

It can be concluded from the above discussion that the initial development and continued evolution of a language, its compilers, and its run-time systems are significant R&D efforts (in software engineering) requiring the same kind of management and technical attention normally given to the development of the weapons system that the ATE is to support. All compilers that are developed should be validated by an ATE software engineering activity that uses a common set of compiler validation tools (software) to insure compliance with the standard language specification. This same focal point should (1) gather data as to the use of the language; (2) disseminate information, compilers, run-time systems, and related software tools; and (3) assure language stability, i.e., prevent the proliferation of dialects and provide for carefully controlled evolution. Since these are R&D activities, it is strongly recommended that this focal point reside in an R&D organization.

4.5.7 The Concept of Language Standardization

Through language standardization, continued undesired proliferation of languages and language dialects can be controlled but only if, in addition, there exists a responsible organization that has (1) the capability to certify that the standard has been met in each case and (2) the authority to stop would-be offenders (or to cause them to be stopped). The use of a small number (ideally, one) of standard languages could cause many benefits to accrue. Common training and concentrated experience in the use of the language would result in the availability and easy transfer of personnel (both within the Government and at the plant) to satisfy new UUT software development requirements. There would eventually exist a large community of users of each standard language which could interact and exchange lessons learned. Efforts (1) to develop software tools for compiler and run-time system generation and validation, (2) to develop systems for data gathering and information dissemination about the use of the language, language standard, and run-time system, and (3) to test and certify newly developed compilers and run-time systems could be concentrated/intensified to achieve significant cost and time benefits. If the language which is standardized is by nature ATE-independent, and if a high-quality language standard is developed, then it would be possible to effectively "transport" previously developed UUT software to the next generation (replacement) ATE or to a coexistent ATE without major redevelopment of such software (in any case, UUT adapters may have to be redeveloped). Further cost benefits should accrue since the standard ATE programming language could serve as a common language for the documentation of test procedures.

4.5.8 Status of the OPAL Language

In the past, military contractors have been allowed to develop and/or use unique ATE programming languages for different ATE systems. The result has been the generation of an unjustifiable ATE language "Tower of Babel", where it is virtually impossible to use any one language across industry or military organizational lines. During the period 1970-1973, the Army made a serious attempt to address this situation through the efforts of an "AMC ATE Language Standardization Committee." Before this committee was able to complete its work, however, the problem was elevated to the DoD level. In January 1973, DoD (I&L) sponsored the formation of a Tri-Service, Army-chaired committee for Defense ATE Language Standardization (DATELS) into which the Army committee's work was to be folded. The DATELS Committee developed a Master Plan which was approved by the DoD in 1974; however, no funds were provided to carry out the plan.

The OPAL Language, which has its roots in an early 1970s' Army technology-base program, became an integral part of the DATELS plan. In early 1975, however, it became apparent that an impass had developed in the DATELS Committee with respect to the ATE language between the Army on the one hand and the Navy and the Air Force on the other. The Army believed that an all-out effort should be made to avoid the declaration of an interim standard and to complete and mature OPAL and bring it into use as early as possible. The Navy and the Air Force preferred that the ATLAS language be sanctioned for immediate use pending the maturity of OPAL. The services then proceeded to each go their own way on the issue.

In March 1975, the Naval Material Command issued NAVMAT Instruction 4120.105, which established ATLAS (based on ARINC Specification 416-9) as the interim Navy Standard ATE Language. The Air Force did not explicitly declare an interim standard but, in September 1975, did indicate its intention to promote the use of ATLAS in new procurements. In December 1975, the Assistant Secretary of the Army (I&L) (1) indicated that an interim Army standard language will not be adopted, (2) reported on near-term plans to develop several OPAL compilers and to achieve an early maturity of the language, and (3) invited Air Force and Navy participation in the effort to mature OPAL. In February 1976, the Adjutant General of the Army issued the requirement that Army ATE contractors should use the OPAL language for their products. In May 1976, the DoD (I&L) addressed the ATLAS-OPAL issue and took the position that neither of these languages (in their present forms) fully satisfies the requirement for the long-term DoD language standard. It was declared that both OPAL and ATLAS require additional development, refinement, and experience in realistic user environments to exploit their latent strengths, to ameliorate their present weaknesses, and to continue their covergence into a single language or language family. In this correspondence, DoD asked for the support of the Military Departments (1) in declaring ATLAS and OPAL as the only interim standards and (2) to accomplish a merger of ATLAS and OPAL into a single high-order language or language family as the DoD long-term standard.

The OPAL language has been undergoing a rapid evolution. Its original specification, proposed MIL-STD-1462, dated 30 September 1975, underwent a major revision which was published as Change 1, dated 25 May 1976. This version was the basis for development of an experimental translator from OPAL to ATS-BASIC that then provided the first hands-on experience/experimentation with OPAL (summer 1976). Experience gained through the OPAL to ATS-BASIC translator by McDonnell Douglas Corp., Tobyhanna Army Depot, and Frankford Arsenal, and an in-depth review of the OPAL language by the Army's Center for Tactical Computer Sciences (CENTACS) led to the preparation of the second major revision of OPAL, which was published as Change 2 on 22 September 1976. It was known at that time, however, that several problem areas still existed in the OPAL specification that required resolution. In spite of this, in an attempt to be responsive to the DA guidance and the TAG letter, a contract was awarded on 30 September 1976 to produce an OPAL compiler for the EQUATE system. Simultaneously, a committee of language experts was assembled under the leadership of CENTACS, during the period from 15 October 1976 through 15 December 1976, to resolve the known problems in the OPAL language. As a result of this effort, many of the known problems were solved, but many remained unsolved and many new problems were surfaced. Consequently, Change 3, dated 5 January 1977, was prepared; however, the preface of this specification identifies 23 important areas in which OPAL is incomplete. Further, many of the concepts incorporated into OPAL were novel enough to warrant an experimental validation and it was concluded that OPAL was still in an R&D status. Therefore, the contract was modified to address resolution of the incomplete areas of OPAL and to test the language's readability and writeability through the generation of UUT programs. The compiler development portion of the original contract has been postponed.

4.5.9 Basics of the OPAL-ATLAS Issue

Why continue with OPAL at all? Why not simply adopt ATLAS? Strong arguments can be (and have been) mounted on both sides of this issue. Clearly, ATLAS is the first widely accepted high-order language for ATE, and it certainly does capture most of the needs of automatic testing. It represents an evolution from the mid-sixties from ARINC ATLAS 416-1 through ARINC ATLAS 416-13 to the present IEEE 416-1976. While, ostensibly, this appears to be a healthy situation, in reality, the situation today is that there are so many different ATLAS versions that the language has become its own Tower of Babel. This has come about through an "escape clause" in the various ATLAS specifications that sanctions tailoring of the language to specific ATE, i.e., that tacitly supports the proliferation of ATLAS dialects. An important question arises at this point: If a test programmer was trained on one version of ATLAS, would he recognize another version as ATLAS and would he be able to use it? In most (but not all) cases, he would recognize the dialect to be ATLAS-based, but he probably would not be able to use it without training. (In some cases, this retraining might be substantial). Another important question is: Can the software developed using one version of ATLAS be transported to another ATE whose compiler recognizes another version of ATLAS? Not without a substantial amount of rework, but the similarities of most versions to each other may prevent going back to the original test requirements analysis.

ATLAS is basically a 1960s vintage language, thereby reflecting much of the early thought in language structure. In its early days, it was never intended to be both a test "programming" language and a manual test "procedure" language. Its success in the latter category is open to question; yet the language today remains somewhat schizophrenic in this regard; i.e., many features are irrelevant, even cumbersome, from the programming or the compiler viewpoint. The various ATLAS dialects exhibit a lack of modern structure with limited orientation toward reliability and readability, and an inability to support modern structured programming concepts, although several of these concepts have been included in the most recent ATLAS specification. The difficulty with today's ATLAS specification, however, is that new and old structures have been permitted to coexist, resulting in a language that is more complex and cumbersome than necessary.

OPAL represents the first really new approach to ATE languages and is generally recognized/accepted as the only ongoing R&D effort in ATE languages among the services. It is a state-of-the-art language that holds the promise of software readability and reliability and offers the promise of significant reduction of ATE software costs. It supports structured programming and has potentially new and important features for automatic testing such as those supporting virtual resources, variable partitioning, modularity, decision tables, software interrupts, UUT specification, units of measure, and test station description. OPAL permits the doing away with test and step numbers, which can be cluttering and cumbersome. However, there are 23 areas in OPAL that require additional work. They are: (1) the USE statement, (2) complex impedance, (3) thru-impedance, (4) test adapters and signal conditioning, (5) interrupt facility, (6) multitasking, (7) simultaneous usage identification, (8) precision timing, (9) additional test resources, (10) test system operator interface, (11) expanded virtual device concept, (12) synchronization, (13) triggering, (14) time interval measurement, (15) modulation, (16) nouns, (17) modifiers, (18) pin descriptors, (19) language violation actions, (20) semantic checking, (21) portability, (22) programming system, and (23) specification format. The work required in each of these areas is described in the preface to the Change 3 OPAL Specification.

4.5.10 The OPAL-ATLAS Merger

On 9 December 1976, the DoD (I&L) took action to start the formation of a DoD ATE Language Committee to provide control and lend stability to the current ATE language situation within the DoD and to address the requirement for a long-term common DoD ATE language. With this committee established, three major thrusts in ATE languages are evident: (1) the DoD ATLAS, (2) the IEEE ATLAS, and (3) OPAL. In order to prevent a divergence between the DoD and industry ATLAS proponents, a major effort in coordination will be required.

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In order to begin a merger, the items to be merged must be known quantities. In the case of OPAL and ATLAS, a baseline for a merger has not been established, since neither OPAL nor the DoD consolidation of ATLAS is ready. Only when OPAL and the DoD ATLAS are defined sufficiently and validated, will a serious attempt at a merger be feasible. However, it is important to realize that if OPAL and ATLAS become stabilized and controlled, then DoD will have gone a long way toward reducing ATE language proliferation. A merger at this point would make sense technically; however, it should be understood that such a merger would involve the design of a new language, which would be a long and complex process, the end result of which might be the addition of yet another ATE language to DoD's inventory. Further, history has shown that the design of a new language by a committee does not have a good chance of becoming a high-quality product. Consequently, it is recommended (1) that the OPAL language development be allowed to complete its R&D phase as originally intended by DoD, (2) that the Army support the DoD effort to reduce the proliferation of ATLAS through the DoD committee established for this purpose, and (3) that no effort toward a merger be undertaken at this time without a thorough analysis and clearly defined, agreed upon objectives (Note: TRI-SERVICE efforts are now underway to insure the DoD objective of a standard language is met.)

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4.6 CURRENT ATE CAPABILITIES

4.6.1 Industry Survey

The ATSS Task Force conducted a survey of industry in order to assess present ATE capabilities. Thirty-eight organizations were requested to complete a detailed capabilities matrix on the items in their ATE product lines. The data received constitute an adequate sample to represent the current state of the ATE industry. The following organizations responded with either completed matrices or very detailed capability data in other than matrix format:

- AAI
- Bendix
- Emerson
- General Radio
- General Dynamics
- Grumman
- Hamilton Test
- Hewlett Packard
- Honeywell
- Hughes
- Martin Marietta
- PRD
- Rockwell
- RCA

(In addition, the Task Force has had numerous discussions with many other companies involved in various aspects of ATE.) The capability data received have been consolidated, and a summary is included in Appendix I of this report. It is apparent that there now exists a burgeoning ATE industry replete with new concepts, competition, planned system growth, and the potential for production volume. (At the present time, however, production volumes of current-generation ATE are low. This will be discussed in more detail later.)

4.6.2 Use of Commercial ATE

If the industry investment in commercial ATE can be exploited to satisfy Army requirements, significant benefits are potentially achievable with respect to cost, delivery, performance, reliability, and support parameters. The existence of production items can insure low costs and shorter delivery times. In order to enhance their competitive positions, industrial organizations are continually attempting to offer products with improved performance and higher reliability. In addition, competitive production items tend to be better supported in the areas of logistics, maintenance, and training than items that are not in this class.

The commercial ATE is a composite/integrated system made up of (1) off-the-shelf commercial instruments, (2) an off-the-shelf computer system, (3) a system architecture and busing structure, (4) a switching capability, (5) special instruments (that are not off-the-shelf), and (6) a unified approach to physical integration and installation. Generally, only the commercial instruments and the computer systems are high-production-volume items that are widely used in both ATE and non-ATE applications. The remaining items tend to be peculiar to the specific ATE in order to provide the intended total system testing capabilities; i.e., they are special products of the ATE system integrator that are not generally available off-the-shelf. In order to satisfy the requirements of a customer, the ATE supplier performs the role of a systems integrator and, working with the customer, fashions a system containing only those testing capabilities required by the customer. A list of representative ATE system components is given in Table 4-4. A representative system configuration is shown in Figure 4-2.

Table 4-4. REPRESENTATIVE ATE SYSTEM COMPONENTS

DC Power Supplies	Waveform Analyzer
AC Sources	Logic Driver
Calibration Standards	Logic Receivers
Digital Voltmeters	Switching Matrix
Frequency Counters	Bus Structure
Function Generators	Computer
Frequency Synthesizer	Memory
RF Signal Generator	Display
Spectrum Analyzer	Printer
Harmonic Analyzer	Disk Files
Pulse Generator	Magnetic Tape Units

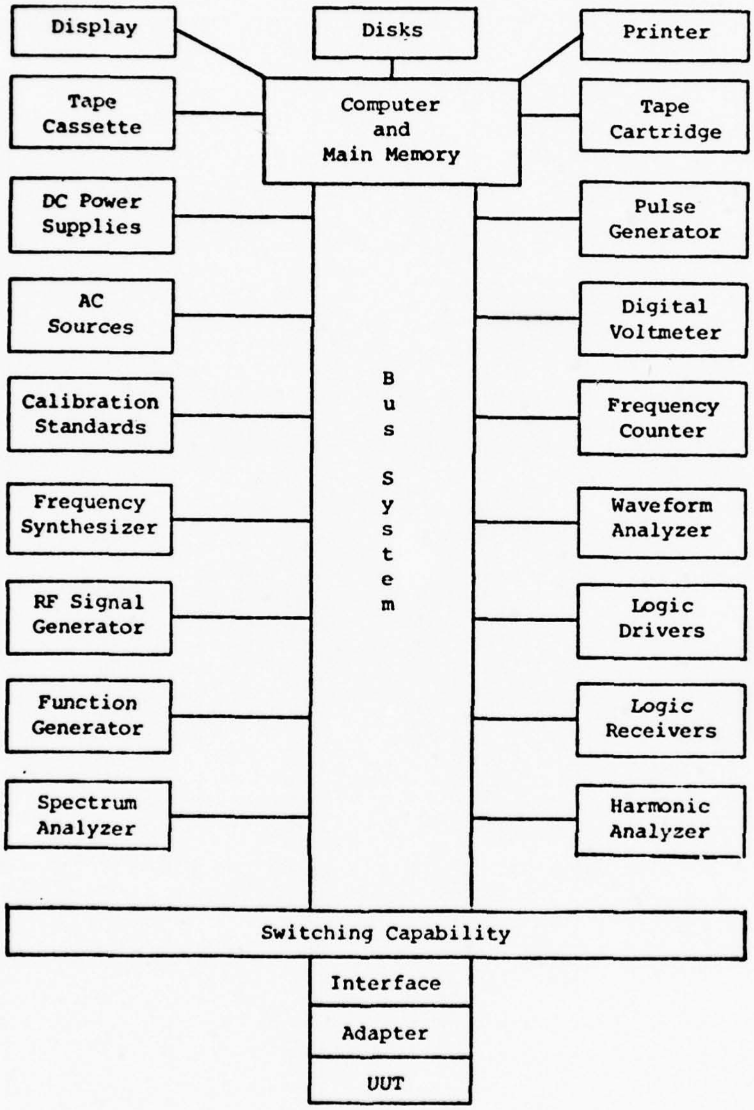


Figure 4-2. A REPRESENTATIVE ATE SYSTEM

The ATE system can be viewed as a collection of subsystems: (1) the computer system (items at the top of Figure 4-2), (2) the instrumentation subsystem, (3) the busing subsystem, and (4) the switching subsystem. Systems that are configured in this way can accommodate a wide range of testing capabilities through the flexibility of both the bus system and the computer software and the modularity of both the instruments and the switching system components.

As an example, two different ATE systems each use commercial computers, peripherals and Off-the-Shelf Electronic Test Equipment (OTS-ETE). One system is generally designed for interfacing discrete instruments that are generally designed on a series of special circuit cards based on government owned drawings and as such the use of OTS-ETE is minimized.

Quantities of Army-owned latest generation ATE is shown in Table 4-5. Clearly, these systems have not yet reached a level of production maturity. All of these systems are limited to operation in a reasonably benign commercial environment, even though the military is by far the largest single customer.

Table 4-5. CURRENT-GENERATION ATE

System	Manufacturer	Number Delivered	Number Being Produced
TAFFS	Hughes	0	6
5565	AAI	4	8
MATE	Martin-Marietta	3	2
VSM/410	RCA	6	8
HP 9580	Hewlett Packard	1	8
HATS	General Dynamics	19	3
SCATEMARK II	General Dynamics	0	16
8200-8205	Emerson	13	3

Can commercial ATE satisfy the Army's testing needs? With regard to functionality, analysis of the ATE requirements and capability data submitted to the Task Force indicate that, collectively, the required capabilities exist in industry today in the latest-generation commercial ATE. With regard to ruggedization, it appears that the requirements delineated in Section 4.3 for RGS-level use can be met by the commercial ATE. One distinction between a commercial product and one whose development and production are wholly supported by the military is that, for the latter, the Government must sponsor the capability for all production, provisioning, maintenance, training, etc. It is well known that this is an expensive proposition. Many dollars could be saved if industry could be relied on to sponsor and continue to support this capability. The Task Force has queried industry about this matter, with the following results:

- Reliability Improvement Warranty (RIW). An RIW plan that commits the contractor to perform depot-type repair services for a fixed duration of operating time, calendar time, or both, at a fixed price appears desirable. While the major expenditures of a warranty procurement are for the repair services involved, the prime thrust of the approach is to achieve acceptable reliability. The question of whether the contractor can provide depot repair services at a cost lower than that of military repair is secondary to the objective of reliability achievement. It appears that the required levels of reliability can be achieved and RIW can provide the vehicle for its achievement.

- *Production and Replacement.* ATE components can be expected to have an active production period of from five to seven years. However, industry tends to support its customers by upgrading as technology advances in order to produce new items that can replace previous items with plug-to-plug physical as well as functional compatibility. Generally, the new items tend to have improved speed, performance, and reliability; and reduced size, weight, power, and cost.

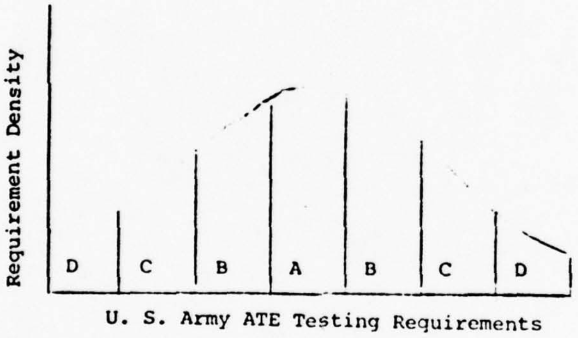
- Parts and Service. Spare parts and maintenance service as well as operational maintenance training can be expected to be available for about nine to ten years; after this period, such support will become increasingly more expensive. The logistics support is complicated by the introduction of newer model instruments in place of the older version and the fact that a controlled cannibalization program must be instituted to extend the useful life of some of the older versions of the instruments.

- Dependence. It is obvious that there will be a strong dependence on the commercial ATE supplier. Will the Government find itself in a position in which the commercial supplier will be able to gain an unfair advantage? During the active production period, marketing goals will keep prices competitive; nonetheless, the Government may eventually be "locked in" to his supplier because a shift to another ATE generally involves a redevelopment of the UUT software. The best way to avoid this problem is to structure the software for transportability and to use a standard ATE language. Today, however, no such language exists (see Section 4.5). Another approach to avoiding the lock-in problem is to adopt or select an ATE whose structure is sufficiently modular that it could be supported by a second-source systems integrator. Specifically, if off-the-shelf instruments are used to the maximum extent possible, with the number of special instruments kept to a minimum, if the computer system is off-the-shelf, and if a standard bus structure is used (the only one currently in existence is the IEEE bus), then dependence on the original system integrator can be reduced significantly.

4.6.3 The Core Concept

The concept of a core ATE has been discussed extensively by the Task Force. In this concept, it is assumed that a core ATE system could be expanded or tailored to satisfy specific classes of UUT testing requirements, such as those for radios, microwave systems, digital systems, automotive systems, hydraulic systems, etc. For example, every testing system needs power supplies, but the needs vary widely.

The thrust of the core concept is to achieve a significant degree of commonality across ATE requirements for disparate testing in order to realize the kinds of cost savings that usually result from commonality. Figure 4-3 illustrates such a concept.



A - Common core requirements
B - Modular add-ons to the core
C - Interface adapters and ancillary equipments will satisfy these requirements
D - Not cost effective for ATE use

Figure 4.3. THE ATE CORE CONCEPT

4.6.4 Modular Concept

A concept that can offer the desired commonality is "modularity". The modularity concept for ATE parallels modularity in computer systems. In essence, a flexible total system ATE architecture is adopted or defined that embodies the computer subsystem, the UUT interface subsystem, the busing structure, and the physical/mechanical system for mounting, cooling, etc. Each of these subsystems will have its own degree of modularity, i.e., will be expandable from its own "common core". The instrumentation capability derives from attaching to the bus various modules as required. What is important here is not a core testing capability but the proper definition of the range of testing capability, i.e., the instrumentation modules that can be added to the bus. Also, the computer system software (compiler and run-time system) must be "aware" of the specific modules to be used in a specific testing configuration. In this concept, the user of the ATE will be able to configure a specific system out of a modular family of ATE building blocks to satisfy his needs. The modular approach also makes it possible for the entire modular family to grow by the definition and addition of new modules as requirements demand expanded testing capabilities.

4.7 ATE FUTURE CAPABILITIES

4.7.1 Future Testing Needs

Future testing needs will differ markedly from those of today, especially in the area of electronics. This change will result from the tremendous increases in circuit density and complexity per discrete element, extremely sharp reductions in cost per circuit, and great improvements in reliability. Many of these changes are already evident in digital electronics. The number of gates per chip (discrete element) has doubled each year since 1960 (an increase of three to four orders of magnitude) and promises to double every two years during the next six years. In the area of microcomputers, the potential exists for 100,000 gates per chip for the CPU and 1,000,000 gates per chip for the memory. By 1980 we should be able to buy a 16-bit CPU with 32 kilobits of memory all on a single chip operating at a million instructions per second. We should also be able to buy a 64-kilobit RAM chip within the next few years.

As the number of active elements on a chip has doubled, the cost per active element has approximately halved. Today, the cost of a single gate is less than $0.05. Stated another way, the cost of 20 gates today is about the same as that of a solder joint. The cost of the 16-bit CPU with 32 kilobit memory mentioned above will be about $10. The INTEL 8080 computer, which cost $300 in 1974, now sells for under $20.

Circuit reliability has increased three orders of magnitude since 1960 and promises continued improvement. A MTBF of 100,000 hours per chip is being approached rapidly.

At present, the military is building equipment with complex many (710) layer printed circuit boards containing many discrete and LSI circuit elements. The task of testing such a PCB is extremely difficult since the number of externally accessible points is very small compared with the extent of the electronics internal to the PCB. In effect, there is a limited electronics "window" into such a complex PCB, and every attempt to widen this window will either increase the size of the PCB or force the use of greater numbers of smaller, less dense PCBs. In either case, the net effect is an increase in size and weight, i.e., a reduction in overall equipment density in order to support the testing function. Actually, the ability to test even a single LSI chip properly without highly specialized test equipment is questionable, and this raises serious doubts about the ability to test such items at any level in the field.

The situation depicted above does not apply to all of the PCBs or LRUs to be tested by the Army in the field during the next 10 years, but it does present a real problem which will affect future ATE requirements. While the large-scale general purpose ATE will still be required, it will probably not be adequate for testing tomorrow's more complex, high-density digital electronics. The approach to be followed with respect to such electronics is to take advantage of the low-cost/high-density situation by introducing fault-tolerance capabilities to increase effective MTBF to the point where actual failures are rare and making maximum use of built-in test circuits to achieve effective self-diagnosis. It should be anticipated that built-in test capability will increase PCB costs by approximately 10 percent.

4.7.2 Future ATE

Future equipments will also use more sophisticated non-electronic components that will require testing in areas such as optics, fiberoptics, pneumatics, hydraulics, infra-red, lasers, and temperature. Most of the interfaces of such devices to the ATE, however, will be through electronics means, and it is anticipated that the general purpose ATE will be able to satisfy those testing requirements through the use of devices peripheral to the ATE that are oriented to the technology at hand.

ATE capabilities will tend to grow in an attempt to meet the level of sophistication of tomorrow's military hardware. The large-scale general purpose ATE will also benefit from advances in technology, especially in the digital area, and will become a good deal smaller, cheaper, more powerful, and more flexible than it is today. Tomorrow's ATE will have much more flexibility within its established maximum configuration. Such flexibility will come about through modularity, which will allow the construction of a wide range of configurations up to the maximum configuration. These ATE will also be more adaptable in the sense that they will be able to readily accommodate new testing capabilities by modular addition to the established maximum configuration. A common busing structure, including standard instrument interfaces, modular expandable run-time (operating) systems, and "smart" instruments that include microcomputers, will facilitate a high degree of flexibility and adaptability. Such systems will tend to be more technology-independent and open-ended. The concept of adaptability mentioned above will be supported by modularly structured compilers that will be readily able to accommodate new testing capabilities in the ATE high-order language. In the future, some progress should also be made toward achieving standard interfaces between the ATE and the UUT.

Tomorrow's ATE language should be a modern language that will offer significant improvement in UUT software costs, reliability, and growth over the current languages. The future language will be supported by a software development environment that will reduce UUT software costs drastically by providing sophisticated tools to aid software design development, software changes, software testing, and software configuration control. This is one area that, up to this point, has been badly neglected.

Future ATE systems will facilitate the configuration of a distributed ATE in which there could exist multiple test stations that would operate under the supervision of a controller. There would be a computer at each test station as well as at the controller, but the controller configuration would probably contain a fully expanded computer system with a large main memory and a large disk file.

Each test station would contain only those testing capabilities (modules) required to do its job. For example, there might be a microwave test station, an RF test station, an optical test station, a digital test station, etc. The controller might perform the functions of scheduling and dispatching, provide a common software library, perform configuration control, serve as a test station back-up, provide a software development environment, consolidate and analyze test data, and prepare orders for replacement parts.

Tomorrow's ATE must facilitate simultaneous set-up, testing, program development, and self-check. Simultaneous set-up and testing is extremely important since so many problems in practice are due to the test set-up itself (cable problems, etc). It would be far more effective if the equipment remained connected to the ATE until the repair was completed and verified.

Other features that may aid testing in the future include voice instruction, automation (to an extent) of UUT software generation from circuit descriptions, and inclusion of optical or magnetic data on PCBs that will be readable by the ATE in order to eliminate manual lookup of PCB type data to feed the ATE. This will also facilitate recordkeeping with respect to each individual card.

4.8 DEVELOPMENT AND PROCUREMENT OPTIONS

4.8.1 General Issues and Constraints

Historically, procurement has been one of the most vexing aspects of the materiel system life cycle. There are many factors that contribute to this situation. In addition to serving the immediate military need, the procurement process must also consider serving a number of other objectives, including the furthering of socio-economic programs relating to the use of small businesses, minority business enterprises, and labor-surplus-area firms. This, coupled with the budget cycle, funding problems, and prevailing laws and regulations, seriously constrain procurement action. The foregoing factors influence administrative lead time, development lead time, and production lead time required for procurements. All of these mitigate against meeting the delivery requirements of the user. In the following paragraphs, procurement issues related to competition, use of commercial/commercially based equipments, maintenance, warranties, technical data packages, and full-scale engineering development are discussed, with emphasis on current ATE problems.

4.8.1.1 Competition

Complicating the ATE procurement problem further is the intense industry competition relative to electronics and electronic devices and equipments. This competition, which is highly beneficial in most cases, promotes the submission of proposals from marginally qualified as well as unqualified bidders. Each proposal received demands full consideration and evaluation, with the result that contract award is often delayed. Procurement statutes and regulations require competition be solicited in all practicable cases. Competitive procurement techniques must be utilized unless cogent reasons can be shown (and the appropriate level of approval obtained) in support of a conclusion that such competition is not practical or is not in the best interests of the Government.

The decision as to whether to enable competition in the acquisition of an ATE system is any subsequent procurement should be based on an economic analysis that considers what might be saved through competition and the costs of acquiring and validating the technical data package as suitable for competitive procurement. In addition to the cost considerations, the time required to acquire and validate the technical data packages must be considered with respect to user need dates for the added systems. An example of such a situation might be a life-cycle-cost analysis demonstrating that continued sole-source procurement of an existing fielded system would be necessary because of field limitations on maintenance support or overall reduced life-cycle cost to the Government through the elimination of different systems.

The pressure for competitive procurement, in turn, may require the breakout of certain components for competitive procurement in an approved sole-source system procurement. Therefore, consideration also must be given to the feasibility of component breakout for system components on which the Government possesses form, fit, and function data sufficient to permit competition. These "black box" components would themselves be commercial items (for example, power supplies, DVMs, etc.). The feasibility of such component breakout must be determined on the basis of a decision risk analysis, which would consider the possible procurement cost savings obtainable through competition and such offsetting factors as the risk of delaying the system prime contractor through late receipt of GFE, possible incompatibilities between the GFE items and system needs resulting from engineering changes, and the dilution of the system prime contractor's responsibility for overall system performance. If the system is still undergoing some development, the system prime contractor, in accomplishing his system's integration responsibilities, may find it necessary to modify the prospective GFE items; and the introduction of the Government as the supplier of those commercial items at this time would tend to impair timely and efficient prime contract performance. (On the basis of the foregoing considerations, it appears that such a component breakout would probably present an unacceptably high risk in connection with ATE procurements during the near term.)

4.8.1.2 Use of Commercial Equipment

A further procurement complication has recently been introduced by the policy that requires maximum reliance on the use of commercial equipment (off-the-shelf equipment whose performance is described by the manufacturer's specification) rather than development and procurement of items to special military design, provided that the commercial item meets the military need.

This complication affects the evaluation process in the placing of awards remains an important factor throughout the life cycle of the item being procured, particularly in connection with the provisioning for and maintenance of the item. In addition, current Army policy draft AR 700-18) requires that commercially available end items not be provisioned without prior validation of a need for on-hand inventories of support items in lieu of reliance on commercial sources for support. (In its application to ATE, this policy could mean that black box components -- for example, a digital voltmeter (DVM) -- would not be provisioned as a spare when it could be reasonably expected that maintenance needs for the DVM could be met through direct/local procurement from commercial inventories or through commercial repair of malfunctioning DVMs.

Policy emphasis is on the maximum use of commercially available items and maximum reliance on commercial maintenance support for such items stems from the desire to minimize Government expenditures by eliminating unnecessary R&D, investment in large repair parts inventories that may not be needed and have the potential of becoming obsolete, and the expense and difficulty of maintaining the highly skilled military maintenance personnel needed to perform organic repair of commercial equipments.

From the foregoing, it becomes apparent that the economies which may be achieved by eliminating military piece-part inventories and repair capabilities is incompatible with the important military objective of maintaining immediate combat readiness for military activity on a worldwide basis. Those facilities which are available under peacetime conditions may not exist in a wartime environment; for example, a number of electronics manufacturers have worldwide repair facilities to which equipments may be returned for repair or replacement. In the event of a national emergency and active combat, the availability of such overseas facilities immediately becomes questionable, as does the commercial pipeline necessary to assure the required supply of parts and replacement equipments. Additional tactical considerations, such as the time required to secure commercial repair and the difficulty of returning malfunctioning units to the repair site, represent a degree of risk that may be intolerable in terms of equipment downtime and reduced combat capability. These factors become particularly significant when ATE unavailability may, in turn, prevent operation of a large number of tactical weapon systems supported by it. Accordingly, it is considered necessary to develop a balanced procurement strategy that provides sufficient assurance of mobilization readiness under a variety of possible conditions, while recognizing the cost trade-offs involved through complete reliance on the commercial sector.

If it is assumed that maximum use will be made of commercial equipment, then the Government Technical Data Package would define the commercial equipment by performance specifications, source control drawings, specification control drawings, or manufacturer's numbers. Each of these specification methods and associated procurement factors is explored in the following paragraphs.

Performance Specification. A performance specification is a statement of technical requirements setting forth performance parameters (measurement and stimulus capabilities, size, weight, etc.) that must be met by the item under procurement. If a performance specification is used as the basis of procurement, the Government assumes complete responsibility for adequacy and accuracy of the equipment purchased to that performance specification. The procurement can be competitive. A disadvantage of this approach is that repair by the Army is not feasible; we cannot define the internal design of the item(s) in a performance specification.

Source Control Drawing. A source control drawing identifies a required item (component, subassembly, or complete item) by a manufacturer's part number or model. The drawing may also contain the dimensional outline and some performance characteristics. A source control drawing is effective only for sole-source procurements. This method permits procurement from reputable suppliers and provides for short procurement lead times, adequate technical manuals, parts support, and availability of training at the box level. A disadvantage of this approach is that it precludes any cost break through competition. Furthermore, sole source or single source is contrary to established DoD procurement policy.

Specification Control Drawings. A specification control drawing sets forth form, fit, and function of a required item (piece-part, subassembly, or entire item). This drawing may also contain a dimensional outline. If equipment is bought to specification control drawings, competitive procurement is enhanced. One of the advantages of the use of specification control drawings is that we can define the form, fit, and function requirements through the piece-part level. The disadvantage is that no support of the internal configuration of an assemblage or support or documentation for maintenance, training, or supply is possible.

Manufacturer's Part Number. Items procured by manufacturer's part number are subject to the same procurement constraints as those procured under Source Control Drawings.

Maintenance Support. Although military readiness dictates efforts to develop an organic maintenance capability, if the initial density of the equipment is low, then consideration should be given to procuring maintenance services from the system contractor. Action should be initiated as soon as possible thereafter to transfer the maintenance expertise to an appropriate military cadre to obtain the mobilization readiness and versatility inherent in an organic repair capability. (Military repair capability for ATE necessitates the availability of commercial equipment manuals, both operator and repair type. Permission must be obtained under the copyright clause to enable printing and distribution of such manuals by The Adjutant General [ATG]).

Warranties. Use of contractor warranty as a means of equipment maintenance or system support offers some advantages in terms of minimizing investment in parts inventory and in assuring the quality of the repairs performed. The major problem in this regard is the lack of a uniform warranty provision suitable for Government use; specifically, the length of the warranty period and the start time for the warranty do not meet Government needs. This problem is compounded by the fact that we propose to use a large number of commercial items of equipment in the ATE, each having its own warranty conditions and provisions. A satisfactory warranty provision for this situation does not exist. The same area has been addressed by the Defense Science Board Task Force on general purpose off-the-shelf electronic test equipment. The DoD implementing measures resulting from this latter group's activities will be monitored for their applicability to the ATE situation.

Applicability of reliability improvement warranties should be studied. Reliability-improvement warranties are normally negotiated in association with the product contract and apply to the operational use of the production items. Because of the long-term commitment being made by the contractor, warranty is recognized as an added service that the prospective contractors are asked to quote at a separate cost. This provides the government the opportunity to evaluate the economics of the warranty versus non-warranty procurement. Funds for warranty have been obtained from both production and operation/maintenance sources. If operation/maintenance funds are to be used, incremental funding may be necessary for long-term warranty since this funds category can be committed on an annual basis only.

4.8.2 ATE Development/Procurement Options

Requirements for ATE delivery dates that fall within the next two to three years can be satisfied only by systems that now exist or are nearing the completion of development. It is anticipated that the systems so selected will be operational well into the 1980s. An important goal for this period is the minimization and control of ATE system proliferation to reduce the number of different ATEs to be introduced into the field and the depots.

Near-term commonality has many dimensions:

- PM Control of Commonality. This approach would give control to the weapon system PM and it would probably involve a significant degree of vertical commonality .
- Ad-Hoc Control of Commonality. The decision as to whether a horizontal commonality approach would be pursued for a given PM system would be made at ATE selection time and not on the basis of any pre-established policies.
- Commodity Commonality. An interim standard ATE would be established separately for each commodity class: missiles, communications, avionics, tactical data, tank-automotive, target acquisition, etc.
- Cross-Commodity Commonality. There would be a standard across two or more commodity classes but not necessarily across all such class, e.g., commonality across communications, avionics, and tactical data systems.
- Single Standard. This involves the selection of a standard ATE for use in every system. Both vertical and horizontal commonality are implied.

The ideal case for commonality is that which employs a single standard. However, it has not been shown that this approach is cost-effective nor has it the fewest technical, procurement, and management risks. Even if a single standard were not immediately achievable, commodity or cross-commodity commonality might offer significant reductions in proliferation and significant cost benefits. Analysis of the ATE requirements matrices indicates that both commodity commonality and cross-commodity commonality can be achieved through the use of today's ATE. (This is a result of the bus organizations and the modular expansion capabilities of such ATE, which will permit each system to accommodate a wide range of instrumentation.) This degree of commonality could be achieved through the selection of one or more ATEs now being used by the Army, the selection of one or more ATEs now available but not being used by the Army, the engineering development of a new ATE for Army use, or a combination of these approaches.

4.9 MANAGEMENT OF ATE

In the past little guidance has been available for managing ATE acquisition and use within the Army. Each individual user has developed his own procedures, and configuration management has been a major problem because of people at each level "getting into the act", the proliferation of projects within the Army that involve ATE acquisition, and the lack of standards. At times, the people with the most funding have controlled management at the expense of other people in the chain. Clearly, a plan of action is needed to determine how to handle ATE management and who is responsible for each part of it. Specifically, the following questions should be addressed:

- At which level (commodity, contractor, command, service, maintenance) should changes be managed?
- Who should pay for any changes (change initiator or people affected by change)?
- Who should develop test program sets (TPS) and TPS standards?
- Who should manage TPS and testability standards?
- Who should manage new techniques for application software generation and language development?

4.9.1 Organizations Currently Involved in ATE Management

A system's PM decision regarding the specific ATE to be utilized in support of its equipment may currently be subject to challenge or approval from the commodity command and TRADOC. It is significant that the ATE decision criteria may be dissimilar and have conflicting decision frameworks. Example:

The PM is motivated by schedule and technical performance criteria as they apply specifically to the items to be fielded and to minimizing those ATE costs under PM control. A commodity command can (as is currently the case) restrict the PM's ATE choice so as to optimize cost, schedule, and technical performance considerations within a commodity command context. TRADOC is concerned over the considerable burden on our readiness posture by supporting multiple ATE systems.

4.9.2 AR 1000-1 vs AR 750-43

The question of who will make the final decision on TMDE required to support a weapon system -- the PM of the weapon system; the commodity manager; or others. AR-1000-1 states the basic policies for systems acquisition and, starting with the LOA, addresses the logistic support requirements of these systems. These requirements, which include TMDE, are stressed throughout the system acquisition process. AR 1000-1 further states that there are three methods for satisfying Army needs, the first of which is ".....buying equipment already developed". This implies that if a standard item exists and it meets the system requirements, the PM is obligated to use that standard item.

AR 750-43 prescribes policies for TMDE. Should a particular problem not be resolved, the AR then states that the conflict will be surfaced at DA for resolution.

TMDE decisions are as follows: The weapon system PM selects from the Preferred Items List (PIL) those standard TMDE required to support the system. If the PIL items are not technically or functionally acceptable, the PM has three choices: (1) recommend the modification of a PIL item, (2) recommend the development of a new item, or (3) recommend the selection of another existing Army TMDE.

4.9.3 Alternatives Available

Two fundamental organizational concepts are considered viable, each containing numerious options:

A. The Status Quo alternative with no fundamental changes in organizational responsibilities for the interim with PM-ATSS for the future.

B. A Program Manager approach, whereby ATE management functions are immediately consolidated.

There are inherent benefits and penalties associated with each alternative. While the Status Quo solution results in minimal organizational disruptions and provides a stable base to improve upon known faults through clarification of roles, it will also tend to perpetuate existing inadequacies and delay required organizational changes. The approach can provide for intensive management at a level close to day-to-day operations. The Program Management concept can permit optimized acquisition and fielding decisions.

4.10 COST ANALYSIS

During the time the Task Force was in session, efforts were made to perform a comparative cost analysis between two systems. The effort was not completed for two primary reasons: (1) the Task Force was unable to establish a basis for a valid comparison; and (2) the cost data received by the Cost Analysts from the contractors could not be validated by the Comptroller's Office because of a lack of detailed justification in certain areas. Consequently, no comparative cost analysis is published as a part of this report.

4.11 TRAINING CONCEPT

4.11.1 Assumptions

The following assumptions are made:

- The ATE selected for Army use will be designed for minimal operator skills.
- The equipment function will be computer-directed, providing the operator with complete instructions for operating the equipment and conducting appropriate UUT testing.
- The equipment will have a self-test/diagnostic capability to automatically detect and isolate single failures to a replaceable module or instrument level.
- The materiel developer will have the responsibility for interfacing the peculiar UUTs to the test set.
- The operator will not be permitted to perform software maintenance or program development.
- Operator maintenance will be limited to preventive maintenance and to instrument or module replacement only. Operator diagnostics will be limited to those functions automatically directed by the ATE.

4.11.2 Circumstances Bearing on the Problem

The following circumstances will incluence the training concept:

- ATE will be employed at the commodity-oriented GS facilities.
- Module/PCB repair (component replaceable on board) will be performed at the GS facility for selected items on the basis of appropriate Repair Level analysis (use of GEMM TRIM, and/or other appropriate models).
- Adaptors will be peculiar to the Weapon System UUTs being supported. Maximum commonality of adaptors by weapon system will be employed (one adaptor that can handle a group or family of UUTs).
- Commonality of adaptors across weapon system lines would be desirable, but this would require a complex development program because of the coordination effort required between PMs.
- There will be a requirement for ATE maintenance beyond the organizational level. This will require a fault-isolation and correction capability beyond that which is computer-directed.

4.11.3 Discussion

The operator of the ATE will have two primary functions: (1) to use the ATE as an instrument to check and diagnose faults on LRUs, PCBs, modules, and repairable assemblies sent to the RGS facility for screening or repair; and (2) to perform organizational maintenance on the ATE itself. Due to the cost vs. throughput of any ATE selected, the GS must make maximum use of the equipment and minimize any downtime resulting from system or subsystem failure. The ATE selected should therefore have an automatic self-test and diagnostic capability that 95 percent of the time permits fault detection and isolation down to an operator-replaceable module or instrument. The operator could thus operate and maintain the equipment most of the time with minimum skills peculiar to the ATE.

For failures that cannot be isolated by means of the ATE self-test capability, a skilled ATE repairman will be required. This individual must be intimately familiar with the peculiarities of the ATE being supported and be able to augment its inherent self-test capability to diagnose faults and effect repair. The importance of this distinction is a function of capability gained through specialized training and experience. Assuming that the ATE selected has an MTBF of 250 hours with an inherent availability (A_I) of .99 and operates 24 hours per day (23 hours for mission, 1 hour for PM), the system will then be operational 8,672 hours out of a possible 8,760 hours per year and require 32 separate maintenance actions. These figures are based on inherent availability and do not include normal logistical downtime (NLDT). If the ATE can automatically diagnose 95 percent of all single malfunctions to an operatcr-replaceable component (instrument, card, or module) and the ratio between single malfunctions and multiple malfunctions is 5 to 1, the 32 maintenance actions per year can be broken down as follows:

- Single malfunctions - 25
- Multiple malfunctions - 5
- Manual diagnostic action - 2

Further, with a total MTTR of 2.5 hours for all levels of maintenance, the annual maintenance burden is 80 hours. If the operator performs maintenance actions only when the fault is diagnosed automatically and the operator MTTR is 0.58 hour (30 minutes for automatic fault isolation and 5 minutes for removal and replacement). The annual operator maintenance burden is 14 hours for 24 maintenance actions per machine. The remaining 8 maintenance actions would require intermediate maintenance and account for 66 annual hours of maintenance per machine. This translates into an average of 5.5 hours of maintenance above operator level per month. Thus if it were desired that all maintenance be performed by the operator, it appears that the frequency of fault isolation and repair beyond that which is computer-directed would be so low that he would never become proficient. On the other hand, if a separate skill were established for this maintenance, then the number of repairmen authorized would be based on the density of ATE supported. The operator's workload would then be such that he could maintain his proficiency, and efficiently and effectively maintain the equipment.

If the goal of developing a common core family of ATE for the Army is met, then it follows that MOS could be designed to perform intermediate maintenance on this common family. The ATE maintenance technician would have a system maintenance responsibility and provide the expertise necessary to isolate and correct those malfunctions not correctable at the operator/organizational level. The skills required would have to include computer maintenance (since without the computer there is no automatic self test) and extensive knowledge in electronic troubleshooting. In many cases, no matter how effective the self-test procedures are for any equipment, multiple failures can cause ambiguities that cannot be isolated through automatic test. Further, there may be failures in one component that affect other circuits in such a manner (because of dependent relationships) that a good component appears defective and "fools" the automatic self test. In addition, software maintenance skills will be required at the intermediate level to provide at least the capability to distinguish the difference between software- and hardware-related faults and submit software investigation reports (SIRs) when anomalies are found.

The operator, relieved of the maintenance responsibility, will spend most of his time interfacing, testing, and repairing commodity-peculiar UUTs, using the common ATE. As the skills required to operate the ATE are expected to be minimal, his predominant skills will be oriented toward the commodity-peculiar adaptors, interface devices, and UUTs to be tested. The operator's UUT knowledge should be sufficient to augment automatic diagnostic procedures performed by the ATE and to repair unserviceables while they are affixed to the ATE (when this is determined to be advantageous). In addition, if the application program is faulty or the ATE fails during a UUT test, the indication could be ambiguous and show a UUT failure. To effectively differentiate between UUT failures and ATE failure, then, the operator must have an intimate knowledge of the UUT. Thus, in addition to ATE operation, he must have a detailed knowledge of the electronic, mechanical, and optical characteristics of the commodity UUTs. This evaluation is consistent with other service lessons learned and Army testing of the AN/USM-410.

It does not seem possible that one course or one school could effectively teach an operator to use all possible adaptors and interfaces and test and repair all peculiar UUTs. It does appear feasible, however, to develop one Plan of Instruction (POI) for ATE peculiar operation--that is, to instruct the operator in the loading and running of programs, the use of all I/O devices, and the operation of ATE self-test and calibration procedures.

The training period must be short (no more than 160 hours). Therefore, little would be gained by providing centralized training for operation and then shipping an operator to a commodity-oriented school for the remainder of his training on the commodity-peculiar devices. Further, to reduce MOS proliferation, existing commodity-oriented Military Occupational Speciality (MOS) selected by each commodity would already include training on the maintenance of peculiar UUTs, the inclusion of ATE operation should provide little increase in course length. This approach has several distinct advantages. First, the operator MOS would not be peculiar; thus a density of operators would be available in the shop. This ensures that sufficient operators will be available in the facility to permit rotation and prevent the boredom inherent in operating automatic equipment. Second, since the individual has commodity skills in addition to ATE operation, he can be effectively utilized when the ATE is down for maintenance. Third, the total skills required by the operator will be oriented toward the actual task complexity.

Intermediate maintenance of common ATE components should be consolidated into one GS facility. At this facility, the ATE modules/instruments will be treated, like any other UUT, as part of the scheduled workload. This relieves the other sets of a self-maintenance function and dedicates them to the peculiar systems that they are supporting. It also consolidates the adaptors and programs required for the ATE modules and instruments into the one facility that has the greatest capability for supporting this equipment. In addition, it limits the amount of ATE repair training required to MOSs within one commodity only.

4.11.4 Conclusions

The following conclusions can be made from the foregoing discussion:

- Use of ATE for an existing system would require inclusion of additional ATE operator training in the current MOS producing course being conducted for that system. The system maintenance technician receiving this training would be provided an Additional Skill Indicator (ASI) identifying him as an ATE operator.

- ATE-peculiar operator training should be limited to those skills necessary to conduct UUT tests and perform ATE automatic self checks.

- ATE operator maintenance skills should be limited to those skills necessary to identify computer-located faults and to remove and replace faulty modules and instruments as directed by the self test.

- The training required by the ATE operator will be commodity-peculiar, strongly UUT-oriented as well as ATE-oriented. This includes care and maintenance of peculiar adaptors and interface devices. He must be sufficiently knowledgeable about the UUT being tested to be able to understand the UUT test logic and distinguish between UUT failures and ATE failures.

- One POI for ATE operation should be developed and provided to each commodity school as an addendum to the MOS producing course(s) that will include ATE operation.

- A skilled ATE maintenance technician will be required. His skills should include the software and hardware maintenance of the common family of ATE down to the piece-part level.

- One commodity (communications electronics) should be given the mission of supporting ATSS standard equipment and USA Signal School should be tasked to develop an MOS and MOS producing course to perform this mission (based on the Task and Skill Analysis/Qualitative and Quantitative Personnel Requirements Information (TASA/QQPRI).

- The C-E GS facility should perform ATE module and instrument repair and provide on-site maintenance support to the other GS centers using ATE. The MOS decisions should be based on the TASA/QQPRI.

4.12 LCSS REPLACEMENT

This section addresses the potential replacement of LCSS by a new Army Standard ATE. The TRADOC community has supported the Product Improvement Proposal (PIP) to LCSS and, on the basis of the current effort to identify potential application of the ATE, has requested a review of the potential phaseout of LCSS and fielding of the standard ATE as its replacement.

As a result of drastic increases in the deployment densities of the TOW and Dragon Missile Systems, there is a requirement for additional LCSSs at the Divisional support level. The LCSS, originally procured as a Divisional system, was fielded at the rate of one per Division, with primary application at the Corps/GS level. Current workload requirements dictate at least two LCSSs per heavy division. It is planned to shift all LCSSs to the Division level for the 16 active Divisions and for the eight reserve Divisions. In addition, some separate Brigade organizations require LCSSs for DS/GS support. It is readily apparent that there are not enough LCSSs to meet the Divisional support (DS) requirement, much less to supply any for General Support (GS) or Depot.

Missile Command recommendations to DARCOM were that ATE be procured to replace LCSS at Depot and GS and that LCSS remain in the field at the DS until the systems supported by LCSS are replaced or phased out.

With much interest in ATE standardization and an attempt to improve procurement management, the Maintenance Management Center (MMC) recommended that some PIPs on LCSS not be applied and that the PIPs' funds be spent instead on the development of an ATE replacement for LCSS. Keeping this in mind, the Task Force reviewed the LCSS situation and found the following:

- LCSS has an expected life through the 1990s.
- TOW and Dragon could conceivably be replaced by 1990.
- The current LCSS investment is in excess of $150 million.
- The following PIPs are considered essential by the Missile Materiel Readiness Command for LCSS:

Item	Cost ($ Millions)
Test Adapter	14.996
Solid State Visual	0.859
Power Monitor	0.153
IR Probe	0.114
Lam PX Mod	1.007
Troubleshooting Devices	0.123
Nitrogen Purge	0.140
Manual Input	0.025
Dragon Supplemental Mods (three)	0.238
Lance Supplemental Mod	0.150
Total Master PIP	17.805
Additional ECP required for the LCSS Supply Kit	0.018
Total Cost	17.823

Although the LCSS has been fielded for several years, it is just now achieving its required MTBF of 35 hours. The test adapter PIP is expected to increase LCSS reliability and productivity by as much as 30 percent, improving LCSS ability to meet the increased support workload. Other PIPs listed are required to meet system support requirements and to improve LCSS efficiency. Although a single-van improvement to LCSS is considered a valid requirement, the Missile Materiel Readiness Command (MIRCOM) agreed that is was not absolutely essential and could be delayed. However, MIRCOM does recommend considering LCSS lessons learned in the development of the ATE and exercising caution in deciding on the proper packaging of ATE. Work already performed on the single-van approach to LCSS should be considered for the standard ATE.

The ATE operational mode summary developed by the Task Force allows for potential use of commercial off-the-shelf equipment in the Corps area, limiting movement over unimproved roads. The family approach to ATE provides for an ATE that could be developed to meet Divisional support requirements. There are questions concerning the application of commercial nonruggedized, nonmilitarized ATE in the forward areas of the Division. Little is known about the extensive use of commercial ATE in the field environment. The fielding of commercial-design ATE at the Corps will provide a test bed for developing useful data on this topic. In addition, the use of commercial nonmilitarized ATE in the Division to support the ROLAND Missile System will provide an excellent pilot program for the Army in developing a divisional configuration of the ATE. This is not to say that it is not feasible to begin development of a replacement for LCSS at this time with ATE. However, because there is no urgent need to replace LCSS, only to supplement it at GS and Depot, a lower-risk program may now be developed for LCSS replacement in the near future.

An ATE replacement for LCSS (possibly requiring a separate LOA and ROC) can be developed in 48 to 54 months from funding availability. Because the MICOM position has been not to replace LCSS, this development effort is not now in the five-year R&D program for missile ATE.

A militarized version of the ATE is expected to cost between $1.5 and 2 million for hardware and approximately $15 million for software on TOW, Dragon, Shillelagh, and Lance. To replace LCSS completely and also meet total LCSS requirements, a minimum of 16 Divisional ATEs and three separate unit ATEs for the active Army, plus 8 Divisional and 7 separate unit ATEs, in the reserve components, will be required. With float, school training, Depot application, etc., approximately 55 LCSS replacement type units of ATE will be required. Therefore, approximately $100 to $125 million -- not including R&D cost of the ATE for DS -- will be required to meet the LCSS DS requirement.

With the expected LCSS life of 10 to 15 years, perhaps $17.8 million for PIPs is a modest investment in view of the fact that an LCSS replacement would be almost ten years old technologically when TOW and Dragon were phased out and new systems fielded. At that time, it would be necessary again to consider PIPs for the LCSS so that it would last until the next generation of ATE.

The following conclusions can be made:

- ATE could replace LCSS if funded and developed with properly ruggedization and militarization.
- Development of an LCSS replacement would take a minimum of four years.
- The remaining LCSS life of approximately 10 to 15 years allows for redistribution of LCSS as a valid alternative.
- LCSS PIPs could imporve the reliability and productivity of the LCSS.
- The Operational Mode Summary for ATSS/RGS does not provide for Divisional support.
- LCSS replacement is an alternative, not a requirement.

APPENDIX A

ATTENDEES - ATSS STEERING GROUP 10 FEBRUARY 1977

Name	ORGANIZATION
MG GRIFFITH (CHAIRMAN)	DARCOM
MG THOMPSON	DCSLOG
MG VINSON	TRADOC
MG GRAHAM	LOG CEN
MG OTIS	CAC
MG POWERS	TECOM
MG MYER	USASIGS
MG DECKER	TARADCOM
MG STONER	ECOM
MG MEANS	PATRIOT
BG (P) HILSMAN	ARTADS
BG (P) ROLYA	INSCOM
BG CANEDY	ODCSOPS
BG JUNOT	TROSCOM
BG TATE	MERADCOM
BG PATTERSON (USAF)	WRIGHT-PATTERSON AFB
BG AUGERSON	OFC SURGEON GEN
BG PAIGE	CSA
BG EINSEL	PICATINNY ARSENAL
DR. SPERRAZZA	AMSSA
MR. LYNCH	AMSSA
CPT WALKER (USN)	NAVY MATERIEL COM
COL (P) BROWNE	AVSCOM
COL (P) MALONEY	ODSRADA
COL ROESLER	ODSRADA

COL SHAVE	C.T.A.
COL PASSI (USAF)	WRIGHT-PATTERSON
COL CARACCIA	ARM ELEC MATERIEL RDNS ACT
COL ST LOUIS	AAH
COL D. SMITH	PATRIOT
COL HUKKALA	DARCOM
COL SUNELL	TARADCOM
MR. DE ROZE	OSD
MR. HOLLIS	OTEA
MR. ASHENDORF	TRI-TAC
MR. WEINTRAUB	TECOM
MR. CARTER	ECOM
MR. LONG	AVSCOM
MR. NICHOLAS	DARCOM
MR. BUKOWSKI	DARCOM
MR. SCHLOSSER	NAVY MATERIEL COM
MR. NEUMANN	NAVY MATERIEL COM
MR. LORBER	DARCOM
MR. MORRIS	DEP SYS COM
MR. HOWARD	DCSLOG
MR. TENZER	ECOM
MR. MANNEL	USASIGS
MR. WILLIAMS	INSCOM
MR. P. SMITH	C.T.A.
MR. GATES	ARMY SCIEN ADV PANEL
LTC STOUT	OTEA
LTC BEAVERS	MERADCOM
LTC WEST	XMI
LTC MIAL	DARCOM
LTC WIGINGTON	USASIGS
LTC MILLIRON	TARADCOM
MAJ FITZGERALD	LOG CEN
MAJ KLINE	DCSOPS
CPT WILSON	LOG CEN

[illegible]

ATTENDEES - SECOND ATSS STEERING GROUP 24 MARCH 1977

NAME	ORGANIZATION
MG GRIFFITH (HOST)	DARCOM
MG DECKER	TARADCOM
MG GRAHAM	LOGCEN
MG HANCOCK	CSC
MG MEANS	PATRIOT
MG POWERS	TECOM
MG STAHL, USA RET	GENERAL ELECTRIC
MG STONER	ECOM
MG THOMPSON	ODCSLOG
MG TURNMEYER	MIRCOM
MG VINSON	TRADOC
BG (P) HILSMAN	ARTADS
BR EINSEL	ARRADCOM
BG PAIGE	CSA
BG TATE	MIRADCOM
COL BUNKER	NSA
COL CARACCIA	EMRA
COL DRUDIK	DAMO-ROC
COL GOODWIN	INSCOM
COL HAMMER	DARCOM
COL HUKKALA	BSI
COL MIAL	DARCOM
COL ST. LOUIS	AVSCOM
COL SHAVE	MAINT MGT CTR
COL SIEVERS	PM, MEP
COL D. SMITH	PATRIOT
COL SPENCER	DARCOM
COL TOOLE	CDR, TOAD
LTC GABRYSIAK	
LTC WILKERSON, AF	WPAFB

LTC WIGINGTON	USAIGS
LTC STOUT	OTEA
LTC MILLIRON	TARCOM
LTC CANTRELL	MIRADCOM
LTC LOUNDERMON	LOGCEN
MAJ HARNISH	PATRIOT
MAJ HENRY	DCSRDA
MAJ WELBORN	MIRADCOM
CPT TREXLER	
MR. ADENAUER	LOGCEN
MR. ASHENDORF	ODCSLOG
MR. BUDDENHAGEN	DA
MR. BUKOWSKI	DARCOM
MR. CARRIGY	MISSILE SCHOOL
MR. CARTER	ECOM
MR. DE ROZE	OSD
DR. DICKINSON	DRCBSI
MR. FRACE	TOAD
MR. GARRISON	EMRA
MR. GATES	SCI ADV PANEL
MR. GENSIOR	DARCOM
DR. HALEY	DARCOM
MR. HARRIS	ROLAND
MR. HOWARD	ODCSLOG
MR. KLINGER	MIRADCOM
DR. LIEBLEIN	ECOM
MR. LIVELY	MIRADCOM
MR. LONG	AVSCOM
MR. LORBER	DARCOM
MR. LYNCH	AMSSA
MR. MACHLIN	DARCOM
MR. MATHUSZ	LOGCEN

MR. MORRIS	TOAD
MR. NEUMANN	NAV MAT COM
MR. PHEIFFER	ECOM
MR. PLATT	LOGCEN
MR. RAFFA	ARTADS
MR. SCHLOSSER	NAVY CONSULTANT
MR. SHIRES	NCAD
DR. H. SMITH	DCSRDA
MR. P. SMITH	C.T.A.
MR. TENZER	ECOM
MR. THOMAS	CENTRAL DA TMDE ACTIVITY
MR. TZUDIKER	CSC
MR. WEINTRAUB	TECOM
CPT WELCH	LOGCEN
DR. WILLIAMS	INSCOM
MR. BENANTI	
MR. VALERI	
MR. COLON	
MR. PERRAPATO	
MR. MYSLINSKI	
MR. KASTNING	

APPENDIX B

MEMBERS OF THE ATSS TASK FORCE

Name	REPRESENTING
C. G. ADENAUER	USA LOG CEN
R. BURCHACKI	PM, ATSS
N. J. CAMPBELL	MIRADCOM
R. E. CAYS	TOBYHANNA
R. CHOUINARD	PM, ATSS
W. COLON	PM, ATSS
T. A. COX	FRANKFORD ARSENAL
W. DUDA	ECOM
J. FRACE	TOBYHANNA
LTC W. GABRYSIAK	PM, ATSS
H. GRIFFITH	PATRIOT PROJECT
W. D. HAGLER	MIRADCOM
MAJ C. HARNISH	PATRIOT
J. S. C. HECHT	USACSA, CCM-RD
L. HEIDEN	ECOM, ET&D LAB
R. M. HEMPHILL	TMDE DIV, MAINT DIR, ECOM
W. HNATCZUK	TARADCOM
J. KASTNING	PM, ATSS
H. M. KAUNZINGER	PM, ARTADS (CENTACS)
E. LIEBLEIN	CENTACS, PM, ARTADS
LTC C. LOUNDERMAN	LOG CENTER
J. LUGREZIO	ECOM, DRSEL-MA-DM
D. LYNCH	AMSAA
R. MC ALPINE	AMSAA
B. A. MC LAUGHLIN	USACSA, CCM-RD

R. MOOR	MICOM
J. MYSLINSKI	PM, ATSS
G. NEUMAN	ECOM, SYS ANAL OFC
W. PARKS	PM, ATSS
J. PISANO	TOBYHANNA
A. PLATT	LOG CENTER
SFC D. PUFNOCK	USACSA
R. SANTOYO	TROSCOM
M. SCHWARTZ	MAINT DIR, ECOM
P. SMITH	DA CENTRAL TMDE ACT
E. THOMAS	CTA
S. TORREY	FRANKFORD ARSENAL
D. TOWNSON	AMSAA
MAJ L. WELBORN	CH, ATE MGT OF, MIRADCOM
W. H. WHITE	P&P DIR, ECOM
F. WILLIAMS	USA INSCOM
MAJ A. WOYTEK	PM, XMI
R. KOLE	ARINC RESEARCH
A. SIMMONS	ARINC RESEARCH
L. GRAHAM	ARINC RESEARCH

APPENDIX C

LETTER OF AGREEMENT FOR THE INVESTIGATION OF A FAMILY OF AUTOMATIC TEST SUPPORT SYSTEMS (ATSS)

1. INTRODUCTION

a. This Letter of Agreement (LOA) gives initial support to the development of two Automatic Test Support Systems (ATSS) configurations: an avionics configuration and an electronics configuration. The avionics configuration could support systems such as the advanced attack helicopter (AAH) and the electronics configuration could support systems such as the Tactical Emitter Location Identification System (TACELIS), Tactical Fire Direction System (TACFIRE), TRI-TAC Communications Switch (AN/TTC-39), and high density combat communications equipment. As a result of detailed cost and operational effectiveness and logistic support analyses performed concurrently with this development effort, additional configuration and/or applications are anticipated and will be supported by subsequent revisions to this agreement.

b. The undersigned are agreed that a program should be initiated to investigate the technical feasibility, employment concepts, and operational desirability of developing a family of automatic test support systems (ATSS) to be used for the maintenance of Army materiel.

2. NEED FOR SYSTEM

a. Maintenance capability goals indicate the necessity to take advantage of automatic test equipment (ATE) capability at all levels of maintenance. The present proliferation and lack of interface within commodity oriented Test Measurement and Diagnostic Equipment (TMDE) has placed a burden on the Army in logistics and training. This proliferation of makes and models of TMDE increases the requirement for personnel in the highly skilled disciplines related to testing, diagnosis, and fault isolation. The advantages of placing ATE capability into the inventory include the following:

(1) Reduces incorrect diagnosis and unnecessary repairs.

(2) Reduces diagnostic time and manpower requirements.

(3) Reduces cost of developing and procuring special, peculiar, and common test equipment.

(4) Reduces necessity of large numbers of skilled diagnosticians.

(5) Greatly reduces the calibration load through the reduction of TMDE inventory.

b. CARDS reference number: 1600A

3. SYSTEM CONCEPT

It appears feasible to develop a family of automatic test support systems to support all Army materiel. These systems would share a standard system computer, a standard software operating system, and a standard test procedure language. In addition, it is envisioned that some measurement, stimulus, switching, and peripheral equipment will be standardized. As a result of the standardization involved, the ATSS would allow test equipment evolution independent of the prime systems supported. The ATSS family will automatically test, diagnose, and fault isolate major items, components, assemblies, subassemblies, modules, and printed circuit boards. ATSS will be tailored to the mission at each maintenance location. Early design characteristics for ATSS configuration include:

a. Be simple to operate, maintain, and calibrate.

b. Be standardized to maximum extent feasible and cost-effective.

c. Take maximum advantage of existing equipment, commercial or service-developed.

4. PROSPECTIVE RELATIVE EFFECTIVENESS

The preliminary appraisal that explored the relative merits of computer controlled automatic test equipment for test, diagnosis, and fault isolation in comparison with special support equipment and inventory test equipment (SSE/ITE) has indicated high probability of savings in cost and manpower. Although the analysis focuses on the avionics configuration in support of the Advanced Attack Helicopter (AAH), the commonality of components renders many facets of the rationale applicable to other prospective configurations. By using the workload that could be expected for a fleet of 218 AAH in context of the ME-1 scenario, it was determined that eight sets of ATSS VS 37 SSE/ITE sets would be required. The initial findings in this preliminary appraisal indicate the ATSS approach offers a 4:1 reduction in personnel and more than a 2:1 cost reduction.

5. PROSPECTIVE UPPER LIMIT ON UNIT COSTS

Unit cost for ATSS will depend on the application, quantity, and complexity of each configuration. However, estimates for these costs provided by Frankford Arsenal, USAECOM and AAH Project Manager, are shown in paragraph 11.

6. INVESTIGATIONS TO DEVELOP THE OPERATIONAL, TECHNICAL, AND LOGISTICAL CONCEPTS

Investigations to develop the Operational, Technical, and Logistical concepts will be accomplished as follows:

a. Commander, TRADOC will conduct the necessary field tests and experiments, using the ATSS configurations and other support provided by AMC to:

(1) Develop the operational employment concept for the ATSS.

(2) Determine the optimum maintenance level to assign each ATSS configuration.

(3) Research in Human Factors Engineering is required to insure that operational performance objectives for the man-materiel system can be achieved by the personnel that will be available to the organization employing the system. In addition, training requirements to include Training Extension Courses, training literature, simulation, training devices requirements, and training hardware requirements for institutions and units must be examined as part of the system proposals and operational concepts.

(4) Determine the reliability, availability, and maintainability (RAM) characteristics for the system/configurations.

(5) Provide support as required to Commander, AMC in development of the integrated logistical support plan for the ATSS.

(6) Conduct a detailed COEA to service as a basis for continuing, reorienting, or terminating development of the ATSS. The COEA will include consideration of all candidate line replaceable units (LRUs) that can be supported by ATSS.

b. Commander, AMC will:

(1) Procure the required quantity of ATSS configurations and provide an appropriate number of these to Commander, TRADOC to conduct their investigation.

(2) Conduct engineering analyses and investigations which address other potential applications for the ATSS. Priority consideration should be given to a calibration application.

(3) Coordinate with Commander, TRADOC and Commander, LEA on the implications of the ATSS on current and planned logistical doctrine and organizations.

(4) Provide technical and cost information and such other support as required, to Commander, TRADOC to assist in the conduct of the detailed COEA.

(5) Provide contractor support and training program for ATSS configurations.

(6) Provide funding estimates as required.

(7) Develop in coordination with Commander, TRADOC and Commander, LEA the logistical support concept for ATSS. Important study areas in this regard will be to determine:

(a) Effect of ATSS on current TMDE inventory.

(b) Optimum repair facilities for LRUs, modules, and printed circuit boards.

7. UNKNOWNS TO BE RESOLVED

a. Ability of Army personnel to operate and maintain the ATSS.

b. Determination of optimum maintenance level and repair capability (Org, DS, GS, AVUM and Depot) to maximize system effectiveness.

c. Impact of ATSS on existing/pending TMDE (e.g., ATE/ICE, STE/ICE, AIDAPS and inventory Test Equipment).

d. Determination of potential applications and configurations.

e. Determination of optimum interface with other logistic support measures (e.g., built-in test equipment [BITE], built-in test [BIT]).

f. On-board sensors, transducers, accessible test points, special fixtures and diagnostic connectors are not available on most Army end items, components and printed circuit boards. This situation must be addressed to arrive at cost effective solutions.

g. Advantages and disadvantages of programmable interfaces.

h. Advantages and disadvantages of computer driven stimulus.

i. Advantages and disadvantages of programmable power supplies.

j. Advantages and disadvantages of distributive and stand-alone units.

8. TECHNICAL RISKS

a. The risk of developing the initial two configurations described in paragraph 1 are minimal. Commerical ATE adaptations are available to satisfy these requirements. Selected components of commercial ATE will have to be ruggedized to meet military standards.

b. If organizational applications are identified during the course of this investigation the risk is considered moderate because size, weight, and cost constraints dictate equipment barely within the state-of-the-art.

c. The technology to develop a commodity-oriented family of automatic test equipment has not been demonstrated. Therefore, this approach may possess capability only to satisfying electronic/electrical type requirements.

9. SCHEDULES AND MILESTONES

a. Early efforts on the avionics and electronics configurations have been underway since July 1974, and this program is expected to be terminated in FY 79. Attached is the proposed milestone schedule (see Figure 1).

b. The detailed COEA and Logistics Support Analysis are scheduled for completion by July 1978.

c. Submission of Required Operational Capability (ROC) document(s) by April 1979.

10. CRITICAL ISSUES FOR TEST

a. The tests, as outlined in Figure 2, will be conducted to address those critical issues which could cancel or extensively modify this program. Materiel development issues that are in this category include the following:

(1) The ATSS concept offers significant potential for reducing the Army logistic support burden. The implementation of this concept may show that major changes to present support philosophy and policies are cost effective. Because of the many ramifications of the ATSS concept program management, effort must be intensive

to assure that results obtained are an accurate prediction of the value of the ATSS concept. This issue is critical because of the complexities of a significant non-weapon development effort impacting on all Army systems and the tremendous technical and administrative coordination effort required.

(2) The second critical issue to be determined is whether the ATSS family concept will provide a cost effective contribution to present and future Army support problems. The unknowns listed in paragraph 7 will require answers during initial efforts to provide basis for this determination.

b. Combat development issues that are in this category include, but are not limited to:

(1) Is there a reduction of personnel significant enough to warrant the development of a particular application of ATSS?

(2) Is the ATSS susceptible to a hostile ECM environment?

(3) Will the ability of the average soldier allow him to operate the ATSS to proper advantage?

(4) Will the use of this system be adaptable to the mobility required on the battlefield?

c. As the AMC/TRADOC joint effort on ATSS becomes more definitive, other critical issues may be developed.

11. ADVANCED DEVELOPMENT AND ENGINEERING DEVELOPMENT FUNDS (MILLIONS)

Funding: Summary of estimated range of research and development costs as defined in AR 37-18 is expressed in inflated FY 74 dollars ($M-Millions):

	LOW	HIGH
a. Advanced Development (6.3)	$4.078M	$5.012M

FY 75	FY 76	FY-T	FY 77	FY 78	FY 79	Total
$.104M	$1.428M	$.86M	$1.39M	$.49M	$.325M	$4.604M

NOTE 1: Number of Prototypes 1

	LOW	HIGH
b. Engineering Development (6.4)	$8.480M	$10.364M

FY 79	FY 80	FY 81	FY-	FY-	Total
$2.122M	$5.426M	$1.874M	$--	$--	$9.422M

NOTE 2: Number of Prototypes 2

NOTE 3: Composite indices have been used in accordance with the guidance provided on 23 October 1974.

c. Broad based estimate of unit flyaway cost expressed in constant FY 74 dollars.

ITEM	UNIT COST	QTY	LEARNING-SLOPE
AN/USM-410( ) (V)	$.800M	100	85%

NOTE 4:

a. The advanced development costs above represent only the portion of the ATSS LOA effort to be undertaken by the material developer.

b. RDT&E funds are also anticipated to be expanded for other ATSS effort shown on the Milestone Schedule Chart and for the period shown thereon, as follows:

(1) PM AAH (6.4 funds). There are part of the AAH program requirements. $21.2M to $26.2M

(2) PM Multi-Service Communications Systems (6.4 funds). ATSS is being considered for the AN/TTC-39. However, final selection of ATE has not been completed. If ATSS is selected, indications are that support of the AN/TTC-39 with ATSS will require $1.2M to $1.5M

(3) Army Security Agency (6.3 funds). Considering only those ASA programs whose ATSS support are indicated in this LOA and which contribute to this effort (CEFLY LANCER and TACELIS), ASA anticipated the expenditure of $3.7M to $4.7M

c. The results of the efforts indicated in b above, of this Note 4, are required in conjunction with the ECOM effort preliminary to proceeding into ATSS Engineering Development.

Figure 1. ATSS MILESTONE SCHEDULE

ATSS	Planned Utilization	FY 75	FY 76	FY 77	FY 78	FY 79
1,2	(MASSTER TEST) Validation	△				
3,4	ASA (TACELIS)	△				
5	ECOM Validation	△				
6,7,8	AAH		△			
9	AN/TTC-39		△			
10	TACFIRE		△ △			
Data Collection Completed						
COEA Completed					△	
Spare Parts			△			△
Training -	Electronics Configuration		△ △			
	Avionics Configuration				△	
Applications Program		△				△
Maintenance Program		△				△
Operational Software		△				△
ROC Completed						△

△ Start/Delivery dates.

[redacted]

Figure 2. ATSS PROPOSED TESTS AND EXPERIMENTS

1. MASSTER Test - Combat Communications-Electronics

2. AAH DT/OT II - Avionics Electronic Systems (include Electro-Optical Equipment)

3. AM/TTC-39 DT/OT II and MASSTER Test - Digital Communications-Electronics System.

4. TACELIS DT/OT II - Electronic Warfare and Countermeasures Systems.

5. TACFIRE DT/OT III - Digital Electronic Fire Direction System.

6. Combat Unit Field Test - High Density Combat Communications Equipments.

[redacted]

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APPENDIX D

LESSONS LEARNED

INTRODUCTION

"Lessons Learned" is a collection of the experience highlights gained in the ATE field, and is the result of a careful review of the studies and papers available on the subject. Materials related to unique situations (ATEs or UUTs), issues which technologically or for other reasons no longer present a problem or espouse a philosophical point of issue, and personal opinions have been avoided. Following each lesson learned is a letter in parenthesis that identifies the source. The letter can be correlated to the *List of References at the end of this Appendix.*

The "lessons learned" is provided as non-argumentative information appropriate for the 1977 time-frame and the ATSS Task Force does not sanction or necessarily agree with its contents and conclusions.

[redacted]

TABLE OF CONTENTS

1. ATE SYSTEM DESIGN

Present designs of various ATE systems do not feature operating and maintenance of environments that provide for accessibility, testability, and safeguards for circuits and circuit malfunctions, which could result in serious equipment failure.

a. "With emphasis being placed on changing to the Metric System, any new ATE should be designed using the Metric System. This would also make it easier to interface with foreign design systems." (A)

b. "Do not simplify hardware at the expense of making the software more complex. Also, do not restrict hardware design which restricts flexibility of software." (A)

c. "Use field repairable cables, such as Icore Cables. (A)

d. Design assemblies so that they can be pulled from racks without breaking power connections for easy adjustments, etc." (A)

e. "Every effort should be made to reduce calibration time on ATE. Use "C" level calibration to maximum extent." (A)

f. "Start off with the largest van available. The van should have a low profile for easy entering and exiting with UUTs. The LCSS has outgrown its shelters and is cramped for operational space as well as storage space. Allow for growth." (A)

g. "The LCSS should have used a computer or micro processor rather than punched Mylar tape with a tape reader." (A)

h. "Design ATE to operate on 50-400 Hertz input power. LCSS has experienced difficulties by only being able to operate on 400 Hertz power." (A)

i. "Definitely need hardware and software (when using mag tape or discs) protection in the event of prime power failure and/or surges." (A)

j. "Meters should be installed on the power distribution panel to allow the operator to monitor the frequency, voltage, etc., from within the van rather than going out to the generator." (A)

k. "The system should be protected from prime power failures or surges. Also protect circuits should be designed in for all system power supplies. Protect the hardware as much as possible from malfunctions or operator errors." (A)

l. "It is not necessary to environmentally harden a system as much as LCSS. More commercial equipment could be used at greatly reduced cost, especially at GS level." (A)

m. "Eliminate electro-mechanical devices as much as possible."

n. "Minimize operator intervention and decision making as much as possible."

o. "Minimize Technical Manuals as much as possible." (A)

p. "Eliminate hard copy printers in the field; however, they are necessary during validation and at depot. Could use an external printer." (A)

q. "There are three (3) major elements which lengthen the useful life of equipment and lower overall program life cycle costs. They are:

(1) Design to the anticipated environment;
(2) Design for program change;
(3) Design for maintenance and support." (E)

r. "Van should have a good environmental control system. Air should be routed through the chassis rather than just to the chassis. Control system should have humidity as well as temperature control." (A)

s. "In new equipment procurements with words as 'testability will be considered in the design' and other broad phrases, such design 'goals' receiver very little priority since there isn't a measurable way to evaluate how well the 'goals' have been met. One good example of how this can be accomplished is being implemented at Hewlett-Packard. This company normally maintains its own ATE products in the field via contract maintenance. Therefore, it has a strong motivation to design equipment which can be economically tested. As a result, any new digital board is modeled during the initial design and run on HP's ATPG. Areas which cannot be fault-isolated are redesigned (additional test points & etc.), so it can be rigidly tested. All this occurs before the design drawings ever receive approval for fabrication. Result - it works! Solution: I don't know. However, until we invent a way to reward an avionics vendor for a testable design and to penalize him for a poor one, we won't get anywhere. We must involve him (and his pocketbook) in designing products which can be tested and writing good programs to test them. Possibly we could require him to do a free repair for a couple of years on any UUT that his test program doesn't test properly in normal USAF field and depot testing."(V)

t. "There has been considerable attention paid to the directly related facets of automatic testing. A number of equally important, but indirect factors have been ignored. One of these critical factors concerns providing adequate checks and controls to make certain that the UUTs are in fact testable on the ATS. It is commonly agreed that the most effective test system and highest quality test programs will be severely constrained in providing effective support if the UUT is not designed for testability. Design for testability includes, as a minimum, adequate test points made accessable to the test system, modular functional design and appropriate buffering, and isolation and loading considerations." (C)

u. "In some ways the introduction of powerful ATS (Automatic Testing Systems) such as the Navy's VAST (AN/USM-247) has complicated what was once a very simple process. The responsibility for support for air weapon systems was naturally assumed to belong in the province of the airframe manufactures. Much in the manner of a divine right, the airframe manufacturers were to build and integrate the aircraft as well as identify the manner in which it would be supported. Occassionally they would dispense a support subcontract. However, most often they would design and build those elements of special test equipment they felt could do the job, with little attention being paid to the problems created by this form of doing business. The expensive training, time consuming repair procedures, extensive sparing, erroneous and shotgun diagnostic and repair efforts, and generally degraded readiness posture caused by these elements could be overlooked because the military/political environment made these considerations fade into the noise level of other considerations." (C)

v. "Design for General Testability - Lack of physical accessibility making fault isolation difficult, resulting in lengthening the time considerably. Also, lack of test points and packaging schemes, which split circuits at sensitive points, makes isolation difficult." (A)

w. "Establish a Test Equipment/Missile Equipment compatibility program and implement it before fielding - not after the fact." (A)

x. "Testability must be considered during the design of the avionics. Most avionics equipment designers are primarily interested in the technical performance. However, test points, test circuits, etc., must be designed into the equipment from the beginning." (A)

[redacted]

2. MANAGEMENT

Managers of weapon systems should communicate their ATE support requirements with the contractor early in the end-item acquisition cycle. This leads to standardizing acquisition and operating procedures and policies which can be accomplished by centralization of support equipment management. Experience with AF logistics shows that supportability receives less emphasis than reliability and maintainability as evidenced by the requirement for a procurement of a certain amount of diagnostic equipment to satisfy the conditional maintenance concept philosophy, but the failure to provide funds for diagnostic equipment development. Procedures for defining engineering data essential for determining baseline performance and structural requirements during problem analysis and modification work have not been adequately identified and provided to the military by the contractor. Workflow analysis should provide for effective utilization of ATE equipment and personnel.

a. "The centralization of support equipment management at SA-ALC, resulting from AFLC ALC reorganization, will help the AFSC program directors by establishing a single ALC contact point and standardizing acquisition and operating procedures and policies." (U)

b. SPO/SM activities in many instances have not followed SE IM technical recommendations and have deviated from SE recommendations, thus creating problems at a later time frame in the program. (U)

c. "Work has begun to extract information from the automatic test equipment (ATE) acquisition planning guide for publication of a military standard. The standard will assist the AFSC acquisition activities in contractually implementing the required design objectives and logistic support elements." (U)

d. "A detailed integrated logistic support plan will be published to guide the program directors in logistic planning. The remaining information in the acquisition planning guide will be incorporated into a joint AFSC/AFLC regulation covering acquisition of support equipment and delineating responsibilities to the acquisition activities. We will provide full support to the AFLC programs required to achieve the established goals." (U)

e. "We are concerned that the plans proposed by AFSC do not elevate the emphasis on ATE acquisition to the functional level. In our view, there is a need for an AFSC command organization responsible for ATE acquisition management if we are to give priority and special management emphasis to this program. We recommend AFLC continue the pursuit of a single organizational entity within AFSC with command authority for ATE acquisition policies and procedures. The focal point is essential if we in AFLC are to exert logistic support influences on the acquisition processes and assure cost-effective support of the systems during operational deployment." (U)

f. "The same management attention afforded reliability/maintainability goals should also be focused on timely development and delivery of diagnostic support equipment to the operating commands." (U)

[redacted]

g. "One of the major problems has been reliability and maintainability designed to be obtained in field use are not obtained. Waivers to contractors for not meeting the R&M required should seldom be allowed." (U)

h. "AFLC should not be required to take a weapon system that the R&M designation in the conceptual phase has not been accomplished. R&M requirements should be tested to withstand field environment. This would establish that R&M figures prepared in the conceptual phase were correct and written into the contract definition phase. These figures should not be changed, particularly after the development phase. At this point, changes to modify hardware are very costly. This includes the Production and Operational phases. Testing must be carried out to establish, without a doubt, that required R&M figures are correct and can, and will, be obtained when the weapon system becomes operational." (U)

i. "Even though the Integrated Logistics Support Plan developed by the SPO, contractor, and AFLC are pretty specific in logistics responsibilities during the test programs, problems are always experienced. Experience has shown that more specific guidelines are required in delineating support responsibilities during each phase of the test programs." (U)

j. "Engineering data such as systems performance test reports and stress analysis reports are sometimes not adequately identified and provided to the AFLC center which has price responsibility. These data are essential for determining baseline performance and structural requirements during problem analysis and modification work" (U)

k. "By contract the contractor is required to validate technical orders. Subsequently the Air Force verifies selected TOs. Decision was made on C-5A contract to conduct a joint val/ver review to expedite data availability. This decision places the Air Force in a position of basically developing the data that the contractor is paid for. Not only does this problem prevail, but it provides the contractor with a vehicle for not presenting a finished product." (U)

l. "Assemble a specialized Air Force team to process contractor furnished aeronautical equipment and accessories notices, to establish uniformity of requirements. Accept data for verification that has been validated. Establish definitive guidelines for accepting/rejecting data verified. Require the contractor to reimburse the Air Force for expenses incurred when data is rejected." (U)

m. "Consider all data as interim until a finalized configuration is established. Service test the data on the finalized configuration for 12 months at which time the contractor is required to correct all deficiencies." (U)

n. "Require contractor repairs/overhauls to be accomplished using the ATE/data programmed for AF use. At the present time the contractors use manufacturing support equipment and in-house data. Many problems experienced by AF use could have been corrected by the contractor if they would have used the data." (U)

o. "The Navy's VAST system was the vanguard implementation of this new support concept. However, the change over did not occur without numerous problems. Technological and human hurdles were encountered and to a large extent, overcome. The VAST system today is successfully supporting three major aircraft avionic systems for the U.S. Navy, the F-14A, the E-2C, and the S-3A. However, we are now faced with the task of refining and improving the manner in which we employ the benefits of ATSS. Our experience has shown us that many of our expectations were naive. In addition, numerous management procedures and implementation techniques which were carried forth from earlier support concepts no longer effectively meet the problems presented by the new support concept which employs computer-controlled test equipment as its heart." (U)

p. "It is often possible to observe a tendency for developers and users to become mesmerized with the hardware and software technology of ATE. ATE stimulation and motivation must eminate from the fact that we are dealing with a resource requiring objective management by all." (B)

q. "Work flow analysis is a key element in assuring that ATE money is well spent. It simply means that a production or maintenance environment has to be premeditatedly scrutinized as to how best to use ATE and people in logical efficient complimentary fashion. It takes people who understand what ATE can realistically do as well as fresh thinking on how best to structure the environment. It additionally necessitates a process of educating the novices and generating a degree of motivation to assure overall success of the effort.

r. "The road that led to the current, successful, use of VAST has been technically difficult and costly. To help ourselves and others avoid repeating mistakes that were learned enroute to achieving a successfully operating system, an introspective analysis and exposure was felt to be beneficial. Since the cost for its software has been found to at least equal the cost of the VAST system itself, the question of the application software for VAST cannot be ignored as part of this analysis." (C)

s. "Managers have to learn a technology previously unfamiliar to their work experience." (C)

t. "Established policy and procedures have to be changed or circumvented to procure and deploy multi-weapon equipment in an environment of independent weapon support." (C)

u. "Little attempt has been made to capitalize the managerial advantages realizable from the use of computers in the testing functions due to the preoccupation with meeting the immediate need of providing an operational capability." (C)

v. "About the only aspect of ATE software where any substantial agreement exists is that it 'costs too much.' Why costs are high or what can be done to provide a measure of control are rarely discussed. There is a paucity of such information in the literature. After twenty years of automatic test systems applications, there seems to be no better understanding or control of software costs than there was in the first projects." (C)

w. "Actual costs against a project seem to bear little resemblence to the original plan or bid. Where bids are high, actual costs are still exceeded, often by 100 percent. Where bids are low, the delivered product is extremely inferior or there is not serious attempt to keep costs under control, let alone deliver within schedule or cost." (C)

x. "There are many reasons offered to explain away the software costs, but the fact is that there have been no serious efforts to control costs. To do so requires a substantial effort by knowledgeable people. Attention must be given to cost control beginning with the mission definition phase of the project. Discipline must be imposed each step of the program development process. Actual cost elements must be recorded with sufficient granularity to allow a full history to be reconstructed upon completion of each project. Task definitions and cost relationships must be continually refined, based on actual experience. Differences in project requirements must be noted so that they may be taken into account in future projects to both improve production techniques and project costs more accurately." (C)

y. "The key, therefore, to the effective utilization of ATE is intensive management. If I were to single out one problem as most important, it would be our inability to initiate ATE selection and acquisition early in the end-item acquisition cycle." (U)

z. "Lack of communications between Test Engineer, System Engineer, Management, and Maintenance causes rework, impact schedules, and raises costs." (U)

aa. "Weapon systems or item managers supported by ATE should be made aware of the importance of test equipment in supporting their hardware and provide info, requirements, and hardware to the ATE prime as soon as possible." (A)

bb. "Project Managers of ATE systems should be the same rank as the Project Managers of the system they support." (A)

cc. "An ATE office needs a small group of experts with the ability to buy expertise from other sources or have knowledgeable ATE personnel detailed to augment requirements during peak workloads." (A)

dd. Be sure of your total requirements before stopping production on your system or supplementary equipment. Several more LCSS's could be used if the systems were available. Also, with increased densities of TOW and DRAGON being fielded, additional TOW and DRAGON supplemental kits had to be procured. (A)

3. ATE SUPPORT SYSTEM (LOGISTICS)

Maintenance and support planning for ATE has been lacking as evidenced when ATE fails and ATE downtime becomes excessive due to a shortage of spare parts. This non-operational readiness condition could be attributed to logistics planners not possessing a working knowledge of support required for ATE acquisition.

a. "Every ATE system fielded should have an 'Essential Items Stockage List' (EISL) provided with it as well as a set of troubleshooting devices if possible. The LCSS has been trying for years to get one approved. The EISL would eliminate many of the LCSS's spares problems." (A)

b. "Assembly level schematics should be shown on one fold-out sheet rather than many separate sheets." (A)

c. "There is often a tendency to simply implement ATE/ATSS within a production or maintenance environment and then realize a thoroughly planned integrated working environment was not performed." (B)

d. "A money-making, productive UUT application program for an ATE system isn't an accident. It results from a well-conceived design which reflects all requirements of a production or maintenance environment." (B)

e. "In the past, major test systems procurements did not stress the logistics support factors which are necessary for overall program success." (B)

f. "As an integral part of the competitive procurement plan, the inclusion of warranty or maintenance provisions for the developed software is being considered. The complexity of the TPS development process can be expected to result in a product which contains errors. Many of these errors will be discovered and corrected during review, validation, and acceptance testing. Others will be uncovered during the rate tooling process, however, some will escape unnoticed until the TPSs are deployed and put into use. The problems caused by this have been described previously." (C)

g. "It is well known and readily determinable that the savings accrued in the support and maintenance of the system far outweigh the initial development cost." (E)

h. "Deficient automatic test systems and complex support equipment items have been acquired and deployed for operational support of Air Force weapons. The following conditions are identified as contributing to the problem.

(1) The communications between the OPR in the supporting command and the OPR in the implementing command do not always convey the necessary exchange of vital information during acquisition.

(2) OPR's in both commands do not fully understand the complex logistics support requirements and critical acquisition functions essential for effective acquisition and deployment of the automatic test systems and complex support equipment.

AD-A061 756 ARINC RESEARCH CORP ANNAPOLIS MD F/G 15/5
THE ARMY TASK FORCE REPORT ON AUTOMATIC TEST SUPPORT SYSTEMS (A--ETC(U)
MAY 78 R S KALE, L J GRAHAM, A L SIMMONS DAEA18-72-A-0005
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(3) Effective interface and early participation in the acquisition phases by the supporting and using commands are not always evident.

(4) Availability of organic expertise to guide contractors in engineering and technical matters during the concept, validation, and full-scale development phases is usually limited.

(5) With the advent of complex new weapons systems, the need for more and more items of SE of a complex nature has become a necessity in both the manual and automatic area. In order to support the maintenance concept of new SE, a comprehensive and positive spares program must be developed to assure minimal effect on weapons system downtime. Due to the concept being levied in many cases of Built In Test (BIT) on new weapons systems (F-15, F-16, E3A, etc.), the intermediate shop equipment and depot equipment became of prime importance in preventing aircraft NORS conditions. When BIT indicates removal of an aircraft line replaceable unit (LRU), the intermediate SE must then come into play to test and repair LRU. Failure of the SE at intermediate level and organizational level at this point can create problems. One of the major aspects in keeping SE operationally ready is spare parts support. Failure to program for sufficient spares can badly impact a program." (U)

4. STANDARDIZATION

Standardization of ATE hardware and software can reduce proliferation of automatic test systems and ATE support equipment. Production of test program sets which could interface with a variety of testers would enhance configuration control and be cost effective. Important factors of standardization are dictated by AR 8, 9, and 10.

a. "Anyone experienced in ATE knows that standardization effort must begin at the system (hardware and software) design level if it is to be realized effectively at the user or test language level." (P)

b. "It is essential that application program documentation requirements and standards be established at the onset of an ATE effort. Consideration of documentation requirements must address application program technical traceability and completeness, source document references, all key elements to sustain configuration control, and quality standards." (B)

c. "It is essential that new designs consider the constraints imposed by human engineering, human factors, and standard support asset specifications and standards." (E)

d. "As more and more test systems are deployed to support F-15 squadrons throughout the world, the benefits of this design and the development approach will accrue to the users. Significant among these are:

(1) The complete interchangeability elements of Configuration Control Management.

(2) The maintenance capabilities of on-equipment fault isolation to the lowest replaceable module.

(3) The simplified man-machine interface." (E)

e. "Inspectors and auditors frequently voice criticism concerning proliferation and lack of standardization in acquisitions of support equipment and automatic test systems. The state of the art in automatic test systems advances rapidly and the technology is a dynamic design posture. The development of an automatic test system often starts 3-5 years before operational deployment and design of a test system to existing equipment specifications can result in the deployment of a technologically obsolete test system." (U)

f. "Indications are that certain components comprising an individual item of support equipment can be standardized to a selected group or family of components which are logistically supportable in the existing inventory. Extensive study and evaluation will be required to identify feasible candidates for standardization. The modular automatic test equipment (MATE) study effort being staffed by ASD/AEG is considered adequate to determine feasibility of standardizing support equipment." (U)

g. "One method of achieving economy in the development of software is to produce test program sets which are usable to some extent in different testers." (J)

5. TEST PROGRAM SET (TPS) RESOURCES/PROCEDURES

Test programming cost should include non-recurring costs of Interface Devices (IDs). Test Program Instructions (TPIs) and Test Program Design Cost, because they are so interwoven with the test program as to be considered part of the TPS. Sufficient numbers of UUTs should be procured for test programs design and validation phases and allow test program developer to employ them to assure the required fault insertion can be employed to provide effective program quality assurance. Positive action should be taken to plan and institute procedures for assuring testability and availability of UUT's in a timely fashion to prevent the effectiveness of ATE support from being compromised. Experience and knowledge of ATE, test programming, and test techniques is equally as important as knowledge of the hardware for TPS development.

a. "TPS Verification and Update: Experience has shown that no matter how thoroughly TPS are checked at contractor sites, installing them at Navy sites requires a substantial verification effort. This effort involves trying each TPS against one or two corresponding avionic UUTs to assure compatibility. Any problems are then resolved through NAVY-contractor efforts coordinated by a NAVY TPS engineer". (P)

b. "In order to provide a more orderly and planned approach to TPS correction, the contracts for TPS development for new programs should contain a correction of defects warrantee or maintenance provisions. This will guarantee at the beginning of the contract that funds have been set aside to correct TPS defects which typically occur, allow for a better budgeting, and provide an added incentive to the contractor to more thoroughly effect TPS preparation." (C)

c. "Wherever possible at the conclusion of UUT application program validation, it is an excellent practice to perform a preproduction exercise in the actual planned testing environment." (B)

d. "Do not assume that deliverable ATS/ATSS system software is always error free." (B)

e. "Possession of a single UUT for test programs design and validation phases can be a risky business. Undetected idiosyncrasies of the UUT can emerge after the application program is placed in ATE production usage." (B)

f. "The second critical factor concerns the availability of UUTs to allow timely program development. Often the number and need for the UUTs limit the time that they will be available for program development and the natural course of production. The advantages of this approach are an early exposure to others that debug WRAs/VAST stations; elimination of factory test equipment; screening of Class II avionic changes to insure new TPs play with the new avionic configurations; screening of 'TPS only' changes for upward compatibility; movement toward simultaneous availability of support design changes; and improved quality of the resulting programs. This approach will also provide added incentive to the users to make the test programs as fast and thorough as possible because his production and delivery rate will depend on them. The disadvantages of this approach are the required additional assets for test and potential aircraft production line holdup because of the non-availability of an updated TPS which matches the design changed avionics." (C)

g. "Consideration is now being given to contracting for future TPS development via competitive procurements. The cost advantages to the hardware purchases under a competitive stimulus is well known. There is good reason to believe that these advantages would also exist in the case of TPS development. In order to efficiently implement a competitive TPS procurement for new programs the following is planned:

(1) A general Request for Quote (RFQ) and/or contact format will be developed.

(2) The requirement specifications AR-8, AR-9, and AR-10, previously used for VAST procurements, will be further expanded and definitized. The areas concerning TPS requirements and acceptance test procedures will be given particular attention as will use and application of automatic test generation techniques and establishment of ambiguity groups for state of the art electronic.

(3) Establishment of a qualified bidders list.

(4) Performance of necessary scheduling and planning to assure that GFE (Government Furnished Equipment) such as ATE's, WRA's, etc., will be available at the appropriate locations and times.

(5) Assurance that the data provisions for the prime equipment are adequate to allow expeditious TPS development.

(6) Review of the prime contract for adequate provisions which will enable early review and participation by Navy ATE cognizant personnel in the UUT development to guarantee ATE compatability and general testability." (C)

h. "Presently, the majority of TPSs are procured by NAVAIR from the weapons system prime contractor. This practice has been predicated on assumptions which were quite logical when they were implemented: The prime is most knowledgeable concerning the equipment being designed; and the prime has the necessary data for TPS development. Because of these facts the prime should be able to prepare the TPS most efficiently and least expensively. Experience gained over the years has brought these assumptions into question. These experiences indicate: In many cases the prime sub-contracts for much of the equipment and hence is only little more knowledgeable than an outside contractor; the prime must acquire the data for sub-contracted equipment and often is no better off than outside contractors as regards source data; experience and knowledge of the ATE, test programming, and test techniques are equally as important as knowledge of the hardware for TPS development, the prime seldom has the equipment designer design the TPS for that equipment, circumventing much of his expected advantage The cost for TPS development by the prime, over the years, has been unacceptably high and has shown no sign of being reduced due to learning; and effective low-cost programs have been produced by ATE specialists other than primes, sometimes with minimal source documentation." (C)

i. "Large numbers and complexity of TPS precludes detailed review of each element, and contractors develop their own versions of software tools for TPS production at substantial cost and virtually no standardization." (P)

j. "Allocation of Responsibility: One of the serious carry overs from the way earlier business was done was the concept of where and to whom responsibility for providing support was to be allocated. As explained earlier, this was almost automatically assigned to the airframe developer. The philosophy used was that he was the entity who was most knowledgeable of the systems to be tested and further he was the possessor of the necessary source documentation. The advent of ATS's modified this concept to some extent. In some cases the airframe manufacturers were told which support equipment would be used to support their systems. In many cases the large manufacturers, after some initial resistance, merely modified their approach and began to develop automatic systems to provide the necessary support. In effect, a new type of special purpose test equipment was developed. However, the proliferation and limited utility of these systems were not the most serious consequence. More serious was the almost automatic allocation of responsibility to the weapon system developer for design and development of the test programs which would support their weapon systems. It did not take long for the fallacies underlying the surface logic of this allocation to become clear, especially in cases where the test system was developed elsewhere and provided to the prime weapons system developer. One of the most significant of the overlooked problems, was the fact that the system designer was seldom, if ever, the same person as the test program designer and consequently the advantage of the knowledge concerning the UUT operation was lost. A second problem was the fact that many of the WRA's (Weapon Replaceable Assemblies) were subcontracted and consequently the prime manufacturer had little advantage over anyone else as regards system operation or documentation. Thirdly, the need for test program personnel to have knowledge and experience in program development was overlooked. This cause a recurring expense related to the learning curve effect each time a new staff of engineers had to be trained by the prime manufacturer. In addition, the training and organization used was often defective due to a lack of experience on the part of the prime management (i.e., development of a cost-effective, quality set of test programs requires different organization, supervision and controls than that required for development of hardware). Fourth, the transfer of knowledge concerning the operation of a UUT was not recognized as being simpler than the transfer of knowledge concerning the functioning and operation of the ATE and the techniques, procedures, and design requirements for automatic test system programs. Experience with test programs and programs and programming staffs seem to strongly indicate that an engineer does not become proficient at test program development until he has benefited from the exposure of validating several of the programs he has developed. This assumes that he was initially capable and oriented toward test programming to start with. Finally, the allocation of program development to the weapon system prime, imposed a large cost burden on the programming effort. Not only were the overhead structures of the larger prime with its normally enormous factory and facilities requirements imposed on the programming effort, but also, the impetus of lower cost through competitive procurement were lost as a result of the support costs being thrown in as part of the 'cost plus' prize resulting from the award of the weapon development contract." (C)

k. "In order to alleviate the problem introduced by improper LORA, one must either plan for and fund complete test coverage or find a more effective means of determining which UUT's will be supported by the ATE. The approach contemplated for new programs (e.g., F18) will involve both approaches. It is anticipated that the aircraft avionic WRAs will receive complete test coverage, however, the SRAs will be treated differently. Initially all SRA's will be spared at a higher than normal level and field data will be collected on the operational reliability and mission essentially of the units in use. This will provide an objective assessment of SRA factors which would be used to determine the need for and number of SRA TPSs. Thus SRA TPSs would only be developed as their need becomes manifest. The delay in SRA TPS availability would be offset by the temporary higher level of SRA spares. Significant savings in investment costs should accrue to the project as a result of this process." (C)

l. "Because of its tangible characteristics, it is a natural and human failing to think of automatic testing in terms of the hardware or electrical systems. Hardware can be seen, touched, and heard. Consequently a tremendous amount of effort has been expended in system performance. It is not the intention of the authors to ignore the importance of a system's ability to work well in accordance with its specifications and to be reliable. However, it is also important to recognize that the major difficulties which are encountered when using an automatic test system are related to the quality of its programs and the design of the UUT (Unit Under Test). Good systems can be rendered virtually useless and weak systems made to appear good depending on the quality of the test programs and whether the UUT is designed for testability. It is sufficient to note that continuing difficulties have been experienced in implementing automatic test systems in spite of major improvements in systems performance.

m. "As has been mentioned above, it is planned that ATE cognizant experienced personnel will be involved in the new program development process at an earlier date than had been the previous practice. These personnel will either be resident at the UUT developers facility or visit on a regular basis to verify that the requirements necessary to make the UUT ATE compatible and testable have been adhered to. It is recognized that these people must have sufficient control to enforce compatibility and testability requirements. In addition they would monitor for appropriate development of source documentation. One means of imposing the required control is to not allow any UUT to be released for production until it has been approved by the ATE monitoring personnel." (C)

n. "Future aircraft/avionics will have the advantage of not having to undergo the inherent problems which result from virtually simultaneous development of the test system, language, compiler, and test programs. The ATE to be used in this example is VAST (which exists), is reasonably mature and has a well defined development for the WRA's as well as a fixed baseline by which to measure test compatibility of the UUTs. In addition will allow more accurate scheduling to ensure emplacement of the test systems in a timely fashion." (C)

6. PROCUREMENT/FUNDING

Procurement of support equipment has caused acquisition logistics problems because the manufacturer is pressured to sell a specific end-item which has a leadtime somewhat less than that of the support equipment required for the end-item. Therefore, forecasting requirements for procured equipment can shorten lead times and reduce RDT&E funded procurements. Software development effort should be funded prior to the deployment of hardware in ground support equipment and the software costs should be tracked in the system acquisition process.

a. "Factors being utilized by contractor relative to MTBF/MTBD are unrealistic and not real world. They do not take into consideration realistic operating times of SE." (U)

b. "Spares Support funding is not sufficient to fully procure needed items for O&I and Depot." (U)

c. "Total ISSL requirements are not initially programmed, thus leaving a void for site activations." (U)

d. "The use of such programs as MOD-METRIC is difficult to implement and does not blend with SE type of spares programming."

e. "When a new weapons system utilizes previously procured GFE, they assume spares are available to support ISSL requirements, etc. This is normally not true, and SPO/SM activities should develop program documents in conjunction with IM activities to program spares for the new application." (U)

f. "It is recommended that a Blue Ribbon Panel of experienced personnel be called to discuss impacts of past and present spare parts acquisition procedures on new weapons systems to determine improved methods. Methods should take into consideration real world conditions." (U)

g. "Acquisition logistics problems are being experienced in procurement of major items of common support equipment in support of weapon system sales to foreign governments under the Security Assistance Program (SAP). The basic problem is the aircraft manufacturer can produce the aircraft in 18 months, and some of the essential common support equipment require 24 to 36 month production lead time. Commitments are made to provide the aircraft in less than support equipment lead time due to pressures to 'sell' a specific weapon system or be competitive with third country aircraft. These commitments inevitably lead to marginally supported program that requires development of 'work around' procedures to cope with the lack of support equipment and dissatisfaction on the part of all concerned." (U)

h. "It is recommended that the acquisition process of weapon systems for SAP be expanded to consider lead time for common support equipment as well as peculiar development support equipment and the aircraft." (U)

i. "Significant surprises are surfacing when the bottom line costs of computer resources (includes software) are revealed. Software costs are not tracked in the system acquisition phases. To do so, software requirements must be specified as contract line items. In addition, software data documentation requirements must be included on the contractually identified in the contract work breakdown structure (MIL-STD-881) level 3. These actions, combined, will provide software cost visibility and the source data for conduct of the Life-Cycle-Cost Analysis. It will also enable the acquiring activity to evaluate and compare the contract software costs with costs to generate the software organically. These lessons need to be made available to each AFLC system manager and the AFSC product divisions." (Q)

j. "It is sometimes decided early in a program's development that insufficient funds exist to provide complete coverage on the test system. Normally, a level of repair analysis (LORA) is performed. Only certain UUTs are selected for support because of their cost, expected reliability, or mission criticality. Normally, all WRAs are supported, and Shop Replaceable Assemblies (SRAs) are partially supported. Experience has shown that the LORA analysis is too often inaccurate. In many cases the SRAs included in ambiguity groups are not considered or the SRAs are considered in isolation without adequate consideration to system imposed stresses such as heat, transients, noise,or loads. The result often appears as an inability to provide adequate support because of inadequate spares or lack of test programs required to repair UUTs necessary to restore WRAs to a condition where they are RFI (Ready for ISSUE)." (C)

k. "New ATE systems should be fully funded. Incremental funding can cause numerous delays." (A)

l. "The need to fund an extensive software development effort prior to deployment of the hardware introduces a significant new cost element in ground support equipment procurement." (P)

m. "We feel, based on economic analysis, that we can safely predict ten year amortization of a procurement of $250,000 for a single station analog ATE and one shift operation. Multiple shifts of course will amortize more." (X)

7. ATE DEPLOYMENT CONCEPT

Deployment requirements for intermediate level test stations should be based upon wartime environment and the ATE must provide flexibility to accomplish quality control, quality assurance, and diagnostics. The real driver of placing ATE at each maintenance level is related to the amount of items to be supported. If the number of items is small then the selected ATE should be relatively inexpensive. If the workload is high then a more costly ATE can be justified. Therefore, the key to cost effectivity in selecting ATE is directly proportionate to the workload it will see.

a. "Contractor SAIE and depot equipment should be the same hardware to reduce incompatibilities in weapon system testing." (A)

b. "Now let me tell you why we didn't use some of our other ATE equipment. We have not successfully trained our test personnel to accept and use ATE equipment." (C)

c. "We, both government and industry, have designed equipment with complete lack of knowledge of how the user was going to handle it." (C)

d. There are some who advocate reduced environmental requirements (commercial design) for intermediate level test systems based upon the availability of sheltered operational facilities. These proponents neglect the impact this approach imposes on the deployment requirements of the test system during a wartime environment. In a wartime or other deployment situation, the user must also bring along the supporting environmental equipment necessary to sustain operation and mission readiness. This becomes a cumbersome and unnecessary impediment at a time when swiftness and mobility are paramount." (C)

e. "ATE provides the flexibility needed at both the DS and GS maintenance facility to accomplish quality control and quality assurance tasks in addition to the diagnostics during action repair operators." (H)

f. "There is no substitute for having a firm understanding of your own specific goals and objectives prior to departure in your voyage into the world of ATE." (D)

g. "Second, movement of equipment to be tested must be kept to a minimum. This is an item that is usually ignored in analysis, but if time and motion studies are performed it will bear out that great amounts of funded time is presently being used in moving materiel to and from large central test stations." (D)

h. "Reconfiguring (using building blocks with heavy usage that could be grouped into a core VAST configuration substantially smaller than the full (VAST) two of the three VAST stations intended for shipboard installation could yield three lesser configurations for about the same cost and floor space as two full stations. Preliminary analyses indicated that up to an additional 25% workload increase over the three stations configuration could be handled in this manner." (I)

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8. TRAINING/PERSONNEL CONSIDERATIONS/SKILL LEVEL DETERMINATION

a. "The original concept of automatic test systems envisioned the use of an operator with minimal training. This operator need only be required to know how to operate the ATE and follow the instructions provided in the test program. This concept has been shown lacking because it anticipates a situation in which the program will be perfect, the machine will always operate properly, and documentation associated with the testing process will always be up to date and correct. Experience has shown that all of these factors seldom prevail in spite of the most stringent efforts. Consequently the operator must have some knowledge of the test system and the test program to allow him to efficiently overcome test inconsistency, ambiguities, and anomalies that may be encountered." (C9)

b. "The marketplace abounds with a variety of modern software aids. There often exists a tendency for software suppliers to imply, and users to believe, that software is a substitute for technical expertise and the thinking process."

c. "Unfortunately insufficient emphasis is placed upon man/machine interface. It is imperative that the ATE operator and his interaction with the UUT plus the ATE be established as an integral consideration of the program design. Premediated evaluation of man/machine interface will enhance optimum thruput in a realistic human environment. The application program designer must become involved and cognizant of the actual operating environment of his product." (B)

d. "Establishment of trust in Automatic Testing - How does one go about making the operator/repairman believe a component or module is actually the faulty item by a printout on paper? Is the Assembled Program Listing (APL) and English Language Test Design Document (ELTD), along with considerable technical manual theory, required by the user? These are requirements because of a machine failure or intermittents causing distrust. Management as well as the user has distrusts." (A)

e. "Inadequate or lack of training to the user causes hardship between user and developer when program fails." (A)

f. Shop personnel have limited knowledge of procedures.

(1) Cause: High turnover and rotation of personnel.

(2) Solution: Organize and plan ATE personnel rotation and maintain a core staff." (S)

g. "Be sure that enough operators are programmed through the school to meet the operational needs as well as the turnover rate." (A)

h. "At the present time the LCSS operator is also the repairman. Some thought should be given to separating these functions." (A)

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i. "It often required engineering judgement to interpret the data so that highly skilled technicians were required even for what seemed to be routine data collection tasks." (P)

j. "Based on studies to date, we can estimate that the length of training required to enable a technician to go beyond BIT would be approximately one to one and a half years. While this is only an estimate, it is sufficiently accurate to indicate that this approach would not be cost effective since the majority of the technicians would leave after their first enlistment. There is another alternative that should be investigated. The previously addressed problems with BIT and automatic test equipment do not represent the majority of the maintenance transactions. As a result, a highly skilled technician is not required in all cases. Therefore, it would be effective to divide the training into two broad categories. The first category would be the training that is required to troubleshoot the 'normal' problems. That is, those that BIT and the automatic test station can identify. New technicians would be trained to this level. The second category would cover those areas beyond BIT and the automated routines. The training would be given to those individuals who elected to re-enlist." (Y)

k. "The first category would cover the 'normal' technical requirements associated with automated fault isolation. The second category would cover those areas that cannot be effectively fault-isolated through automated routines. Due to the length of training required for the second level, it would be cost effective to limit it to career airmen." (Y)

l. "The ATE must be married to the journeyman technician in order to realize maximum benefits from diagnostic testing. These programs are exceptionally difficult, if not impossible, to devise. By marrying the test equipment to the technician, as with conventional test equipment, the maximum benefits are realized. A skeleton of diagnostics can be preprogrammed to place the technician in the proper area and the technicians skills can then be used to take the problem down to a replaceable component. (X)

m. "Fact: Resolution of discrepancies not timely or adequate.

(1) Cause: Discrepancy report system inadequate. Overwhelming complexity. Inadequate training.

(2) Recommendation: Field multidiscipline, quick-reaction teams for six to nine months to resolve induction problems on the spot and provide special hands-on training " (T)

n. "The report further indicates that in spite of built-in-test and automatic/semi-automatic test equipment, there still is a requirement for skilled technicians." (T)

o. "The need for training on future programs is recognized and the training of the VAST operators is being upgraded and improved both in maintenance and functional understanding. However, it is also felt that effort must be undertaken to mitigate the problems faced by the VAST maintenance and operations personnel. To this end, recommendations have been made that steps be taken in the contract award phase of TPS development to assure an efficient effort. One of these steps include a mandatory training and experience level for at least 30-50% of the engineers assigned to the TPS

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development task. The required training to qualify an engineer for test program set (TPS) development would be designed and developed by the Navy." (C)

p. "Personnel turnover of contractor (technical and management) and government (civilian and military) requiring considerable time to educate due to newness and complexity of test programming." (A)

q. "Extensive diagnostics only waste time when high skill levels are available."

9. CONFIGURATION CONTROL - SOFTWARE

Software elements must be described at project concept stage and this description must be quantitative with performance measurement parameters defined. System development process should be recorded, and this history should include how software elements were developed, evaluated, integrated into the total system, and deployed. Experience can be handed down to project managers and lead to systematic procedures for optimizing software development cycle. Quality assurance and product evaluation are achieved by in-process control rather than end-item testing.

The program developer can develop an effective test program for a UUT by understanding the manner in which the UUT functions, the manner in which UUT failures manifest themselve, the ATE capabilities, and preferred automatic testing procedures and techniques. This knowledge is required to enhance throughput, repeatibility, ambiguity level, and program completeness.

1. A tightly controlled configuration control scheme for software is a must. (A)

2. Similar deployments of ATE have found it impractical to allow individual operating activities to police their own program changes or to make one depot the watchdog of another in matters pertaining to software configuration control. (P)

3. HATS operating system software is completely 'locked out' so as to be inaccessible to Navy maintenance personnel. (W)

4. <u>Software Generation Process Poorly Defined</u>

a. There are those who claim software requirements differ too widely among applications to be subject to the usual disciplines of quality assurance or strict configuration management. This is nonsense. The fact that software projects tend to vary widely is all the more reason why a particular process should be defined in detail with quality and configuration criteria established at the outset of the project. The fact is that the factors of production and procedures for developing software for specific projects are rarely defined at all. In proposals, for example, system hardware requirements are often defined to the point where the design is practically frozen to a given configuration even before the preliminary design phase. Software on the other hand, is covered by a few "motherhood" statements to the effect that it is to be compatible with the hardware and be of "sound" design. It is a revealing exercise to count the pages of a proposal or system specification devoted to hardware and compare that to those devoted to software for the same system. Hardware'generally exceeds software discussion ten to one. This same over-emphasis of hardware (or under emphasis of software) in documents is symptomatic of the problem in all efforts dealing with a total system. It is not that software requirements cannot be defined in advance. It is simply that people who write and approve project plans tend to be less knowledgeable of software elements and therefore neglect them in favor of more hardware discussion.

b. At the project conception stage, software elements must be defined with at least the same detail as hardware. These descriptions must be quantitative with performance measurement parameters defined. Those elements that cannot be fully defined at the project inception should be defined as the project progresses, but always prior to actual design of the element to be controlled. At the very least, the process used for system development should be recorded. The history should include how software elements were developed, evaluated, integrated into the total system, and deployed. With this history, subsequent efforts and projects of a similar nature will have a basis for emulation or deviation, should the results warrant. This experience can then be passed on to their project managers and lead to systematic procedures for optimizing the software development cycle as well as the hardware development. If the software development process were thusly defined on individual projects, it would soon become clear to project planners and managers that there are recurring, predictable factors involved, and discipline could be injected into the process. (D)

5. ATE Software vs EDP Software

Software relating to automatic testing technology has much in common with that used in most data processing functions in as much as it must be ingested by a computer. At least the form factors are the same, consisting of huge quantities of pulses stored on a tape, together with corresponding listings of coded information which, to the uninitiated, is not much more intelligible than the stream of pulses on the tape. In most EDP applications, the computer operates on a problem or task defined by the input data and produces more data in a new form, hopefully representing the solution to the problem and thus the completion of the task. The computer in an automatic test system also does this but the task is not finished when the data has been transformed. The ATE (Automatic Test Equipment) must then use the generated data to control the dynamic process of testing hardware. The resources of the ATE dedicated to the execution of the testing process far exceeds those dedicated to data processing. For example, the cost of the computer and its peripherals in a typical ATE is about ten percent of the hardware cost. The same proportional split exists in the level of complexity of the computer subsystem compared to the remainder of the ATE. From this, it follows that the more logical person to apply ATE effectively is one who understands the test system elements, rather than being expert in the computer subsystem. That is why experience has shown engineers and technicians are better at ATE software design than logisticians or mathematicians. The prime contributions of logisticians to ATE have been not in test program design, but rather in developing software tools for ATE. Such tools include language translators, operating systems, and circuit models for test design. This paper will not dwell on software tools because they are not the prime cost factors in ATE software. Also, such tools are much more EDP oriented and thus not substantially different in nature from the bulk of computer applications. (U)

6. Software Not Easily Evaluated

a. Some would have the world believe that it is impossible to tell how good software is until it is deployed. This belief rationalizes the fact that most software exhibits very poor performance after delivery. The fact is

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that it is more difficult to evaluate software quality than it is to ascertain the same degree of confidence in hardware. The reason is that software is almost spiritual in character. It takes a great deal of understanding of its make-up to tell if it even addresses the right problem. It relates an intricate logic sequence (or algorithm) which cannot be judged by sight or other quick test applicable to most hardware elements. The only tool to date that has proven of value in evaluating software rapidly is a simulator. Simulators, however, are not cheap. A lot of similar software must be produced to pay for the initial investment, and the use of simulators is neither easy nor foolproof.

b. Recognizing that evaluating software requires an in-depth insight into its make-up, the best way to evaluate it is to monitor the product in process. If knowledgeable people representing the customer's interest are involved in software development, beginning with the specification of requirements, continuing through design reviews, and finally acceptance demonstrations, it is not necessary to fully test the final program in all of its complex loops. In other words, quality assurance and product evaluation are achieved by in-process control, rather than end-item testing. That is the only practical solution to software evaluation, and it offers the bonus of having the user organization become knowledgeable in the product prior to deployment and substantially reduces dependency on the manufacturer for any future changes or improvements. (D)

c. Lessons are being learned continually in supporting ATE software organically. Costly interim contract support is usually required to maintain and support the software until Air Force activities can achieve an organic capability. Organic support of software is being hampered significantly because the necessary rights are not being acquired with the data documentation. It is imperative that sufficient rights in data (ASPR 7-104.9, paragraph b, 2) be acquired to permit the Air Force activities to use the data acquired for the purpose of organically manufacturing hardware (interface test adapters), updating the delivered software, and creating new software required to add testing capabilities to the acquired ATS. In addition, the data documentation and equipment required to maintain software organically must be identified at a timely plateau in the acquisition cycle to permit contractual implementation and delivery of the required equipment and data. A rapid response library of this type lessons learned would assist significantly in preventing each AFLC system manager and AFSC product division from repeating the mistakes. (Q)

d. The reliability and maintainability of ATS software is generally poor. Air Force inspectors, auditors, users, etc., have generally been critical of the quality and usefullness of test software. It has been estimated that 60% of the test software delivered does not perform the functions for which it was intended and acquired. Significant organic updating/modification is required. Software validation and verification is essential throughout the acquisition cycle. The software validation and verification prescribed by AFR 8-2 and TO 00-5-1. The principal difference is that validation and verification of software begins with development/design of the software and continues into deployment. Validation is essentially an action by the contractor and verification is an action by the government. To be effective, the two actions should be separate. It is important that verification of software by the government begin early because necessary changes

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can be made with minimum cost/schedule impact. All major software design changes should be made before starting production of software; hence, concept, validation, and full-scale development phases are critical and contractor efforts in this time frame must be verified. (Q)

e. Contractors generally use specialized software generating equipment and other programming aids, simulators, analyzers, and so forth, to generate the software delivered on Air Force contracts. When the Air Force modifies the delivered software or creates additional software organically, the tasks cannot be accomplished because the items used by the contractor in the initial efforts were not contractually identified and delivered with the software. The achievement of organic support for software is impacted significantly by nondelivery of these items. These lessons need to be readily available to each AFLC system manager and the AFSC product divisions.

f. Use high level language such as ATLAS (A)

g. A continuing theme throughout the development and implementation of the ATE concept has been that the programming language was the key to facilitating less expensive and higher quality test programs. The quest for higher order test language has consumed considerable energy and expense. Early, the recuring theme promulgated among users was that languages had been designed that were so conversational that anyone could develop programs. Anyone included technicians, secretaries, strangers "off-the-street", and trained monkeys. Many users were lulled by these tales into acquiring systems, turning them over to their personnel and then waiting for the high quality test programs to pour forth. Disappointment was almost universal. The problem of course was due to a misunderstanding of the requirements for writing test programs. In order to develop an effective test program for a UUT of any significant complexity, the program developer must have an intimate understanding of the manner in which the UUT functions, the manner in which UUT failures manifest themselves, the capabilities of the ATE, and preferred automatic testing procedures and techniques. Without this knowledge, throughput, repeatability, ambiguity level, and program completeness must suffer. (C)

h. While the test language per se normally will not have a major impact on program development, the importance of a well defined compiler which is easy and convenient to use is important. The new programs will benefit from prior experience on other VAST programs as well as from the development of the MINIVITAL compiler system developed to make modifications and updates more convenient and less expensive. An area in which language and communications is critical is where the UUT developer must communicate test requirements to the test program developer. This communication should be clear, unambiguous, and well defined. To assure this type of communication, a requirement will be imposed to employ ATLAS (416-10) as the communications vehicle. To assure that the requirements of 416-10 are fully followed, a syntax analyzer will be developed by the Navy through which each of the developed test specifications must pass successfully. (C)

10. CONFIGURATION CONTROL - HARDWARE

Configuration management and control is a life-cycle process, and personnel with an appropriate technical background must exercise technical control over ATE system once the equipment baseline has been established, and monitor deviations stringently. Traceability for all application programs must be established by administering technical control over product improvements, modifications, and changes. Configuration control can aid in avoiding proliferation of ATE systems by selecting the best available tester and interface design based on performance in field environments.

a. "Inadequate background of technical design monitors or lack of personnel (spread too thin) causing them not to know well enough what they will be buying during R&D." (A)

b. "While interface design must consider all technical requirements of the overall program task, it is additionally necessary to consider durability, repairability, and configuration control." (B)

c. "ATE configuration management and control is a life-cycle process. For example, the life cycle for a UUT application program can be many years during which time the UUT may undergo considerable product improvements or changes. It is vital that technical control and traceability exist for all application programs." (B)

d. "Multiple test stations must be available to prevent bottlenecking production. This could be accomplished by distributed systems, minicomputer stand alone systems,or calculator based systems." (X)

e. "Once the initial design and development is completed, and the first system is delivered to the user (generally referred to as operational status), the equipment and its documentation (drawings and software) must be audited in accordance with the defining military specifications. The result of this audit is the equipment baseline. It is extremely important to record this configuration and not to deviate from it without proper configuration control techniques." (E)

f. "Configuration control requirements must be passed along to these subcontractors at the outset of the development. If this is not accomplished, many configuration baselines for the same equipment will result, and subsequent necessary changes thereto will result in excessive test system downtime, as well as costly implementation delays." (E)

g. "A commercial manufacturer will constantly upgrade his product line to gain a competitive advantage. Unless a constraint is imposed under the development program, he has no obligation to maintain configuration." (E)

h. "Testing by function allows consolidation of equipment, thereby reducing duplication of stimulus and measurement capabilities across test stations." (E)

i. "The ultimate user must have the ability to maintain and support the test system, or forever be dependent upon the manufacturer. This is where the significant advantages of a militarized design which embodies (1) the complete interchangeability elements of Configuration Control Management, (2) the maintenance capabilities of on-equipment fault isolation to the lowest replaceable module, and (3) the simplified man-machine interface begin to unfold. These three design considerations minimize downtime, increase equipment availability, and provide lowest overall logistics life-cycle cost." (E)

j. "In the interest of avoiding proliferation of ATE systems and their associated test languages and software, it was concluded that a hybrid tester was the logical choice should the S3A program require an SRA tester in addition to VAST. Later analysis of SRAs confirmed that hybrid testers were able to test 50 percent of the pertinent SRAs whereas the best of the purely digital testers could handle only about 35 percent of the SRAs." (P)

11. SPECIFICATIONS/CONTRACTS

Factory and military specifications are being used in the development and production of ATE systems, and experience indicates that these two kind of specifications do not always agree on design tolerances and testing of operating parameters. Specifications should contractually define demonstration rules to contribute to organized program development and technique efforts and to place a constraint on the design so as to insure ATE will perform in its intended operational environment.

a. "A Tolerance Tree should be provided by the supported weapon systems. This LCSS tests the weapon systems to their respective MISs which are factory specifications. This has caused considerable rejection of good items of hardware in the field." (A)

b. "When a contractor is demonstrating to the Government that the ATE can find faults, the demonstration rules should be fully defined in the contract and also be part of the Data Items, if possible. LCSS personnel experienced numerous problems with the prime contractor during demonstration because of rather vague rules." (A)

c. "Drawings which have been superseded should be 'obsoleted.' Drawings not obsoleted have caused considerable procurement problems for LCSS." (A)

d. "Specifications and Documentation - Lack of basic design tolerances or operating parameters which must be tested. Specification incompatibilities, further complicated by SAIE (Factory Test Equip), differ from specs and sometimes lack of specification on the SAIE causes automatic testing differences on production hardware." (A)

e. "Test equipment design deficiencies, accuracy vs specifications, operation vs specifications -- these and others cause alternate test techniques to be devised, signal conditioners to be designed, and many changes to test programs during the validation exercise." (A)

f. "UUT Test specifications and test source documents remain as perhaps the most singular area of ATE requiring improvement. UUT test specifications are often vague and ambiguous, with semantic (vocabulary) that can be interpreted to mean many things. Test application program design cost and subsequent success is directly based upon a quality, comprehensible, are non-ambiguous test specification." (B)

g. "The type of organization to be used for the TPD development task as well as allocation of responsibility and quality control provisions should be defined in the contract. In addition, a set of guidelines peculiar to the aircraft TPS development requirements containing good practices and recommended programming techniques should also be developed and applied as a contract requirement. This approach should enable the Navy to preclude the consequences of overly segmented and disorganized program development efforts which have been experienced in the past." (C)

h. "Specifications and standards serve to define the support requirements of the test system and, at the same time, constrain the design so that it is compatible with the operational environment anticipated." (E)

i. "Defined constraints in the form of specifications and standards governing the requirements must be implemented in the design/development phase of the test system program." (E)

j. "One vehicle used for defining ATE Independent Test Requirements is to develop a Test Requirements Document (TRD) Specification. The TRD specification approach has been used by the Air Force with apparent success. Using the TRD specification as a guide, the contractor prepares a TRD for each item to be tested. This then is translated by a man and machine combination into a test program." (P)

k. "Do not reinvent the wheel each time a new aircraft is built. Leave out the goldplated item and stay with FAA requirements unless justified. Use FAA speicifications and existing design as a baseline design. Only in justified cases shall the ROC and design deviate from this baseline. By doing so, the cost of an air vehicle could be drastically reduced." (U)

12. MAINTENANCE DATA COLLECTION/PRODUCTION CONTROL

Maintenance data collection should commence early in the program design phase by determining which critical or major elements/parameters within the ATE/ATSS system are going to be tracked. This data, based on failure rated MTBF, will provide a measure of performance of the ATE system after it has been initially fielded.

ATE hardware/software should be designed so that failure data on end item support could be transcribed on tape and stored for subsequent engineering analysis and product improvements.

Production control can be enhanced by insuring that workflow analysis has been performed and applied to achieve optimum man/machine interface requirements, ATE thruput, and the control of application programs.

a. "Data capture and collection, if desired, for a UUT application program, should be an early consideration within the program design phase. Establish what is worthy of capture and then ascertain the optimum methodology of collection." (B)

b. "ATE should have some form of automatic logging of Go/No-Gos." (A)

c. "ATE utilization is what we should achieve in our production or maintenance environment if we have properly performed the following:

Establish the production or maintenance workload

Performed an integrated workflow analysis

Established the ATE posture in the workflow stream

Consulted with the user

Assessed the optimum man/machine interface requirements

Determined the optimum ATE Thruput

Designed/debugged and implemented the application programs.

Sustained a 'follow-on effort' as a part of Resource Management requirements to assure all needs and goals were met." (B)

d. "ATE thruput is a very misunderstood term. Many people relate thruput only to the execution time of a measurement and stimulus device or the speed of a peripheral device. In reality it amounts to combined time that is required for a man to connect an interface between an ATE/UUT, press a button, then mutually interact with required elements of the ATE, and the UUT under the designed, premeditated control of an UUT application program until the entire effort is terminated. All of the above elements can independently or mutually influence thruput." (B)

e. "No traceability on performance of test programs in terms of how well the repaired SRAs work in WRAs, as Lockheed was permitted to make its own determination of end-to-end SRA tests and test tolerances without any requirement for demonstrating that an SRA tested to these tolerances will work properly as part of the WRA (black box)." (W)

13. TECHNOLOGY

Testability should be considered as a design goal and test equipment should be designed so that it can be economically tested. Fault isolation of a board having several microprocessors should be addressed in the initial design and programming phases. Fault isolation to a module has proven to be the most cost-effective maintenance concept for intermediate level test systems. Built-in test requirements for test systems has reduced proliferation of support equipment for testing the assemblies in the test system.

a. "A digital pulse comparison tester. This type of testing is now discredited as a viable means of performing digital testing." (X)

b. "I advocate fault simulation testing with a guided probe due to the need for 100% detection. For field use, a transition counter would appear to be a good bet, but again, the confidence factor could affect the decision based on the availability of replacement cards and mission requirements." (X)

c. "Depth of testing - When is it feasible to write a test program or test manually? Should we always isolate every component regardless of cost? Where does automation of testing end and manual testing start?" (A)

d. "Technical Manual Interface - Where should automation end in terms of print instructions to the operator? What is the best method and most feasible use of the printer or tech manuals?" (A)

e. "With ever-increasing complexity of avionics, the vendors must plan for fault identification and isolation, both at LRU and SRU level, during the initial design of their products. 'After the fact' test programs are becoming increasingly difficult and expensive, particularly on digital equipment." (V)

f. "Micropressors add a frightening new dimension to this problem. Testing on single micropressor chip is not very difficult, since it will simply be replaced if the output is wrong with proper known input. However, a board with several micropressors will be impossible to fault isolate to a single chip unless the manufacturer address this problem in his initial design and programming." (V)

g. "Built-in test requirements have become the standard for test systems developments in recent years. No longer is there a proliferation of support equipment to test and maintain major assemblies within a test system. Fault isolation to the module has been proven to be the most cost-effective maintenance concept for intermediate level test systems." (E)

h. "Depot support equipment and support software activation of organic facility is often late, very costly, and test methods may not be compatible with intermediate level testing. This impacts overall operational effectiveness; i.e., distribution of assets, spares computations, maintenance of computer programs, etc." (U)

i. "Depot support is normally the last function to be activated, and does not receive the same attention and funding as organizational/intermediate support during early phases of acquisition. Data requirements may be deferred for later funding or deleted entirely. The rationale is usually that factory test equipment and data from the production facility can be used, and any deficiencies can be offset by contract engineering service or mainteannce support until organic facilities are operational. Such delay allows the contract to proceed with decisions for production of hardware and software without regard to support requirements or the need to prepare and deliver support software documentation. This has the effect of placing the vendor in a 'can't lose' sole source position for maintenance of hardware and software."(U)

j. "The technical interchange between Government and contractor for definition of hardware/software support is cost effective only if accomplished early in the program. Future acquisitions should establish a higher priority for this action." (U)

k. "In the sixties, the situation began to change in many respects. Technology began to make staggering advances. Avionic systems were not only becoming smaller and lighter, but also more complex. Many new functions were now being designed into each major weapon system since the reduced weight, size, and power required by the new avionics allowed for added capability. Additionally, the design techniques traditionally used in weapons systems were changing (traditional analog functions in communications and navigation were giving way to digital techniques and the computer). In keeping with one of the corollaries of Murphy's Law which says, 'If things can get worse, they will,' this was also the time that the services were losing their trained people at a furious rate to opportunities in the civilian sector." (C)

l. "With useability as a design goal, the next generation of ATE tools may be more encompassing and much more efficient than past systems." (G)

m. "The test program acquisition and development process not only offers the most fertile area for general elimination of problems, but also offers an opportunity for significant reduction in the costs associated with implementing an automatic support concept. The phenomenon of the software costs equalling or exceeding that of the hardware has been pointed out on numerous occasions." (C)

n. "Lockheed feels that 'BITE' is 98% effective in identifying faulty WRAs. (Virtually all S-3 WRA's contain BITE.)" (W)

o. "The current trend, especially in Avionics, is to design and rely on Built-In Test (BIT) and Automatic Test Equipment (ATE) for both organizational and intermediate level fault isolation. This concept does not require an individual to be trained to a high level of expertise in fundamental electronics. Accordingly, training courses are designed around this concept. However, neither BIT nor ATE can be designed and built to be 100% effective. A void in technical capability exists for that small percentage of complex malfunctions beyond the capabiltiy of BIT and ATE. Since this type of malfunction represents only a small percentage of discrepancies, it would not be cost effective to train everyone to troubleshoot and repair this type of malfunction." (Y)

14. SUITABILITY OF COMMERCIAL AUTOMATIC TEST EQUIPMENT

There are a considerable number of users scattered throughout the military services and other government agencies, who have been successful in obtaining satisfactory service from commercial computerized equipment in fairly rugged environments.

a. "Rack mounted equipment in vans equipped with air suspension systems seem to be adequately protected against shock and vibration resulting from transport over improved roads at highway speeds and over rough terrain at 3 to 5 mph." (N)

b. "Commercial minicomputers seem to require an ambient temperature in the range 60°P to 90°P for proper operation." (N)

c. "Humidity doesn't appear to be a problem unless there is condensation, in which case the equipment may not operate properly until it is dried out. No long-term ill effects have been reported so far, but most of the systems discussed are either kept running full-time or are operated in relatively dry locations. Emphasis will be placed on getting good data concerning humidity effects." (N)

d. "Dust and dirt can cause damage to magnetic disc and tape memory systems. However, air filtration and moderate attention to 'good housekeeping' seem to provide adequate protection against this hazard." (N)

e. "CS^3 consists of an IBM 360/30 computer with associated peripherals (9 disc drivers, 6 tape transports, card reader, card punch, line printer, electric keyboard terminal) all mounted in two 35 foot air-ride vans. This mid-60s vintage commercial ADP equipment was installed in the vans by Lexington Army Depot. Thus far, 15 systems have beeh fielded at Division level, with number 16 now being built." (N)

f. CS^3 is manned by military operators and maintenance people, but there is a backup maintenance contract with IBM for problems not handled by the military personnel." (N)

g. "The spec for CS^3 calls for an operational temperature range of -40°P to +125°P outside the vans. At present, there is some evidence that the air conditioners cannot handle the load above 110°P ambient, but the heaters can probably handle the low temperature satisfactorily." (N)

h. "The system is moved about 2 to 3 times per year, this being into the field located up to 10 miles from its location at WSMR. The first part of the trip (10 miles) is on paved roads but it is sometimes moved over rough terrain (1/4 mile) to the test location. Speed on paved roads is 45 mph; speed on unimproved roads is 10-15 mph. For a short move out to the field (10 miles), the disc is secured as well as some equipment on roller slides. The printer, plotter and CRT which are normally on a table top are placed on the floor of the trailer. Their own driver is employed for short trips. A short move requires 2 people about 1-2 hours to secure the system. Long moves require the equipment to be lashed to the walls and boards fastened to the equipment racks. The system was also designed to be airlifted." (N)

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APPENDIX E

GENERAL SUPPORT ATE REQUIREMENTS

1. PURPOSE

The purpose of this paper is to provide a redimentary methodology for estimating quantity of ATE required to perform Quality Assurance (QA) and Fault Diagnosis (FD) on Line Replaceable Units (LRUs) and Printed Circuit Boards (PCBs) at the General Support (GS) maintenance level.

2. SCOPE

This methodology is intended to serve those supported systems for which detailed workload analysis has not been accomplished. Many assumptions have, of necessity, been made to simplify the analysis and attendant data requirements. All quantities/parameters are subject to change based on individual system analysis. The method does, however, serve to scope the size of the GS ATE resource problem.

3. OVERVIEW OF METHODOLOGY

The method is divided into five parts:

a. Determination of supported system generated maintenance action rate in the area of operations (normally a Corps) served by a GS facility.

b. Determination of the way each failure is manifested (failed LRU or PCB or both) and serviced (percentage of LRUs and PCBs on which FD/QA is accomplished).

c. Assignment of ATE "hands on" time for each action performed using the ATE.

d. Applying "hands on" time to each action; summing these actions to give ATE machine hour requirements.

e. Establishing ATE availability per year. Dividing this number into total "hands on" time will give the machines required to support a given system deployed in a Corps.

4. SYSTEM FAILURE RATE

a. There are many ways to determine system failure rate. The method used depends largely on the life-cycle status of the system and attendant failure data available. For fielded systems validated data may be readily obtainable and can be used with high confidence. For systems in development, data based on testing or MIL-HDBK 217 predictions can be used. This type of predictive data should be used with caution, however, because experience by all the military services show that field failure rates are several times (2-10) greater than those predicted during development. This is caused by false no-go indications, unanticipated rough handling, secondary failures, and improper hookup/operation. Based on experience it is suggested that a factor of 3.5 be used. That is, if predictive techniques (MIL-HDBK 217) indicate an MTBF 100 hours (failure rate of .01/hr), a field MTBF of 28.6 hours (maintenance action rate of .035/hr) should be used. Finally, it is important to exclude those parts of the system that will not be tested on ATE in deriving the failure rate (Mechanical units, Air Conditioners, Generators, etc.).

b. The deployment and annual operating hours of the supported system must also be determined. That is, once a maintenance action rate per system is determined, it must be multiplied by the number of systems deployed in a GS area and the expected annual operating hours of that system under wartime conditions. For example, if there are 20 deployed systems, each with 5000 hours per year operating time and .035 maintenance actions per hours, the total number of maintenance actions per year would be

$$20 \text{ systems} \times \frac{.035 \text{ maintenance actions}}{\text{system - hr}} \times \frac{5000 \text{ hours}}{\text{yr}} =$$

$$\frac{3500 \text{ maintenance actions}}{\text{year}}$$

5. FAILURE MANIFESTATION AND SERVICING

a. The way a maintenance action manifests itself at the GS level is very much dependent upon the logistics support concept of the particular supported system. For example, many systems will have Built In Test Equipment (BITE) which will isolate failures only to the defective LRU. This LRU will be evacuated to the GS level where fault isolation will be accomplished to the PCB level, and for some cards, to the piece part on the defective card. In these cases the load on the ATE will include diagnostics and functional testing on LRUs and PCBs.

b. Other systems may have more sophisticated BITE which allows for fault isolation to a faulty card on a significant number of cards. In this case the GS ATE will be presented with cards and a smaller number of LRUs than the previous case.

c. The most frequently occurring case seems to be as described in Paragraph 5a. Most systems were treated in this manner; however, those systems which were identified as falling into the PCB/LRU category are treated accordingly.

d. Once an LRU reaches the GS ATE the following assumptions are made (per 100 LRUs):

(1) 25 will not in fact be faulty; they therfore will require only a functional (end-to-end) test.

(2) 40 will be faulty and require one fault diagnostic test and one functional check. An average of two PCBs will be removed and replaced off line. One PCB will require only a functional test as it is presumed not to be faulty; one PCB will require a diagnostic test (with repair off lines) and a subsequent functional check.

(3) 35 will be faulty and require an average of 2 diagnostic tests and one functional test (anormalies/multiple failures are the cause of the two diagnostic tests). An average of two PCBs will be removed and replaced per diagnostic test (4 PCB total); two will require only a functional test (one from each diagnostic test), and two will require a functional and diagnostic test.

e. It is estimated that 50% of the faulty PCBs mentioned above will be repaired at GS, with the remaining 50% being repaired at depot. It is assumed, however, that those designated for depot repair will be subjected to a test that amounts to a functional test one-half the length of a normal functional test (encounters a fault indicator half-way through the test and stops with no diagnostic tests since it won't be repaired at GS).

f. For those systems identified as presenting both LRUs and PCBs to the ATE, it was assumed that either 80% or 50% of the failures resulted in 2 PCB's for the ATE with either 20% or 50% of the remaining failures being manifested as LRUs.

6. TIMES FOR ATE ACTIONS

a. General. It is assumed that repair for both LRUs and PCBs will be accomplished off-line such that the ATE will be available for testing during repair actions. It is further assumed that:

(1) Shop management procedures are such that required applications program storage media and interface device/cabling are available at the start of testing.

(2) Any necessary set-up/warm-up/inspection of UUTs has been accomplished prior to testing.

(3) Fault diagnosis times allow for accessing, probling, adjustment and alignments to UUTs.

b. LRUs

(1)	Hookup (LHU)	6 minutes
(2)	Fault Diagnosis (LFD)	35 minutes
(3)	Functional Check (LFC)	25 minutes
(4)	Disconnect, TAG (LDT) for repair	6 minutes

c. PCBs

(1)	Hookup (PHU)	2 minutes
(2)	Fault Diagnosis (PFD)	10 minutes
(3)	Functional Check (PFC)	6 minutes
(4)	Disconnect, TAG (PDT) for repair	2 minutes

d. Figure 1 shows that for each maintenance action manifested as an LRU, 111.25 minutes (1.85 hrs) of ATE time is required to correct it.

Figure 2 shows that for maintenance actions manifested as two PCBs 80% of the time and one LRU 20% of the time, 38.7 minutes (.64 hrs) of ATE time is required.

Figure 3 shows that for maintenance actions manifested as two PCBs 50% of the time and one LRU 50% of the time, 65.9 minutes (1.1 hrs) of ATE time is required.

7. ATE AVAILABILITY AT GS

The ATE will be capable of operating 23 hours per day (1 hour for preventive maintenance). Further, it is assumed that an additional 2.5 hours per day should be allowed for corrective maintenance, operator fatigue/sickness/military details, RGS movement, procedural mistakes, etc. Thus, actual available ATE on station time will be 20.5 hours per day or 7482.5 hours per year (7 days per week).

8. SUMMARY

a. Determine the theoretical Mean Time Between Failure for a single copy of the supported system (hours). Invert to obtain theoretical failure rate, FT (failures per hour).

b. Multiply FT by 3.5 to obtain MAH, maintenance actions per hour at GS (per deployed system).

c. Multiply MAH by the supported system annual operating hrs, OH, to obtain the per deployed system maintenance actions at GS per year. Designate as MAO.

#LRU's	ACTION	TIME (PER LRU)	TOTAL TIME
25	(LHU+LFC+LDT) (Test Good LRU)	37	925
40	(LHU+LFD+LDT) (Diagnose Bad (LRU)	47	1880
	+(LHU+LFC+LDT) (Recheck Repaired LRU)	37	1480
	+(PHU+PFC+PDT) (Check one good PCB)	10	400
	+0.5(PHU+0.5PFC+PDT) (Check only, depot repairable faulty PCB)	3.5	140
	+0.5(PHU+PFD+PDT) (Fault diagnose GS repairable faulty PCB)	7	280
35	2(LHU+LDF+LDT)	94	3290
	+(LHU+LFC+LDT)	37	1295
	+2(PHU+PFC+PDT)	20	700
	+2(0.5)(PHU+0.5PFC+PDT)	7	245
	+2(0.5)(PHU+PFD+PDT)	14	490
			11125 minutes

$$\text{Average LRU ATE Time} = \frac{11125}{100} = 111.25 \text{ minutes or } 1.85 \text{ hours}$$

Figure 1. TIME ALLOCATION PER 100 MAINTENANCE ACTIONS (LRU ONLY)

#MAINTENANCE ACTIONS	ACTION	TIME (PER ACTION)	TOTAL TIME
20	Process LRU per Figure 1	111.25	2225
80	(PHU+PFC+PDT)(Check one good PCB)	10	800
	+0.5(PHU+0.5PFC+PDT)(Check only, depot repairable, faulty PCB)	3.5	280
	+0.5(PHU+PFD+PDT)(Fault diagnose, GS repairable faulty PCB)	7	560
			3865

Average ATE time per Maintenance Actions = $\frac{3865}{100}$ = 38.65 min or .64 hrs.

Figure 2. TIME ALLOCATION PER 100 MAINTENANCE ACTIONS (80% PCB/20% LRU)

#MAINTENANCE ACTIONS	ACTION	TIME (PER ACTION)	TOTAL TIME
50	Process LRU per Figure 1	111.25	5562.5
50	(PHU+PFC+PDT)(Check one good PCB)	10	500
	+0.5(PHU+0.5PFC+PDT)(Check only, depot reparaible, faulty PCB)	3.5	175
	+0.5(PHU+PFD+PDT)(Fault diagnose, GS repairable faulty PCB)	7	350
			6587.5

Average ATE time per Maintenance Action = $\frac{6587.5}{100}$ = 65.87 min or 1.1 hrs.

Figure 3. TIME ALLOCATION PER 100 MAINTENANCE ACTIONS (50% PCB/50% LRU)

d. Multiply MAO by the number of systems deployed in the GS service area to obtain the total maintenance actions requiring service at GS per year. Designate as MAT.

e. For LRU-only systems multiply MAT by 1.85 hours and divide by 7482 hours to obtain the number of ATE required per RGS to support the system. For 80% PCB/20% LRU systems, multiply MAT by .64 hours and divide by 7482 hours to obtain the number of ATE required. For 50% PCB/50% LRU systems, multiply MAT by 1.1 hours and divide by 7482 hours to obtain the number of ATE required.

9. EXAMPLE (All LRUs)

Suppose a system has a theoretical MTBF of 70 hours, operates 5400 hours/year, and is deployed in quantities of 50 per Corps. How many ATE are required to support it?

a.	Theoretical MTBF	70 hours	
b.	Theoretical Failure Rate	.0143/hr	FT
c.	Maintenance Actions Per System, Per Hour (MAH) (3,5 x FT)	.05	MAH
d.	Maintenance Actions Per System, Per Year (MAH x 5400)	270	MAO
e.	Total Maintenance Actions Per Year (MAO x 50)	13,500	MAT
f.	ATE Required $\frac{\text{(MAT x 1.85)}}{7482}$	3.42	Per Corps

10. EXAMPLE (80% PCB/20% LRU)

Suppose the system in Paragraph 9 (MTBF) of 70 hours, 50 per Corps, 5400 annual operating hours has BITE such that for 80% of maintenance actions 2 PCBs are evacuated to GS ATE, and for 20% of maintenance actions LRUs are evacuated to GS ATE. ATE requirements are calculated as follows:

a.	MAT (calculated per Paragraph 9)	13,500
b.	ATE Required $\frac{\text{(MAT x 0.64)}}{7482}$	1.15 per Corps

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11. EXAMPLE (50% PCB/50% LRU)

Suppose the system in Paragraph 9 has BITE such that for 50% maintenance actions 2 PCBs are evacuated to GS ATE, and for 50% of maintenance actions LRUs are evacuated to GS ATE. ATE requirements are calculated as follows:

a. MAT (calculated per Paragraph 9)	13,500
b. ATE Required $\frac{(\mathrm{MAT} \times 1.1)}{7482}$	1.98 per Corps

12. DATA SOURCES

This methodology was prepared after discussions with personnel from Tobyhanna Army Depot, ECOM Systems Analysis Office, Lockheed Corporation, and Westinghouse Corporation. Documents reviewed included an informal COEA for the AAH prepared by RCA Corporation (submitted to TRADOC Jan 1975), Naval Air Development Center on The Views/ATE Simulation Model Final Report (1 Nov 73) and the Reliability Design Handbook published by Reliability Analysis Center, Griffith Air Force Base, March 1976.

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APPENDIX H

DATA FROM ENVIRONMENTAL SURVEY

This appendix consists of collections of raw data put together from telephone calls and interviews made with knowledgeable persons on fielded systems that were adaptations of commercial equipment to meet specific environmental requirements. A list of the sources is given at the end of the Appendix.

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VAN MOUNTED CS3

The Combat Service Support System (CS3) was designed and constructed from "off-the-shelf" commercial equipment to provide automatic data processing in support of Standard Installation Division Personnel Systems (SIDPERS), Maintenance Reporting and Management (MRM), and related functions required by the U.S. Army in a combat environment. There is a total of 16 CS3 systems employed throughout the world: ten in the U.S., four in Germany, one in Korea, and one in Hawaii.

The CS3 is composed of an IBM-360/30 automatic data processing system with an extended memory unit (CMI model TX-30) for a total capacity of 256K bytes. The system is housed in two 35 ft vans and supported by three M-109 trucks (2 1/2 ton capacity-approx) with associated power generation equipment, (see Figure 1). A five ton tractor is required to provide prime mover service for each 35 ft van.

The present CS3 systems were configured from "used" IBM-360/30 systems. These systems were previously used by base operations personnel within a fixed plant environment. The systems were originally purchased from IBM and CMI, commencing in the 1965-66 time frame. The average age of the equipment within the CS3 system is about eight years (from procurement).

The following is an analysis of the peculiarities of the CS3, reflecting "off-the-shelf" equipment in a tactical environment:

Maintenance/Repair:

The majority of the CS3 system located within the US are supported by IBM contracted personnel. The systems located overseas (including Hawaii) are serviced by U. S. Army personnel.

Army personnel are school trained at the IBM facilities in Washington, D. C. The school is six months long and teaches electro-mechanical theory/practical applications. In the field, Army personnel trouble-shoot down to a PCB. Defective PCB are discarded and new ones purchased from IBM.

Per the CS3 maintenance director, IBM did not provide or the U.S. Army did not purchase the technical material needed to repair individual PCB's. Major items (punch heads, read heads, etc.) are returned to IBM for repair.

There were no statistics on mean time between failures or minimum time to repair the system. (It was the opinion of the CS3 personnel that the systems were not a maintenance headache). A CS3 specification sheet dated 20 Oct 76 indicated a MTBF goal of 140 with an organizational MTTR of one hour and a DS/GS MTTR goal of 2 hours ... may indicate that the present MTTR is not great; possibly a good reason not to maintain data.

Future plans include a repair contract with IBM to cover the PCBs. Also it includes the phase-out of the contract maintenance.

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Interconnecting Cables:

The interconnecting cables between the major units of equipment have created some difficulty. The equipment is mounted on hydraulic tracks that allow the units to be moved away from the wall during maintenance. The periodic movement of the equipment has caused many of the cables to wear the protective covering and damage the signal lines within the cable as the cables rubbed against the equipment. The pictures of several CS3 vans showed evidence that no design consideration existed for the cabling. Another contributing factor is the lengths of the cables were quite erratic. Many of the custom fit cables provided by IBM were not a good fit. Many cables had to be looped.

Air Conditioning:

Each of the 35 foot vans is equipped with four 18K BTU air conditioner/heaters. Some vans were designed with air ducts on the ceiling. The cooling fan inputs of the ADP equipment are located on the bottom of the equipment. On many occasions the systems were shut down since the air conditioning could not compensate for external temperature increases. Other vans were equipped with the air ducts under the equipment within close proximity of the fan inputs. No air conditioning problems occurred (reported) with these systems when the air conditioners were functioning. It is not known where these vans were located and to what extreme degree of temperatures they were exposed. (the compressor would run constantly with the air being regulated through the air ducts. This helped to prevent generator under loading and erratic voltage/cycle changes).

Static Electricity:

Both equipment failures and personal discomfort resulted from static charges during dry air spells. These conditions have occurred at Fort Carson, Fort Hood, Fort Campbell and other areas, usually during the winter season when the humidity would drop. This would be further compounded with the continual use of the air conditioner which further decreased the humidity. The low humidity caused static charges estimated to be in excess of 20K volts. The floor carpeting was replaced with a different make which was designed to lower the static charge within the vans; however, it did not lower the charge to a desirable degree. It is believed that many of the "hard errors" within the system were caused by the static charges, mostly parity errors within the memory. These failures were prevalent during the high static conditions. The humidifiers during this period were placing 10 gallons of water into the air per day. The problem still exists. A need for a completely automatic climatic system is most likely required.

Software:

Computer programs are prepared by the Computer Systems Command for all of the CS3 functions. The CS3 may have fifteen programs to support the administrative requirements of the field commander. Due to different (improved, modified, etc.) models of equipment with same model number, many of the programs are not transferable to other CS3 systems with older or newer models. This has caused some difficulty when programs do not perform as they should. (computer systems, CMD in some cases, is not abreast of the equipment changes.) Further, the programs are not supported at the unit level by either the contractor or the Army repairman who is not software orientated.

Power Generation:

The equipment manufacturer recommended "precise" generators should be used as organic power. These generators have an overall frequency (HZ) tolerance of ± .5%. Tests have been conducted with a system using utility generators. The CS3 shut down when the frequency dropped to 56.7HZ and continued to operate at the generators upper frequency extreme of 62HZ. The 20 Oct 76 specification sheet stated precise generators (100 KW) will be used.

Van Transportability:

The 35 ft vans are equipped with a combination of air bags and air suspension systems to cushion the ride. There are no special internal shock mounting for the equipment protection. There are many occasions for the systems to be moved over unimproved roads. Recommended speed is about 5 MPH. There has been no reported failures or problems with the CS3 reflecting the transporting of the van.

For additional information concerning experiences with the Division level systems, contact the following people:

a. Maj. Mantyla, 1st Cav. Div., Fort Hood, AV 737-7487

b. Cpt. Dutzcak, 2nd Armor Div., Fort Hood, AV 737-2412/4631

c. Maj. Richie, 1st Inf. Div., Fort Riley, AV 856-5819/9379

d. Maj. Roberts, 4th Inf. Div., Fort Carson, Av 691-4030

e. Maj. Brown, 7th Inf. Div., Fort Ord, AV 973-4267/2896

f. Cpt. Ritchey, 9th Inf. Div., Fort Lewis, AV 357-5693/3617

g. Maj. Jenkins, 82nd Air. Div., Fort Bragg, AV 236-0817/6806

h. CW2 Wallance, 101st Air. Div., Fort Campbell, AV 635-7525

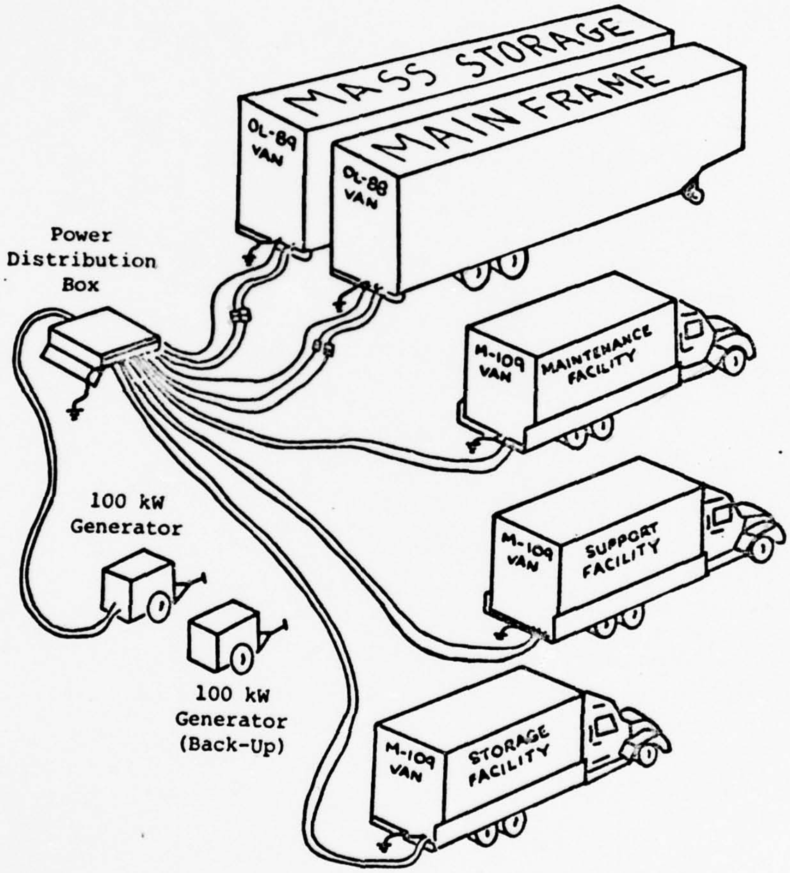
10. For information concerning the CS^3 at 13th COSCOM, contact C. W. O'Hearn, AV 737-4883.

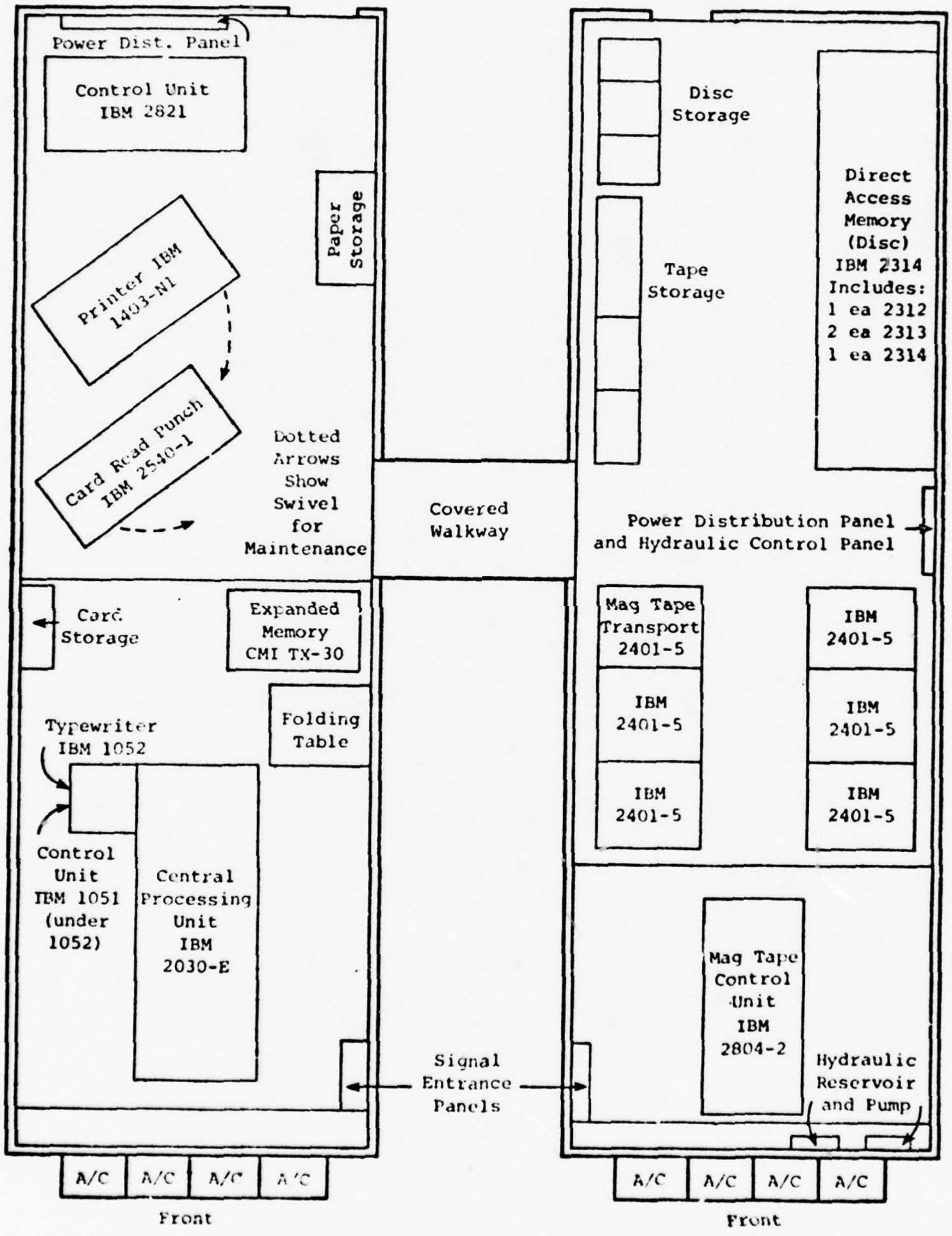
Details concerning specific environmental problems may be available as follows:

humidity - Ft. Campbell

tape head wearout - Ft. Campbell

dust - Ft. Riley


MASS STORAGE
OL-89 VAN
MAIN FRAME
OL-88 VAN
Power Distribution Box
M-109 VAN
MAINTENANCE FACILITY
M-109 VAN
SUPPORT FACILITY
100 kW Generator
100 kW Generator (Back-Up)
M-109 VAN
STORAGE FACILITY



Main Frame Van
(OL-88)

Mass Storage Van
(OL-89)

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ECM WAVEFORM ANALYSIS SYSTEM

The ECM Waveform Analysis System was designed to simulate, measure and analyze the statistical properties of candidate radar countermeasure signals. It consists of two functional subsystems: (1) the digital measurement and analysis system,and (2) an analog simulation system for generating the threat signal scenario and the signal processing required for analysis. The digital measurement portion is built around the HP 5451 Fourier analyzer which measures, stores and analyzes digitized data from radar and ECM signals. The signal simulation system is basically a radar simulator. It contains mostly analog equipment.

The major components include:

HP 5451 Fourier Analyzer

a. HP 5475A Keyboard
b. HP 7004B Plotter
c. HP 5460A Display Unit
d. HP 2100A Computer
e. HP 5465 A/D Converter

(2) HP 7070B Magnetic Tape Drives
HP 13190A Controller

(2) HP 7900A Disc Storage + Drive

HP 2748A Reader
HP 2895A Punch
HP 2767A Line Printer
HP 2600A CRT

Model 8100 Biomation Transient Recorder
Time Interval Equip with HP 5360 Counter
HP 1150A Program Waveform Processor
plus additional equipment: Signal generators etc.

Total of 11 racks of analog simulation equipment
4 racks of digital measurement and analysis equipment.

"I" Beams were installed approx. 2' apart in the center of the trailer. The equipment racks were placed on the "I" beams. A supply air cavity now lies between trailer floor and bottom of "I" beams.

The system is housed in a semitrailer which was built by Diamond B. Corp. - Los Angeles, air ride suspension, 10' wide 50' long.

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This configuration permits either stand alone operation, using only simulated signals or on site operation with actual hardware being analyzed.

System contractor: EPA Electronics, Inc., Palo Alto, Ca.

Contract date: 19 March 1973

Delivery to WSMR: 4 January 1974 (Approx. 9 months)

Final Acceptance: 28 February 1974

First Operational test: August 1974

The system has an elaborate climate control which runs 24 hours a day.

There are special filters: 7-8 microns requirement based or disc system capability.

Operator (civilian) training consisted of 1 month at HP on familiarization with the system and the operating software, and in incorporating software and hardware capabilities.

The system is maintained by HP. They are usually up and running normally in 6 or 7 hours after a failure. Maintenance contract costs approx. 10K per year. Preventative Maintenance is conducted every 4 months.

The inside operating temperature varies between 60° -80°F.

The system is moved about 2 to 3 times per year, this being into the field located up to 10 miles from its location at WSMR. The first part of the trip (10 miles) is on paved roads but it is sometimes moved over rough terrain (1/4 mile) to the test location.

Speed on paved roads	45 mph
Speed on unimproved roads	10-15 mph

For a short move out to the field (10 miles), the disc is secured as well as some equipment on roller slides. The printer, plotter and CRT which are normally on a table top are placed on the floor of the trailer. Their own driver is employed for short trips. A short move requires 2 people about 1-2 hours to secure the system. Long moves require the equipment to be lashed to the walls and boards are fastened to the equipment racks. The system was also designed to be airlifted.

The environmental control system is operated 24 hours a day. Actual machine use is 8 hours a day/40 hours/2k. Under test conditions the machine has 2 shifts and sometimes runs over night unattended. The warm up time for the digital measurement and analysis subsystem is about 4 minutes for the disc rotation to come up to normal operating speed etc. The signal generators also require a warm up period when using the analog simulation subsystem.

Some corrosion on computer cards were found. They were cleaned and the PCB's returned for operation.

Due to fluctuation of power supplied by generators, General Electric voltage regulator transformers on lines were installed. Also RFI filters were used for reducing interference.

There are two generators each supplying power to two different buses. One bus supplies power for lights, heating, air conditioning while the other supplies power for the equipment. Each bus has it own RFI filters.

The system was initially conceived by the Advanced Defense System Team of Electronic Warfare Laboratory/Office of Missile Electronic Warefare. They provided a specification and the procurement package went to the Small Business Administration. The SBA went out on contract (sole source) to EPA Electronics, Inc.

Dimensions 50' long, 10' wide, 11' overall height.

It is equipped with a tandem axle, air ride suspension, and weighs approximately 35,000 pounds. The van currently is configured to meet all ICC requirements for travel on US highways. It was constructed to permit air lifting on either the C130 or C5 aircraft and can be "sling loaded" on board sea going vessels.

The van contains a complete climate control system consisting of a hot gas by pass refrigeration system, with a 7.5 ton capacity, and 16KW of electrical resistive heaters. The entire van is insulated with 3 inches of polyurethane insulation. The van is constructed with a false, inverted "T" grid ceiling and a computer floor. These provide space for supply and return air, electrical receways, a signal cableway, and recessed lighting.

TRANSPORTABLE AUTOMATED ELECTROMAGNETIC COMPATIBILITY MEASURING SYSTEM

Four TAEMS are now being built for fielding, with the first expected to be completed by July 1977. There will also be one abbreviated system for use as a trainer.

The TAEMS will be used in support of the Army Operational Electromagnetic Compatibility Program, in a non-tactical environment, and will cover the frequencies 20Hz to 40GHz. They are based upon a commercial Hewlett-Packard ARS-400 automatic receiver system plus a number of other commercial components. Each system occupies two custom 8 ft x 20 ft vans.

The basic ARS-400 is a computer controlled receiver system (H-P 2100 computer) which covers the frequency range of 100 KHz to 18 GHz, and is intended to be used for "spectrum management, system monitoring, electronic intelligence, electromagnetic interference and site surveillance." The version being adapted for TAEMS comes with a disc operating system called TODS (Test Oriented Disc System), which is also used by older 9500 series H-P automatic test systems. However, the people at the Commerce Department's Institute for Telecommunications Sciences (Boulder, Colorado), who designed and are intergrating the TAEMS, have replaced the TODS operating system with the later and more versatile Hewlett-Packard RTE-II (Real Time Executive II) disc operating system. This effort was performed in-house using standard-issue documentation supplied by H-P, and consisted mostly of adding driver routines to RTE-II. (The H-P documentation was considered to be excellent.) This change brings TAEMS to the state-of-the-art for this type of system (also representative of the state-of-the-art for automatic test systems).

TAEMS is a follow-on to an earlier system, also built by the Institute for Telecommunications Sciences in 1973-74. The earlier system employed the Hewlett-Packard 8580B automatic spectrum analyzer, which has components which are very representative of those used in H-P 9500 series test systems. This earlier system has been used in the field, and should provide some useful data since lessons learned from it were incorporated in the design of TAEMS.

Components for TAEMS are rack-mounted in the vans, with no special provisions for shock isolation. However, the entire vans are mounted on standard General Motors chassis which are equipped with air suspension systems. They are therefore expected to be moved over improved roads at highway speeds, and over cross-country terrain at slow speed adjusted to suit the conditions.

TAEMS will be operated and maintained by approximately an even mix of civilian and military personnel, who will be given extensive training to augment their existing electronics background.

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[1] From Hewlett Packard catalog.

The Air Force has a system similar to the forerunner of TAEMS. It was built by Rome Air Development Center, and is reported to have had some serious problems. This lead will be investigated.

There is also a tactical system known as the AN/TSQ-118, which is a truck-mounted 8580B automatic specturm analyzer used by the SATCOM Agency. This system has undergone a formal test program, with OT being done at Ft. Huachuca, and should provide some useful data.

Based on previous experience, TAEMS is expected to perform well in the field, and does not anticipate environmental problems.

EXCERPTS FROM A YET TO BE PUBLISHED PAPER BY P. C. MINOR AND L. E. WOOD

ON TAEMS

Initial Design Considerations

Some of the general Army requirements that have significantly impacted the TAEMS design are given:

* 20Hz to 40GHz frequency coverage
* Computer controlled measurement instrumentation (with manual control option)
* Mass storage capability for data
* Antenna system with direction finding (DF) and omni coverage capabilities
* Sensitivity comparable to existing communications receivers
* Modular design to permit remote operation of components
* Self-contained and self-supporting (for average task duration)
* Air/ground transportable
* Capable of deployment to remote sites
* Operational in disparate ambient environmental extremes

Equally important, the design was benefically influenced by the experience gained by ITS in several years of successful operation of its mobile Radio Spectrum Measurement System.

As the TAEMS design evolved, it was established that standard or "off-the-shelf" equipment would not satisfy all requirements and that developmental work would be necessary. Most of ITS' developmental effort has been devoted to achieving the full required frequency coverage and implementing a suitable software operating system; however, considerable time and effort were also expended in defining the mobile platform and antenna subsystem. The remaining discussion focuses on these developmental efforts and specific TAEMS characteristics.

Measurement and Control Instrumentation

The heart of the TAEMS is the Hewlett-Packard (HP) ARS-400 Automatic Receiver System, consisting essentially of a multiport automatic spectrum analyzer and various demodulators (AM, SSB, FM, wideband FM) under the control of a minicomputer with 32K words core memory capacity. Figure 1 illustrates the central role of the ARS-400. Standard and optional computer peripherials included in the TAEMS configuration are:

* Cartridge disc system
* Two nine-track tape drives
* Three-deck cassettee unit
* Paper tape reader
* Electrostatic printer/plotter
* Operator console (keyboard, interactive CRT, ASCII printer)

Major ancillary and test equipment, most of which will be interfaced to the minicomputer via the H-P 1B, include:

* Pulse train sorter/analyzer -- a video signal processor to extract pulse repetition rates of up to three pulse trains in a complex signal environment
* Transient digitizer -- a digital sample/store device capable of multimode triggering/recording of transient signals
* Peak pulse power meter -- a digital power meter capable of measuring peak power of pulses 0.1usec to 100usec long
* Frequency counter
* Swept frequency oscillator
* Storage oscilloscope

Mobile Platform

The TAEMS mobile platform was chosen to avoid the difficulties experienced in the past by the Army (and others) with non-self-propelled shelter or trailer configurations for EMC instrumentation. It was also important to achieve good highway handling characteristics and off-road mobility. The resultant mobile platform consists of two, essentially identical 4-wheel drive van type vehicles built on a standard, commercially available chassis. The vehicles, referred to as the Data Acquisition Vehicle (DAV) and the Maintenance and Calibration.

Vehicles (MCV), do have custom bodies to serve their specific purposes. The DAV contains the ARS-400, most of its associated peripherals and the antenna positioner, tower and hoist unit. The MCV contains most of the maintenance equipment, one of the system tape drives, system manuals and storage/work areas.

Each vehicle has its own power generation (two 6.5KW gasoline generators) and environmental control equipment. Electronics and environmental control are powered from separate generators. Comfortable internal working conditions can be maintained in ambient temperature extremes of -30 degrees F to +120 degrees F. Vehicles dimensions, total weight and structure are designed to enable air transport of both system vehicles by military transport aircraft or by helicopter, one vehicle at a time. Air bag suspension helps to protect electronics from abusive shock and vibration during transit. Inter-vehicle communications is provided by a commercial two-way radio and an intercom system.

Additional contracts are:

a. Dr. Lockett Wood (for more on TAEMS) Institute for Telecommunications
Sciencies Boulder, Colorado
Telephone: (303) 499-1000, ext. 3729

b. Mr. John Murray (for earlier 8580B system)
Same address as above
Telephone: (303) 499-1000, ext. 4162

c. Mr. Roland Kurek (AN/TSQ-118)
Ft. Huachuca
Telephone: AV 992-3169

d. Mr. J. J. Terhune (OT of AN/TSQ-118)
Ft. Huachuca
Telephone: (AV 879-6116

e. For Air Force System:

(1) Mr. Baustert
RADC

(2) Mr. Bob Ford
AF Pacific Communications Region
Try Hickam Air Force Base

(3) Mr. Frank LaMaster
AF Communications Service
Richards Gebauer, AFB
Grandview, Mo 64030
Telephone: AV 645-1110 (Op Assist.)

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RESEARCH AIRCRAFT MEASUREMENT SYSTEM

(RAMS)

The system will allow weather researchers at NOAA to fly into the eyes of hurricanes and monitor, in real time and with high accuracy, the results of seeding clouds from the center of the storms.

It consists of: a) (2) HP 2100 computers
b) HP Magnetic Tape Recorders
c) HP Disc
The model #'s are unknown at this time.

The overall system also has a DATACOM Data Acquisition system with Pheonix Data Systems A/D and D/A converters.

The equipment is contained in a rack housed inside the P3 aircraft. Some small reinforcements were made on the system PCB's to guard against vibration. However, he stated that there was relatively little modifications made to the equipment. No special arrangements were made for humidity.

The system contractor was Datacom Inc. Ft. Walton Beach, Florida and represents recent technology (1970's).

Air conditioning is on continuously while plane is in flight. Problems occurred earlier when air conditioning was not running. Temperatures in the 90°'sF.

The systems (2) are presently undergoing modifications in California with the installation of special radar, on the P3 aircraft. They are normally located at the NOAA Flight Facility Miami, Florida. (305-526-2936).

Highly skilled civilian operators and technicians were employed for system operation.

Training (various HP courses) was conducted at the HP plant for both operators and technicians.

NOAA has highly qualified technical people with years of experience in digital circuitry, computers, and systems similiar to Data Acquisition Systems. Initially NOAA had a service contract with HP but costs became prohibitive. With experience gained on the system and with an adequate supply of spare parts, they now have been successful in maintaining the equipment. Regular HP maintenance (PM) is every 3 months.

The operating system temperature is between 60°F-80°F. Temperature range outside the plane varies over a wide range. The system is located in a high humidity environment. Air mobile and usually operated at approx 30,000-35,000 ft. with the cabin area pressurized. The only problem mentioned was that of temperature; when the air conditioning was not running memory failure had occurred.

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NOAA stated that commercial equipment is less costly, easier to obtain access to for repair and not as heavy as its militarized counterpart. Weight was an important criteria due to the fact that the system was installed upon an aircraft.

A possible contact for additional information:

National Center for Atmospheric Research (NCAR) Boulder, Co.

The flight facility telephone # is 303-494-5141.

They have a Data Acquisition System believed to be built with Data General equipment.

NASA-AMES on C-141 use of HP disc.

AN/TSQ-118

AN/TSQ-118 consists primarily of a Hewlett-Packard 8580B automatic spectrum analyzer and some 7.5 GHz communication equipment, mounted in an S-280 shelter and carried by a 2 1/2 ton truck. The 8580B is representative of early 1970's technology. It is also representative of the 9500 series of automatic test systems.

The TSQ-118 exists presently as an engineering development model (EDM), which was built by RCA at Camden, N.J. It is intended for use in monitoring and controlling the access to communications satellites. Only the one model has been built so far, but two more are being built using 30 ft. air suspension vans for inclosures, rather than the S-280 shelter. This change is in response to one of the findings of OT-II (October 1975 to March 1976); namely, that the S-280 did not provide sufficient space for the personnel to operate efficiently.

SATCOM Agency has about nine 8580B's operating in buildings at Fort Monmouth and thus has a basis against which to compare the performance and durability of the shelter mounted system. Although the TSQ-118 EDM has now been moved inside a building, it was outside and adjacent to a swampy area for about two months during the summer of 1976. In this time, it was operated about six hours per day on alternate days and completely shutdown in between (including the air conditioners). There was repeated formation of condensate in the equipment which caused poor performance of the 8580B until it dried out. However, other than rust formation on some of the parts of a cassette tape unit, there were no serious long term effects. All of the printed circuit boards and card edge connectors in the 8580B are gold plated to resist corrosion, and no corrosion was evident. As a precaution, RCA has suggested that the boards be conformally coated. However, since there is not only a cost, but also a risk of changing performance associated with this measure, no such action has been taken. Structural parts of the 8580B are made of either stainless steel or other metals that have been treated to be corrosion resistant.

Due to a problem of poor air circulation, some difficulties were experienced with malfunction of the H-P 2100 computer in the 8580B, when the temperature in the shelter got above 90°F.

The most common causes of parts replacement in the 8580B have been defective sense amplifiers in the computer memory boards and defective components in the computer memory boards and defective components in the phase-lock circuits. Service calls for all reasons (not just the above) have been required about once every 6 to 8 weeks for the 850's in buildings, versus once every 4 to 5 weeks for the shelter mounted system (while outside). Most service calls are for troubles with the cassette tape unit (which is not made by HP). This unit is known for its poor mechanical design. About two service calls per year are required for non-cassette problems in the building installed 8580's.

Some times of interest are:

a. Three hours to pack the TSQ-118 for movement.
b. One hour to unpack the TSQ-118 and get into operation.
c. Roughly ten to fifteen minutes for warmup of the 8580B. It will not

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reach the accuracy specified by Hewlett-Packard until a day or so warmup, but this level of accuracy is not required to perform the function of the TSQ-118.

Delivery of the van mounted system is expected in mid-April 1977.

An Independent Evaluation Report for the AN/TSQ-118 was issued by the Army Communications Command in July 1976 (#QT-227-SM). An updated specification for the TSQ-118 is also available (SCA-2127, Rev C, 29 Feb 76). Despite the spec's having the earlier date, it reflects changes brought about by the testing. The following notes are taken from these documents.

Quotes from the IER:

a. "5.2.5 Can the SCMT [Satellite Communications Monitoring Terminal] be operationally degraded by deployment in extreme climatic areas?

5.2.5.1 Conclusion: Yes

5.2.5.2 Discussion: Spectrum analysis equipment employed in the SCMT is extremely sensitive to environmental conditions; specified temperature and humidity must be rigidly controlled. Environmental control equipment must be highly reliable."

b. "5.2.6 What are the effects of normal rainfall and water accumulation on the SCMT?

5.2.6.1 Conclusion: Serious.

5.2.6.2 Discussion: The SCMT must be improved to correct leakage and personnel safety hazards due to rain and water accumulation." [We have included this because we have heard comments from ECOM that expandable vans leak. However, in this case, it's an S-280 that is leaking, and not an expandable van. The point is, that probably any of the various shelters can leak on occasion.]

c. With respect to RAM, the following excerpt is quoted:

"5.3.1.2 Discussion: Most serious RAM problems encountered in the SCMT relate to the HP 8580 ASA [automatic spectrum analyzer] . . ." [Unfortunately, the commentary on this issue stops here, just when it's getting interesting, and I don't yet have a copy of the QT II report, which hopefully has the details.]

d. "5.5.3 Does [Do] the SCMT operating and maintenance/repair functions exceed the skill level normally available within the services?

5.5.3.1 Conclusion: Yes, the HP 8580 ASA is unique equipment requiring specialized hardware and software training. This training is not currently provided in the services.

5.5.3.2 Discussion: Because of other procurements of the ASA by the three services, discussions were underway in DOD to develop a common training program . . ." [Those who believe that a trained monkey can operate and maintain this kind of equipment, please take note.]

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e. 6.6 Risk mitigating considerations. A high risk is not involved in the SCMT development program because of the following:

a. The HP 8580 ASA is used throughout the American communications industry. It is also used in Government at fixed DSCS stations and by the Federal Communications Commission . . ."

b. The HP 8580 ASA is being procured by all three services for other DOD programs at this time.

Quotes from the spec: These quotations are so extensive the several pages have been copied and are attached as an inclosure 1.

[redacted]

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INCLOSURE 1

QUOTES FROM AN/TSQ-118 SPECIFICATIONS

3.10.17 Environmental Control. The Control Terminal shall use two environmental control units. Each unit shall deliver 60,000 B.T.U./hr of air cooling and 47,000 B.T.U./hr of air heating for the purpose of maintaining the equipment cabinet air temperature and personnel air temperature at 70°F. Under environment extremes, the interior temperature may fall within 65°F to 82°F.

3.10.18 Equipment Cabinets (Racks). Electronics equipment mounted in the shelter shall be installed in equipment cabinets to the extent practicable. The only equipment which may not be cabinet-mounted shall be the equipment in the Office, the teletypes, and test equipment. Equipment cabinets shall be sized to accommodate the MIL-STD-189 (19") face panel and the unitized equipment chassis. Equipment cabinets shall accommodate ventilating air entry at the bottom and exhaust at the top. Unit package components shall be arranged to permit cooling of all components with the cooling air flow through the equipment cabinet in a vertical direction. Unused perimeter floor space in the room which can reasonably accommodate an equipment cabinet shall be furnished with an equipment cabinet. These spare cabinets shall be fitted with facilities such as power and ventilation budgeted on the basis of one prime power outlet and 200 watts of power dissipation for each 7" of front panel space. The cabinet shall be fitted with blank filler panels. This type of spare cabinet space exists in in one full cabinet and in two half-cabinets under the teletypes in the representative layout of Figure 2.

3.10.19 Air Ducts. The equipment cabinets shall be ventilated solely by air ducted from the air conditioner(s). To minimize acoustical coupling, equipment and personnel space air passages shall be kept separated. The ducting shall insure that no operating equipment is exposed to an air temperature greater than 85°F.

3.11 Primary Power Subsystem. Terminal components shall operate from a primary commercial power system with the following characterisitcs:

Voltage:	120/208 VAC ±10%
Frequency:	47.5 to 63 Hz
Phase:	3 Phase 4 Wire
Transient:	120V ±20% (a period not to exceed one minute for a single transient)

The prime power distribution system shall protect the terminal components from damage in the event of voltage or frequency outside of tolerance and reverse phase rotation. The power distribution system shall be protected against excessive load. A switch shall be provided within the shelter to change the power source from the engine generator set to base power. A prime power monitor shall be provided for voltage, frequency, and phase rotation. The monitor shall be electrically located on the source side of the power entry control. Prime power shall enter through line filters.

3.14.12 Air Tightness. Shelters, after equipment installation, shall be impervious to wind, water, snow, dust chemical, and biological agents, in accordance with the requirement of this document. The shelter shall be capable of retaining air to a static pressure of at least .50 inch of water while air is being brought in at the rate of 300 cfm with openings closed for CBR protection.

3.14.13 Connections. Where applicable, quick-disconnect type fittings on electrical connections and harnesses shall be used in order to facilitate maintenance. However, quick disconnect fittings shall not be used on transmit waveguide connections, because of the hazard they pose.

3.15 Service Conditions.

3.15.1 Non-Operating. The equipment installed in the shelter shall comply with the operating requirements of this specification after the shelter has been subjected to any of the following non-operating conditions, successively or in combination.

3.15.1.1 Temperature and Humidity. The Control Terminal shall not be damaged when subjected to storage conditions described in Army Regulation 70-38 for all climatic categories.

3.15.1.2 Altitude. Elevation up to 24,000 feet.

3.15.1.3 Salt Atmosphere. As encountered during coastal service with a maximum of 25 lbs/acre/year.

3.15.1.4 Transport Vibration and Shock. Military transport methods on rail, highways and unimproved roads, and by fixed-wing aircraft.

3.15.1.5 Tropical Conditions. Tropical conditions, including fungus-laden air.

3.15.1.6 Blowing Snow, Sand and Dust.

a. Blowing snow crystals .02 to .9 millimeters in diameter driven by 40 mph winds.

b. Blowing sand particules of .01 to 1.0 millimeters in diameter driven by 40 mph winds.

c. Blowing dust particules .0001 to 01 millimeters in diameter driven by 15 mph winds.

3.15.1.7 Rain. A 12-hour rainfall consisting of the following intensities with winds as high as 40 mph.

Period	Amount (Inches)
1 min	0.45
5 min	1.0
10 min	1.50
1 hr	5.50
12 hr	9.5

3.15.1.8 Ice and Snow. Two (2) inches of clear glaze ice with a specific gravity of .85. Snow load equal to 40 lbs per square foot.

3.15.1.9 Wind. Withstand wind velocities up to 125 mph.

3.15.2 Operating. The equipment installed in the shelter shall comply with the operating requirements of this specification while the shelter is being subjected to the following conditions, successively or in combination.

3.15.2.1 Operation. Continuous (24 hours per day).

3.15.2.2 Temperature and Humidity. The Control Terminal shall be subjected to the operational conditions specified in Army Regulation 70-38 for all eight "Climatic Categories".

3.15.2.3 Blowing Snow, Sand and Dust. Same as non-operating conditions.

3.15.2.4 Rain. Same as non-operating conditions.

3.15.2.5 Salt Spray. As encountered during coastal service.

3.15.2.6 Altitude. Elevation up to 10,000 feet above sea level.

3.15.2.7 Ice and Snow. One-half (1/2) inch of clear glaze ice with a specific gravity of .85 and snow loads of 20 lb/ft^2.

3.15.2.8 Wind. Operate with maximum winds velocity of 80 mph with gusts up to 120 mph.

3.15.2.9 Tropical Condition. Same as non-operating.

3.16 Parts, Materials, and Processes. Parts, materials, and processes shall conform to MIL-P-11268G. The provisions of this paragraph do not apply to the spectrum analyzers or government-furnished equipments.

DATA ACQUISITION RANGING TELEMETRY SYSTEM

(DARTS)

DARTS is built by Hewlett-Packard and consists of a HP 9603 Measurement and Control System. Working as a distributed system, it has both a central station and a satellite station. The central station is composed of a central computer 21MX, (2) disc drives, mag tape, I/O extender, plotter, printer, 2 CRT's and a graphic terminal.

The operating satellite contains other HP equipment. These include:

a. HP 2100 Computer
b. HP 3330 Synthesizer
c. HP 8660B Synthesized Signal Generator
d. Pin Modulators
e. Spectrum Analyzer
f. TTY
g. Paper Tape

There was no special mounting employed. Equipment racks are located down the center of the Van with the racks directly on the floor. It is mounted in a commercial van 40' long and 8' wide.

The system was built for the Electronic Warfare Labs from HP equipment and represents present technology. They have had the system for approximately 2 yrs. Air conditioners and heaters are employed for environmental control. There was only one system built and it is located at WSMR.

The operator (civilian) training was provided by HP at WSMR. A course was given in the RTE III operating system and it proved to be very helpful. They have a maintenance contract with HP. It was stated that HP has done an excellent job. When problems have occured, they (HP) have restored the system to operation in a short time. Regular preventative maintenance is conducted.

The inside temperature is not allowed to rise above 85°F. A thermal cutoff is employed on the HP disc. If the temperature reaches the upper limit (85°F), the disc will cease operation until the inside temperature cools down below cutoff.

The system is employed in a very low humidity environment. Temperature variations are typical of that found in the southeast.

DARTS is moved about 3-4 times per year. When going to the field which may be (40-70 miles), they travel both on paved roads and unpaved roads.

Speed on paved roads - 45 mph
Speed on unpaved roads - 5 mph

For moves to the field braces are placed on top of the racks so that they do not sway from side to side. Also the disc heads are fixed.

Information was obtained on a second system which was built out of commercial equipment.

This system is called the Multi Target Instrumentation Control System which is a range tracking system capable of tracking up to four simultaneous targets.

It was originally built by Scientific Data Systems who are now owned by Xerox. The system consists of three vans with the following equipment.

Van 1	Computer - Sigma 5 by Xerox
50' long	TTY
10' wide	Printer
	Extender I/O
	Card Reader
	(2) Mag Tape Units
	Plotter
Van 2 & 3	Target Trackers
40' long	Receivers, Scientific Atlant
8' wide	Recorders, Ampex

It is housed in commercial vans built by the Aluminum Body Corp. (ABC) of California. The computer van has air ride suspension. The system was built by SDS and represents the technology of the late 1950's.

Air conditioning, heating, filtering and humidifying are employed. There is only one system in operation and this is presently operating in Fairbanks, Alaska.

Operator (civilian) training was provided by Xerox. It consisted of a 3 week course. Maintenance is provided by the system contractor and this has worked out well. The contractor has been in for regular preventative maintenance.

The inside temperature is kept below 80-85°F. Above this temperature A&B. Problems have occurred with the computer. When operating in Alaska outside temperatures have been as low as -30°F. Heaters are employed constantly in this environment with the inside temperature at night kept above freezing.

The system spent 1 month in Florida during which time no problems arose due to the environment. There was a minor problem associated with low humidity (dryness) at WSMR. Static electricity on mag tape heads and tape resulted in the loss of data. After installing a humidifier this problem was corrected.

9e. Present operation is in Fairbanks, Alaska. The vans traveled from WSMR to Seattle, Wash. on regular paved roads at moderate speed (45 mph). From Seattle, it was air transported to Alaska. There were no problems found in transport. The system has also traveled over paved roads to Florida. Once again there were no problems.

The system has been moved 3-4 times per year. For transport, the disc is secured and all table top peripherals (CRT etc) are placed on the floor.

11. Other contacts: Air Force
Hollomand AFB, Cpt Stroud
Commercial 505-675-4386 AV 867-4386

TACTICAL AUTOMATIC DIGITAL SWITCH (TADS) AN/MYQ-2

The following information was obtained from the TADS specification and Military Potential Test (MPT).

TADS is a transportable network of store and forward automatic digital-message switching centers serving the US Army in Europe, both in garrison and in field operations. It is composed of off-the-shelf data-processing and modular components to facilitate network operation and maintenance. TADS is controlled by a solid state, stored program data processor. It will accept messages from its subscribers in real time and will then process and hold all messages until the intended recipient is able to receive them. During the interim period, the switch is responsible and accountable for all messages accepted.

The Commercial Equipment as part of TADS includes the following:

Processor Van	Burroughs	B3500	Processor
	Interdata	Model 4	Processor
	Burroughs	B9381-4	Mag Tape
	Burroughs	B4295-2	Line Printer
	Conrac	B9352	Keyboard/Display
Peripheral Van	Burroughs	B9110	Card Reader
	Burroughs	B9370-2	Disc
	Burroughs	Model 35	TTY
	Burroughs		TTY Patch Panel

The Technical Control Van contains: Approx. 17 commercial items
The Maintenance Van contains: 13 Comm. items including HP counter, voltmeter, oscilloscopes.

The standard equipment modules were mounted on shock isolation platforms. These platforms are structural units containing an equipment mounting deck and facility for air mounts interposed between the platform and the van structure.

The specification call for a change from a semi-fixed strategic operation to a transportable tactical one in less than 8 hours. Shock requirements as stated in system specification are as follows, "The equipment should be free of damaging resonances at frequencies below 55 cps and should be capable of withstanding 10g shcok input of a random nature for a period of 3 hours."

The five ton M291A2C expansible van truck was selected. A total of six of these vans are required, along with a complement of auxillary trailers and trucks, to house each TADS.

The vans are:
1) Processor Van
2) Processor Peripheral Van
3) Maintenance Van
4) Technical Control Van
5) Data COMSEC Van
6) TTY COMSEC Van

The system contractor was Burroughs and represents the technology of late 60's and early 70's. The M291A2 vans were modified to provide heating, cooling, circulation, humidity control and intake filtering. Cooling and humidity control will be provided by trailer mounted refrigeration type air conditioners.

To permit convenient and dry passage for personnel between vans of a TADS center, and to reduce contamination by dirt and mud, completely enclosed walkways are provided. They are raised from the ground such that the walking surface is above ground level at all points. It is easily erectable in a field environment and requires 3 soldiers 1 hour to load/unload one M-35A2 2 1/2 ton truck for its transport. Entrace is gained through the Maintenance Van.

There are two systems. Both are operational in USAREUR. TADS #1 is located in DARMSTADT, TADS #2 in Heilbrown.

The proposed operator is MOS72G Data Communications Switching Center Specialist. The 73G requires 1 mo. formal training plus 60 days OJT for full proficiency.

There are five functional subgroups which contain a function supervisor and support personnel. These are:

1) Switch Supervisory
2) Traffic Control
3) Equipment Support
4) Technical Control
5) Maintenance Support

An overall TADS System Supervisor will have control over the subgroups.

GFE will be maintained by military personnel. Contractor maintenance of TADS (GFE) is required because of its nonstandard status and limited number. Maintenance personnel will be MOS 34D.

Most of the system specifications for section 9 were taken from SCL-12800 "Design of Electronic Equipment for System Installation in Shelters and Vans." Climatic data of different German cities were used to provide input for evaluation of the environment. This included approximately 26 categories, i.e., extreme maximum temp. (°F), extreme minimum temp (°F).

Low Temperature Specification

Operating: With the outside low temperature as low as -50°F, the equipment must give full operation after operation of heating system of 30 minutes at which time the air temp surrounding the equipment is 0°F.

Storage: -65°F

High Temperature Specification

a. Operating: Outside high temperature 120°F plus effects of solar radiation at a rate of 360 BTU/ft^2/hr for periods of 4 hours daily. Full operation of equipment after 30 minutes with use of ventilating system (air conditioning).

b. Storage: +155°F

The humidity requirement states that the equipment be operable without degradation and sustain no physical damage after prolonged exposure to relative humidities as high as 100% at all ambient air temperatures to 85°F. Also it should withstand relative humidities corresponding to a dew point of 85°F at all temperatures between 85°F and 120°F and low relative humidity of 5% at 120°F.

Tests have been conducted at APG, MD. TADS was moved without damage.

1. Perryman Courses

    a. Level Highway
    b Graded Gravel Roads
    c. Cross-Country
    d. Speeds of 60, 25, 20 mph Respectively

2. Munson Test Courses

    a. Washboard
    b. Belgian Block
    c. Radial Washboard
    d. Single Corrogation
    e. Speeds of 5, 20, 15, 20 mph

During these tests, the power distribution and air conditioner trailers suffered physical damage. They were repaired and retested successfully.

Upon acceptance of the TADS on 26 July 1972, USAREUR moved TADS from test location (Karlsruhe) to garrison locations in VII Corps Area (Darmstadt) and V Corps Area (Heilbrown). TADS was easily moved without damage.

TADS is operational 24 hours/day, 7 days/week.

SOURCES OF DATA FOR APPENDIX H

SYSTEM	SOURCE	
CS3	Hans Schmidt Steve Turczym	CENTACS CENTACS Ft. Monmouth, N. J.
ECM Waveform Analysis System	Carl Little C. F. Classen	White Sands Missile Range N. M.
Transportable Automated Electromagnetic Compatibility Measuring System (TAL^{2}MS)	Phil Minor	CCC-EC-L^{2}O Ft. Huachuca, AZ.
Research Aircraft Measurement System (RAMS)	Heiz Grote Byron Phillips	NOAA Boulder Co.
AN/TSQ-118	Roland Kurek	PM-ATSS Ft. Monmouth, N. J.
Data Acquisition Ranging Telemetry System (DARTS)	John Pierce Mr. Ross	DRSEL-WLM-ST White Sands Missile Range, N. M.

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1. Name and Phone Number of Person Contacted
2. Designation of System Involved
3. Number of Systems and Locations
4. System Description
   - a. Purpose or Function
   - b. Major Components (Name, Manufacturer, Model Number)
   - c. Component Mounting
   - d. Type of Shelter
   - e. Name of System Builder
   - f. Time-Frame of Technology Represented by System
   - g. System Environmental Control
5. Operators (Civilian or Military)
6. *Operator Training*
7. Maintainers (Government Civilian, Military, Contract)
8. Maintenance Training (if appropriate)
9. System Specifications (Actual, Achieved)
   - a. Inside Temperature
   - b. Outside Temperature
   - c. Inside Relative Humidity
   - d. Outside Relative Humidity
   - e. Mobility
     - (1) Frequency of Movement
     - (2) Type of Terrain
     - (3) Speed of Travel
     - (4) Special Stowage or Handling Required
10. Operating Schedule
   - a. Total System Power On
   - b. Environmental Control System Power On
   - c. Time Required for System Warmup and Stabilization
11. Problems and Remedies
   - a. Temperature
   - b. Humidity or Condensation
   - c. Shock and Vibration
   - d. Dust and Dirt
   - e. General Ruggedness
     - (1) Printed Circuit Boards
     - (2) Connectors
     - (3) Switches
     - (4) Cables
     - (5) Magnetic Storage Media
     - (6) Keyboards
     - (7) Other
   - f. Power Sources
   - g. Air Conditioners
   - h. Mobility
12. Documentation Available
   - a. Requirements Document (Name, Date, Number)
   - b. Reports
   - c. Trip Reports
   - d. Maintenance Records
   - e. Internal Memoranda
   - f. Other
13. Opinions of Person Contacted Concerning Suitability of Commercial Equipment for Military Applications
14. Suggestions for Other Contacts

SURVEY FORMAT FOR ENVIRONMENTAL, MOBILITY AND RUGGEDIZATION

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APPENDIX I

SUMMARY OF INDUSTRY ATE FUNCTIONAL CAPABILITIES

The capability group of the ATSS Task Force conducted a survey of the available ATE functional capabilities. A matrix form was prepared and sent to ATE manufacturers. Because of insufficient time, some companies chose not to present their data in matrix form. The capabilities group did partially convert the received data in matrix form. These matrices are available from the office of PM ATSS. The following is an extraction of the most significant capability data from these matrices (The page numbers and parameter codes refer to the pages and columns of the capability matrices).

Pages 1-2 DC Power Sources

Generally, the carious ATE vendors provide a wide selection of fixed and programmable DC power supplies ranging from +5 volt ± .02% to 20,000 volts ± 0.25% with many different ranges in between and with accuracies or resolutions ranging from .01% to nearly 10%. Currents range up to 60 amperes. Most systems seem to contain standard catalog items chosen on the basis of specific needs at the time of establishing the configuration.

Some of the MATE ± 20v supplies are of unique design intended as digital stimuli.

Pages 3-5 AC Power Sources

Most of the reviewed systems provide or plan on future installation of a minimum of 1ϕ, 115v, 400Hz power, either by external feed through or by internal power amplifier.

Most also include or plan on including 1ϕ, 115v, 60Hz power.

Several also include or plan to include 3ϕ, 115v, variable frequency (45Hz to 10kHz) supplies.

Pages 6-8 Analog Stimuli, Sinusoidal

a. Low frequency, 0.01 Hz to 6 MHz

All of the reviewed vendors provide a low frequency and amplitude range. Most provide only up to 1 MHz ± 0.01%. The AN/USM-410 (EQUATE) provides 6MHz ± 1 part in 10^7. Voltage amplitudes range from 5 volts to 82 volts and the majority about 0-10 volts peak with ± 1% accuracy.

b. Higher frequencies, 1MHz to 18GHz

Of six systems reviewed, only one includes a full stimulus capability to 18 GHz as a standard functional building block (the EQUATE). One, the Emerson 8205, provides a swept signal from 8GHz to 12.4 GHz and an AM, FM, PM modulatable carrier from 1MHz to 1.3GHz. The AAI 5565 provides an AM/FM modulatable carrier from 1MHz to 1.3GHz. MATE provides an non-modulated frequency synthesizer with a range of 0.01 Hz to 13 MHz. Typical frequency accuracies are 1 part in 10^5 for the frequency synthesizer, 1 part in 10^7 for EQUATE and 3 parts in 10^8 in the modulatable signal generator. The maximum output levels range from +5dBm to +10dBm depending on frequency.

Pages 9-1 Analog Stimulus, Pulse generation

All reviewed systems provided a pulse generator of some sort. Most of the configured systems provide a single delayable pulse train. The AAI 5565 and EQUATE provide dual pulse trains; MATE provides 5. Hughes TAFSS provides no separate pulse generation outside of the digital test capability. Voltage amplitude ranges vary, ranging from 0 to ±5v, to 0 to ±50, with most falling in the ±10v to ±25v range. Voltage accuracies and overshoots range from 0.2% to 5%. The pulse repetition rates vary from 10MHz to 100MHz; the HP1916A plug in provides the 100 MHz; most of the others provide 10 MHz; MATE provides 30 MHz. Most rate accuracies are at 0.1%. EQUATE provides 1 part in 10^7; the AAI 5565 provides approximately ±3%.

Programmable rise and fall times appear to be provided only by EQUATE. The group's rise/fall times vary from 3 nanoseconds through 500 ms.

Pages 11-13 Analog Stimuli, Synchro and Resolver

Only four of the reviewed systems provide a synchro/resolver capability of some kind. The dual capability is provided by the AAI 5565, Hughes aircraft's TAFSS, and GENRAD's 1792D. EQUATE provides only the 3 wire synchro stimulus. The TAFSS capability provides a variable frequency signal from 0.01Hz to 9.999kHz. The others are fixed at 400 Hz. Best frequency accuracy is provided by TAFSS with 0.01%. The others are in the 2% to 5% range.

Pages 13-16 Analog Stimuli, Other Waveforms

Other most common analog waveforms are the tirangular and square waves provided in MATE, Emerson 8205 and GENRAD 1792D through us of the Wavetek 157 Function Generator. It provides signals at ±10 volt ±0.5% from 0.1 MHz to 1 MHz ±0.05%. The GENRAD 1792D also provides the Wavetek 154 as an alternate function generator, increasing the rates to 10MHz ±3%. The AAI5565 function generator also provides a ramp signal of ±0.005 to 4.99v. In addition to all of these standard wave shapes, the EQUATE provides a sawtooth and the ability to program any arbitrarily shaped complex signal to a frequency of 3MHz. Output levels for most vendors are relatively uniform in the 20VP-P range.

Pages 16-17 Analog Stimuli, Time Delayed

These pages represent the time delays inherent in the additional pulses of the EQUATE and MATE pulse generators. The delayed pulses resemble the main pulses of each. The EQUATE provides delays of 20 nanoseconds to 1 second; MATE provides 100 nanoseconds to 6.5 seconds.

Pages 18-21 Digital Stimuli, Serial Data

Parameters 2C1.1 through 2C1.20

Except for the MATE, all other vendors indicate a serial capability. The boundaries of programmable levels of "one" or "zero" states vary from ±15v to ± 30v with setting resolutions between 5 and 50mv. Source and sink current capabilities range from 20 to 100 mA and are sufficient for a normal TTL fanout. The maximum data rate varies between 1 and 10 MHz with corresponding variations in rise and fall time. The message length (as expressed in total No. of bits) ranges up to 32768 stimuli. Although static digital testing is usually done with parallel stimuli and sensors simultaneously applied to all input/output terminals of a UUT, the need for the serial mode is established by transponder pattern simulation and strobing signals at certain data rates.

Pages 21-24 Digital Stimuli, Parallel Data

All ATE's contained in the Matrix have the conventional static parallel stimulus capabilities. Except for execution speed considerations, static digital testing is data rate independent, as parallel steady state responses of parallel stimuli applied to many or all inputs are evaluated. As in the serial data mode above, the boundaries of programmable stimuli levels of "one" or "zero" states vary from ± 15v to ± 30v with setting resolutions between 5 and 50 mv. Source and sink currents range from 10 to 100 mA and are sufficient for a normal TTL fanout and for other known digitally driven devices. Static testing with slow data rate is limited to steady state testing of gates and digital to analog converters.

Shift registers, especially volatile dynamic MOS shift registors require specific data or strobe rates which are usually above 1 MHz. The same applies to analog to digital converters and to most state-of-art LSI (Large Scale Integration(devices. The data rates (parallel digital word rates) in the matrix ranging from .05MHz (MATE) to 10 MHz (AAI 5565) show the general purpose ATE capability, but none of word rates is high engough to reach a max toggle rate in the 30 MHz region for comprehensive tests of high speed devices found in many computers used by the Army and in many other digital and hybrid circuits. The general purpose ATE under consideration in this matrix ranges up to 10 MHz, because it is rise and fall time limited by the relatively large distributed capacitance in the complex switching networks.

Another limitation to digital testing is imposed by the number of programmable stimulus and sensor parts available on a particular ATE (proportional to the digital word length data in the matrix). The word length indicates that the maximum number of available inputs or outputs and ranges from 128 to 360. However some ATE;s in this matrix are limited by the total number of programmable test points with access to digital stimuli and sensors. These are not listed in the matrix, but they range from 128 to 256. There are five different approaches in test point utilization: One separates sensors and stimuli and yields a higher number of total test points. The other method combines stimulus and sensor functions for each test point. This method requires less complex UTT/ATE adaptors at the expense of the number of available total test points. This method is even more adaptor cost saving, if these points also have access to analog stimuli and sensors, as it is the case in the EQUATE.

There is a need for external synchronization of stimuli and sensors from UUT strobe points. Only AAI indicates 7 inputs and 3 outputs from and to the UUT for synchronization. Standard methods for such synchronizations, however, must be established first and coordinated with introduction of appropriate syntax and semantics that are available in high level test language standards.

Pages 25-26 Pressure Stimuli, Absolute Pressure Stability

Only one vendor responded with data on pressure stimuli. This was RCA, with data based on the proposed additions to the EQUATE to be provided on their contract with Hughes Helicopter for the intermediate support of the Advanced Attack Helicopter (AAH). It is scheduled to be operational in the third quarter CY 1978.

Page 27 Analog Measurement, DC Voltage, Parameters 2E1.1 Through 2E1.4

DC voltage measurement capability is provided in every system with most providing capability of measuring ± 1 millivolt to 1000 volts with accuracies ranging from 0.02% (EQUATE) to 0.25% (GenRad). Accuracies of 0.009% and less can be provided by laboratory type digital volt meters which would not be suitable for the less table environmental conditions of a shelterized or van enclosed automatic test system.

Pages 27-28 Analog Measurement, AC Voltage

The AC voltage measurement capabilities vary considerably with respect to frequency range. Maximum frequencies range from 100 kHz to 500MHz. The AAI 5565 and the EQUATE each process 500 MHz signals. Voltage ranges vary from 0-200 volts to 0-1000 volts in the lower frequencies (<10MHz) and from 1v-3v to 1mv-10v in the higher frequencies (10MHz to 500MHz). The voltage accuracies are much better in the lower frequency ranges in all cases with 0.5% common for average AC readings. Generally, RMS measurements are less accurate. As an example, the HP 3455A provides RMS accuracy of approximately 0.04 short term accuracy at 20 kHz and 0.5% at 100 kHz and 5.0% at 1 MHz. It should also be noted that the performance of this instrument is specified at 23°C ± 1°. The performance of all of the ATEs examined are in these general ranges.

Pages 28-29 Analog Measurement, Phase Angle

The reviewed systems provide phase measurement of signals in frequency range of 0-300 kHz, 0-10 MHz with most of the capabilities in the 0-10 MHz, and 0-100 MHz with most of the capabilities in the 0-10 MHz range. All have accuracies which are dependent upon amplitudes, ampitude ratios and frequency and appear to be roughly equivalent.

Pages 30-31 Analog Measurement, Frequency

Generally, frequency measurement capability far exceeds the measurement requirements seen during the the Task Force session. Although source systems provide lesser frequency coverage than others, as can be seen from the data, accuracies vary from 1 part in 10^5 to 1 part in 10^8. The unique EQUATE 0-500 MHz counter/timer provides 1 part in 10^6 compared to the MATE 0-50 MHz counter which provides 1 part in 10^5.

Pages 31-32 Analog Measurement, Time Period

Generally, the reviewed systems can measure time intervals from 2 nanoseconds to 10^8 seconds, depending on which counter/timer is used. The counter offered with the HP 9571A system is the HP 5328A which measures as low as 10 nanoseconds. The EQUATE can measure 20 nanoseconds. Others begin at 200 ns, 10 us, and 10 seconds (according to the submitted data).

Pages 32-33 Analog Measurements, Power

Serial Data Parameters 2E6.2 - 2E6.7

When considering making power measurements, several of the reviewed systems immediately drop out, not being geared to that function. They are the Hughest Tafts System and the General Radio A.T.E. of the remaining systems; we note that the Mate system is capable of making measurements in the low side of the frequency range, 0-100 MHz while the H.P. A.T.E. and the AN/USM-410 operate confortably in the 50 KHz to 18 GHz range. Depending on the application, the H.P. system would utilize the H.P. 8484A or the 8482H. Loading in each case is provided using the standard 50 ohm impedance. Maximum voltage data is represented by only three of the reviewed systems, the Mate, AN/USM-410 and A.A.I. 5565. Both the Mate and the AN/USM-410 offer maximum pk-to-pk voltage measurements of 14V with the A.A.I. 5565 system reaching to only 4.23 V.p.p

Pages 34-37 <u>Analog Measurements, Waveform, Serial Data Parameters</u>

<u>2E7-2E7.3.11</u>

The data compiled on Waveform Amplitude and Rise/Fall time measurements indicate the AN/USM-410 sums up and surpasses the capabilities of the other represented systems. The AN/USM-410 will make amplitude measurements uo to 200V with a combined tolerance (Reading and Range) of .6%. Additionally, the maximum possible amplitude measurement, max. peak-to-peak (200 VPP) voltage measurement, and max. P.R.F. (to 500 MHz) give the AN/USM-410 a commanding advantage.

An analusis of Rise/Fall time data show results which closely parallel the summary of the amplitude measurements capability above.

Page No. 38 <u>Analog Measurement, Resistance, Serial Data Parameters</u>

<u>2E8.1 to 2E8.5</u>.

Resistance measurements range from a low of 0 to 1 MEG represented within the AN/USM-410 system, to a high of 0 to 1,000 MEG present in the tafts system. Tolerances within the systems investigated are comparable. Maximum current flow through an unknown is shown as relatively standard at 10 MA. Maximum excitation voltage ranges from 1 volt within the Mate, to 10 volts within the AN/USM-410.

Page No. 39 <u>Analog Measurement, Distortion, Serial Data Parameters</u>

<u>2E9.1 to 2E9.8</u>

Only two systems have the capability of measuring distortion without getting into special adaptations. They are the AN/USM-410 system and the Tafts system. As the supplied data infers, the AN/USM-410 provides the more extensive range of measurements relative to the Distortion parameter.

Page No. 43 <u>Pressure Measurement Serial Data Parameters 2F.1 - 2F.3</u>

This capability was not present in any of the system investigated.

Pages 43-49 Digital Measurement, Serial Data Parameters 2G1.1.1 Through 2G1.3.20

2G1 Digital Measurement - Serial

The received returns indicate serial digital measurement capability throughout. This statement must be qualified, however. State-of-art serial digital capability implies availability of shift registers for high-speed toggling of digital stimuls and sensors. Indications of such high speed toggling capability can be derived from bit data rate information provided. Data rates below .2 MHz have indicated that sensor evaluation must be completed by software methods before the next evaluation can be initiated. The data rates indicated range from .05 to 10 MHz. For each ATE listed, the measurement rate corresponds to its stimulus rate. The measurable ranges for "one" and "zero" levels are between ± 15 V and ± 200V. Only the EQUATE has the ± 200 V range which allows for evaluation of Nixie-tube drivers and other digital devices having abnormally high output levles. The other products have measurement ranges and tolerances commensurate with the stimulers levels discussed in 2C1 and 2C2. Although, serial digital testing is uncommon, the serial measurement capability at high data rates is essential for transponder pattern recognition within a given time frame and for checking timing or coincidence of strobe signals.

Pages 49-55 2G2 Digital Measurement - Parallel Data Parameter

All responses indicate a static digital parallel measurement capability, described as minimum capability in 2C2 above.

As in the serial digital measurement mode, parallel digital measurements can be performed at "one" or "zero" level ranges varying from ± 15 to ± 200V with accuracies varying from ± mV to ± 150 mV.

Little information exists on methods used to provide appropriate sink currents to UUT outputs near zero volts and to receive appropriate source currents from UUT outputs at other than near zero levels. A study, how to program these currents should be made for subsequent implementation considerations into high level ATE language standards.

Devices requiring a high data or strobe rate for comprehensive testing as described in 2C2 can only be tested up to a 10 MHz toggle rate. Any higher rate would require a high speed shift register setup in the adapter between ATE and UUT. All comments made on stimulus data rates in 2C2 also apply to sensing rate for digital parallel measurements.

An additional limitation to digital measurements is imposed by the number of programmable sensors and/or test points. All comments made on this topic in 2C2 also apply analogously to the parallel digital measurement capability.

The need for external synchronization covered in detail in 2C2 also applies analogously to parallel digital measurements.

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APPENDIX J

ATE REQUIREMENTS FOR APPLICATIONS SOFTWARE GENERATION

1. Purpose. The purpose of this paper is to provide methodology, quantified to the maximum extent possible, that can be used to determine quantities of ATE machinery required to develop applications software used to control fielded ATE's that fault diagnose Line Replaceable Units (LRU's sometimes called boxes) and Printed Circuit Boards/Modules (PCBs).

2. Approach. The approach is to form a quotient of ATE machine hours required divided by time available for program development. The quotient will then give the number of ATEs required as a bulk number and will serve as a departure point for budgeting these requirements by fiscal year.

Each factor is driven by a number of elements, many of which are unknown and must therefore be estimated based upon knowledge of past and current software efforts and technical/schedule peculiarities associated with each supported system. As more programming is accomplished and statistics become available, the methodology will become more refined and associated key parameters more certain.

3. Computation of Machine Hours Required. Two configurations of machines are generally used in the generation of applications software:

(1) A fully configured ATE including computer and associated peripherals (disc, tape drive, CRT/Keyboard, line printer, etc.), stimulus and measurement devices, and electrical/mechanical interface for connecting the Unit Under Test to the ATE.

(2) A compilation station which includes only the computer and associated peripherals.

The compiling station is used in the initial stages of software development when code is being generated, compiled and checked for logical errors. It can also be used during the later phases of program development, validation and acceptance (discussed below) when changes to code are required. Recompilation can be accomplished without tying up the full ATE. Generally, one compilation station per one to three full configured ATE is used. The cost of compilation station is only 5-10% of the full ATE.

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The fully configured ATE is used for software validation and acceptance. Validation is the process of exercising the UUT (Unit Under Test) while it is connected to the ATE. Interface devices as well as functional (sometimes called go-chain or end-to-end tests) and diagnostic software are fully exercised/ debugged during validation. Acceptance is the process involving software developer demonstration to government personnel for buy off purposes. Both processes involve insertion of faults in the UUT either physically or through simulation. They are therefore, both very time consuming and tedious operations. The methodology presented below is intended for estimating fully configured ATE machine hours required for validation and acceptance of applications software. It assumes compile stations are available.

The validation/acceptance time required for an LRU or PCB is a function of many variables; electronic complexity, design maturity, accuracy and degree of available documentation, reliability, capabilities of the ATE and depth of diagnostics required are among the more important factors. Obviously, each UUT is different with respect to each factor. A high confidence estimate of machine validation time requirements for a particular supported system would require detailed analysis of each UUT to determine their individual requirements and totalling them. While this approach should definitely be taken eventually a less time consuming method is now needed for planning. It is therefore necessary to draw upon the experience of past ATE software generation endeavors to arrive at a range of values that would constitute average validation times for future programming. This experience is still emerging but nevertheless available in sufficient detail and amount for the current purpose. Lockheed California Company is programming some 53 LRUs for the Navy S3A Antisubmarine Warfare aircraft (early 70s technology) on the VAST ATE resulted in an average of 1000 hours validation time expended per LRU to complete functional and diagnostic software to the PCB level. However, personnel on that program stated that a significant amount of that time resulted from overly rigid rules surrounding generation and acceptance of the software, an excessive number of ECPs to UUTs (sometimes requiring complete software rewrites), poor UUT documentation, poor initial reliability and inflexible interface of the VAST, and several very complex LRUs programmed. They estimated a figure of 600 hours for a well managed effort using state-of-the-art ATE with higher reliability and a flexible interface capability. Further, Tobyhanna Army Depot has, thus far, estimated a range of 300 hours for the VRC 46 radio to 1300 hours for a TACFIRE Computer CPU. Experience by USAECOM and RCA Corporation in programming the well documented PRC 77 radio and TD352 multichannel equipment was 400 hours. RCA Corporation has experienced an average of 650 hours on some 20 SIGINT/EW LRUs that are currently in engineering development and use mid 70s technology. Considering all the above evidence, it is suggested that an average figure of 650 hours per LRU be used in estimating machine time to validate and accept functional and diagnostic tests (to the PCB level). The same sources mentioned above lead to an average figure of 65 hours required for functional and diagnostic tests (to the piece part level). These figures assume that some means for changing code without typing up the full ATE is available (e.g., compilation station).

In summary, to obtain ATE validation hour requirements to program LRUs to the PCB level and PCBs to the piece part level, multiply the number of

LRU types by 650 and the number of PCB types by 65 and add the two products. If analysis of particular LRUs and PCBs indicate different times, they should of course be used.

4. Calculation of Time Period Available for Programming. There are also a number of factors which determine calendar time available for programming. They are given below.

Completion Dates. Current regulations require that Maintenance Support Packages (MSPs) through GS level be complete before the beginning of OT II. These MSPs should include ATE software for all LRUs and those PCB's that will be tested in the field. However, funding limitations and other factors have led to waivers that allow for demonstration of software on a percentage of the LRUs and PCBs with the understanding that all field level software will be completed by the beginning of OT III or the IOC of system at the latest. Further, it would be desirable to have the balance of PCB software (for those to be repaired only at depot) completed by DT/OT III. However, some supported systems plan to complete this software by the IOC date for the system or even later (assuming perhaps contractor depot support for some period after IOC). Thus, completion dates are a function of decisions made by each system's IPRs/ASARCs/DSARCs. However, it is important that these dates be decided as early as possible.

Beginning Date. The lead time for acquisition of ATE (contracting, fabrication, delivery and acceptance) can easily take 6-12 months.

Software contractors generally require sole use of at least one copy of each UUT for 3-6 months of validations. UUT contractors (if different from software contractor) should be tasked to provide technical consultation throughout the programming period. Software contractors require documentation only (drawings, schematics, QA procedures, etc.) prior to start validation so that program design and initial code generation can be accomplished.

Unless extra UUTs are acquired none will be available for validation during DT/OT II or DT/OT III.

ATE Utilization Rate. Several software efforts in the past have demonstrated the viability of 6000 hours/year validation activities.

Summary: To calculate the number of ATEs required

(1) Multiply for validation the number of LRU types by 650 and the number of PCB types by 65; add the two products to yield validation hours required (designate as VH).

(2) Multiply the number of calendar years available for programming by 6000 to yield equivalent validation time period (designate as TP).

(3) Divide VH by TP to yield number of machines required for validation. Round upward. Designate as NM.

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Example. Suppose a certain system contains 40 LRU types and 250 PCB types. DT/OT II period is 1 January 1979 to 1 July 1979 and DT/OT III period is 1 November 1981 to 1 May 1982. Decisions have been made to only program selected LRU's and PCB's for OT II, but all programming is to be completed by OT III. There are no extra UUT's available for validation. DT/OT II demonstration requirements are for 5 LRU's and 40 PCB's. If procurement action for ATE is begun in March 1977, projected delivery date is January 1978. A course of action might be as follows.

Determine that prior to the beginning of DT/OT II, (5x650) + (40x65)= 5850 hours of validation time is required (VH). The period from delivery of the ATE (Jan 78) to beginning of DT/OT II (Jan 79) is 1 year or 6000 hours (TP). VH divided by TP is .98 or 1 ATE required. The order for 1 ATE is placed in March 77; concurrently, program design for the 5 LRU's and 40 PCB's is begun with a software contractor so that validation can begin immediately upon receipt of the ATE (continuing up to, but not including the DT/OT II period). After DT/OT II 35 LRU's and 210 PCB's will remain to be programmed. Thus, (35x650) + (210x65) = 36,850 hours (VH) of validation time requirements remain. A period of 28 months or 2.33 calendar years is available between the end of DT/OT II (1 July 79) and the beginning of DT/OT III (1 Nov 1981) to accomplish the remaining programming. This is equivalent to 18,396 validation hours available (TP). VH divided by TP is 2.6 or 3 machines required. However, one machine has already been purchased; thus only two more machines need be obtained. Again assuming a 10 month ATE delivery schedule, procurement action for the second machine should begin by September 1978 if it is to be available by the end of DT/OT II for validation. Concurrently with this procurement action, work could begin on designing software for some of the remaining UUT's so that validation could begin immediately after DT/OT II. This effort could be in progress during DT/OT II since it does not require physical access to UUT's. Figure J-1 shows the schedules and milestones discussed in this example.

[redacted]

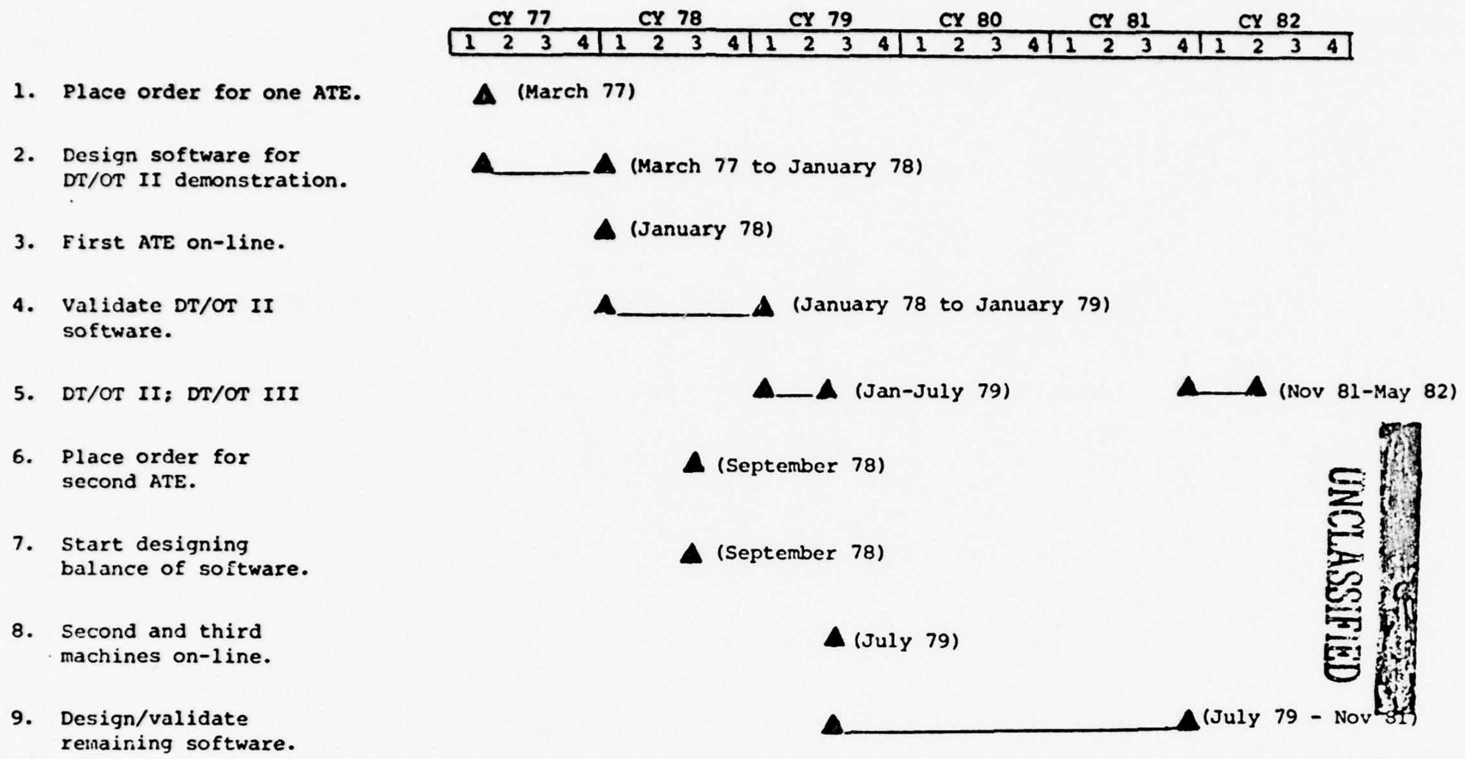

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FIGURE J-1. SCHEDULE MILESTONES OF ATE REQUIREMENTS

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APPENDIX K

THE CASE FOR ATE

1. INTRODUCTION

The need for more effective support methods has long been accepted as commonplace among military weapon systems, developers, and users. The Army, as well as the other services, finds its weapon systems becoming more and more complex and the amount of time to act or react to tactical situations greatly reduced. This dilemma is mainly due to scientific and technological advancements and their application to Army systems.

In recent years the project managers have been faced with the impact of technological advancements, especially in the electronics area. The rapid emergence of digital integrated-circuit technology and microelectronics has substantially changed the support system. In most of the digital printed circuit boards (PCBs) employing digital MSI and LSI, it is no longer feasible to test using manual TMDE. Consequently other weapon systems developers determined that ATE was necessary because the new generation of complex computer-controlled tactical systems, which rely very heavily on advanced circuit technology, will bring hardware of unprecedented complexity into the tactical environment.

2. EMERGENCE OF ATE

The concept of applying automatic control to variable programmed test procedures dates from shortly after the end of the Second World War. Wartime developments in, for example, aerial navigation, radar, computer-controlled gun laying, automatic bombsights, and stabilized control systems had created many new test problems. In most cases, the task had been met by the adoption of existing test methods and by placing greater reliance on the technician's skill and resourcefulness. It became increasingly clear that such measures, although successful in coping with the immediate problems of the time, would not be suitable to meet the needs of the postwar period. The pace of development in electronics and aerospace was rapidly accelerating, and the exploitation of available test resources was, in many applications, fast reaching the saturation point. Throughout the fifties, the development of complex weapon systems and aerospace equipment led in turn to the evolution of more sophisticated test systems, many of them automatically controlled.

Initially the pressures for introducing automatic test methods were primarily concerned with the short reaction and turn-around times which were characteristic of many aircraft, missile, space, and weapon systems. In the late forties and early fifties, for example, a system then considered as complex might have had between 500 and 1000 test points. By the middle sixties, systems with 30,000 test points were not uncommon; and, by the end of the decade, major systems approached 100,000 test points. In many cases this growth in complexity was accompanied by a requirement to carry out test procedures, involving a high proportion of the total test points, immediately prior to operating the system. The demand for speed in

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such instances precluded the use of manual testing methods. It is significant that by 1970, with the larger equipments (e.g., missile and aviation guidance and control systems), the time required to complete a specification performance test by manual methods exceeded the mean time between failures of the systems to be tested. Clearly, it became imperative to adopt automated higher-speed test processes.

3. THE NEED FOR ATE

Test equipment is one of the major items considered during Integrated Logistic Support (ILS) planning (AR-700-127), which is required by all weapon systems. Various studies have shown that ATE is cost-effective in support of weapon systems for the following reasons:

- Automatic methods provide more consistently accurate and faster results and offer the level of test integrity required by engineers concerned with the design, manufacture, quality control, operation, and maintenance of modern equipment. This becomes even more apparent as the need increases for the feedback of authentic field performance data for reliability assessment and guidance in design improvements.

- Automatic testing offers the potential to reduce the total demand for higher-skilled test operators. While there will continue to be a requirement for very high levels of training, based on a knowledge of fundamental theory and its application to the function of specialized equipment, for a number of technicians, it should be possible to simplify the training for a larger number of test operators.

- All equipment is subject to some degree of gradual deterioration in performance. This deterioration, particularly in electronic equipment, is not always easily recognized, and many cases occur in which expensive equipment is operated unknowingly at a performance level much lower than that for which it was designed. That this is wasteful of design and production resources is apparent. ATE is a cost-effective means of periodically testing the performance and insuring acceptable levels of operational readiness.

- By imposing a planning discipline, the ATE ensures that test programs are more carefully and effectively devised and offers the opportunity to prepare and process more detailed test data.

- ATE offers the capability of automatic self test for maintenance and calibration of the test equipment.

- Availability of more ATE testing and diagnostic time reduces the required quantity of test hardware.

- ATE speed in testing and diagnostics potentially increases the operational availability of weapon systems.

DIFFERENCES IN TECHNICAL CHARACTERISTICS OF ATE SYSTEMS

Functional Capabilities	SYSTEM I	SYSTEM II
	Stimuli	
DC Voltage (Programmable Floating Sources, Stackable)	0 to ± 36V @ 15A, 1 ea 0 to ± 36V @ 8A, 2 ea 0 to ± 36V @ 3A, 4 ea 0 to ± 50V @ 60A, 1 ea 0 to ± 50V @ 2A, 1 ea	0 to ± 36V @ 25A, 1 ea 0 to ± 36V @ 9A, 2 ea 0 to ± 60V @ 4A, 2 ea 0 to ± 500V @ 0.4A, 1 ea 0 to ± 1000V @ 0.2A, 1 ea
Fixed Sources (DC)(Other Terminal Grounded)	+24V @ 3A +5V @ 45A +15V @ 18.7A -15V @ 18.7A	+28V @ 5A
Fixed Sources (AC)	additions in progress	single phase AC 115V, 60/400Hz @ 10A
AC Waveforms		
Sine	10^{-4} to 10^{6}Hz	.015 to 6 × 10^{6}Hz
Square	10^{-4} to 10^{6}Hz	.015 to 3 × 10^{6}Hz
Triangular	10^{-4} to 10^{6}Hz	.015 to 3 × 10^{6}Hz
Sawtooth	None	.015 to 3 × 10^{6}Hz
Arbitrary	None	.015 to 3 × 10^{6}Hz
Amplitude	0 to 10V P-P	0 to 20V P-P
Resistive Loads	10Ω to 327, 670Ω in 10Ω steps	0 to 875Ω in 25Ω steps
Power Dissipation	2.5 watts	2 watts
Microwave	None	500 MHz to 18 GHz AM, FM and PM
Pulse Generators	5 Generators 0 to 10 MHz 60 nsec. to 1 sec. 0 to ± 10V Fixed 5 ns rise Fixed 6ns fall (without switching network)	2 Generators 0 to 10 MHz 50 ns to 1 sec. 0 to ± 20V Programmable rise and fall from 25 ns to 500 millisec.
Frequency Synthesizer	10 MHz to 13 MHz 5 VRMS to 50Ω load	Dual 60 KHz to 500 MHz 1 VRMS to 50Ω load
Modulation	No modulation	AM, FM, PM

(continued)

Functional Capabilities	SYSTEM I	SYSTEM II
Synchro	None	0° to 360°; 0 to 11.8V L-L 400 Hz
	Measurement	
Resistance	1Ω to 19 MΩ	0Ω to 10MΩ
DC Voltage	0.1mV to 1500V	0.1mV to 250V
AC Voltage RMS	1mV to 1000V	1mV to 140V
AC Voltage Peak	1mV to 1500V	1mV to 200V
Current	To 50A, 0 to 10 MHz	To 10A, 0-01 MHz
Frequency	To 50 MHz	To 500 MHz
Time Interval	100 ns to 10^8 Sec.	20 ns to 100 Sec.
Capacitance	10 PF to 1900 µF	2 µF to 2000 µF
Inductance	0.1 µH to 190 H	0.1 µH to 150 H
Waveform Analysis	0 - 100 MHz (limited by oscilloscope or counter)	0 to 300 MHz
Phase Angle	0 - 100 MHz (limited by dual trace scope accuracy)	2 to 10 MHz
Synchro Angle	0° to 360° (scope accuracy)	0° to 360°
Modulation - AM FM	None None	5 to 90% 100 kHz to 18 GHz -10 to 30 DBM 100 kHz to 18 GHz
Transfer Function	Limited by scope, DVM and Counter	0 to 175 VRMS, 0° to 360°
Harmonic Distortion	Oscilloscope analysis to 100 MHz	0 to 100%, 2 Hz to 100 MHz
Harmonic Analysis	To 100 MHz using ext. comb filter	0 to 300 MHz, -90 to 0 DB
RF Power Measurement	None	10 MHz to 18 GHz, -35 DBM to +30 DBM
Other Microwave Measurements	None	VSMR, insertion and reflection losses, 100 MHz - 18 GHz

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Functional Capabilities	SYSTEM I	SYSTEM II
	Digital	
Stimuli	Up to 240 parallel; 0 to ± 10 volts individually programmable; no serial capability. Up to 96 bits parallel; 0 to +30V bits; individually controlled; no serial capability.	Up to 128 bits parallel by up to 256 bits deep (serial). 0 to ± 20V common levels for all 1's and 0's. Up to 32 bits parallel by up to 256 bits deep (serial). 0 to ± 10V, common levels for all 1's and 0's.
Sensors	Up to 240 bits parallel; 0 to ± 30V; software evaluation after each sensing up to 40 bits parallel; bits individually sensed.	Up to 128 parallel by up to 256 bits deep (serial); 0 to ± 200V up to 2 MHz. 32 bits by up to 256 bits deep (serial); bits individually sensed.
Data Rate	0 to +15V; up to 50 kHz programmable continuously	0 to ±10V; up to 2 MHz for each block of 256 serial 128- or 32-bit words.
	ATE/UUT Interface	
Dedicated Connections		
Number of Test Points	249	204
Number of Coaxial Conn	14 (BNC)	23 (BNC, TNC)
Number of Probes	2 (up to 100 MHz)	4 (one up to 500 MHz)
Programmable Test Points	0 to ± 200V; to ± 5A; 0 to 5 MHz	0 to ± 200V; 0 to ± 2A; 0 to 10 MHz, Buffer Option
Analog	608 (128 shielded)	128 (128 shielded)
Digital Stimulus	336 (336 shielded)	
Digital Sensor	280 (280 shielded)	128 (128 shielded)
Maximum Number of Relay Contacts	7 per path	12 per path
Typical Number of Relay Contacts	2 per path	4 per path
Current PCB Diagnostic Method	Bed of nails and/or directed probing	Directed probing, usually no probing required in analog test programs or in digital D-LASAR diagnostic programs.

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Functional Capabilities	SYSTEM I	SYSTEM II
Computer Data		
Computer System	Hewlett Packard HP 2112A	Data General NOVA 3
Word Length	16 bits	12 bits
Current Main Memory	128 K bytes	128 K bytes
Effective Cycle Time	590 ns	700 ns
Disk Capacity	5 M bytes fixed, 10 M bytes removable	2.4 M bytes fixed, 2.4 M bytes removable
Test Language	MOTEL; (a derivative of BASIC)	ATLAS-E; Descriptive (an adaptation of ATLAS 416-8)
Bus Structure	Data Bus; High Speed Instr Bus; IEEE Bus	Data Bus; Stimuli Bus Measurement Bus

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APPENDIX M

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APPENDIX N

GLOSSARY OF TERMS AND ACRONYMS

A. DEFINITION OF KEY TERMS USED IN THIS REPORT (extracted from MIL-STD 1309B, May 1975)

Accuracy. The degree of correctness with which a measured value agrees with the true or nominal value (see precision).

Adapter. Adevice or series of devices designed to provide a compatible connection between the unit under test and the test equipment. May include proper stimuli or loads not contained in the test equipment (see interface).

Assembly language. A language in which machine operations and locations are represented by mnemonic symbols.

Automatic test equipment (ATE). Equipment that is designed to conduct analysis of functional or static parameters to evaluate the degree of performance degradation and may be designed to perform fault isolation of unit malfunctions. The decision making, contorl, or evaluative functions are conducted with minimum reliance on human intervention.

ATE control software. Software used during execution of a test program which controls the nontesting operations of the ATE. This software is used to execute a test procedure but does not contain any of the stimuli or measurement parameters used in testing the Unit Under Test (UUT). Where test software and control software are combined in one inseparable program, that program will be treated as test software not control software.

ATE support software. Computer programs which aid in preparing, analyzing, and maintaining test software. Examples are: ATE compilers, translation/analysis programs, and punch/print programs.

Bit. A contraction of the term binary digit (see parity bit).

Buffer storage. A storage device used to compensate for a difference in rate of flow of information or time of occurrence of event when transmitting information from one device to another or within subsections of the same device.

Built-in-test equipment (BITE). Any device which is part of an equipment or system and is used for the express purpose of testing the equipment or system. BITE is an identifiable unit of the equipment or system (see self-test).

Built-in-test (BIT). A test approach using BITE or self test hardware or software to test all or part of the unit under test.

Calibration. The comparison of a measurement system or device of unverified accuracy to a measurement system or device of known and greater accuracy to detect or correct any variation from required performance specifications of the unverified measurement system or device.

Compiler. A software system used as an automatic means of translating statements from problem oriented language to machine oriented language.

Input-output. A general term for the equipment used to communicate with a machine and the data involved in the communication channel in the computer.

Interpreter. (1) An executive routine which, as the computation progresses, translates a stored program, expressed in some machine-like pseudo code into a machine code and performs the indicated operations, by means of subroutines, as they are translated. An interpreter is essentially a closed subroutine which operates successively on an indefinitely long sequence of program parameters, the pseudo instructions and operands. It is usually entered as a closed subroutine and left by a pseudo code exit instruction; and (2) A punch card machine which will take a punched card with no printing on it, read the information in the punched holes, and print a translation in characters in specified rows and columns on the cards.

Language. The characters combining rules and meanings used to express and process information for handling by computers and associated equipment.

Line replaceable unit (LRU). A unit which is designated by the plan for maintenance to be removed upon failure from a larger entity (equipment, system) in the latter's operational environment.

LRU. See line replaceable unit.

Manual test equipment. Test equipment that requires separate manipulations for each task (for example, connection to signal to be measured, selection of suitable range, and insertion of stimuli).

Off-line testing. Testing of the unit under test removed from its operational environment or its operational equipment. Shop testing.

On-line testing. Testing of the unit under test in its operational environment (see interference testing and non-interference testing).

Parity bit. An additional bit used in a tape frame or computer word or other forms of digital data transmission to make the number of 1 bits it contains either odd or even. Parity bits are error detecting bits that do not contain useful information.

Programmable stimuli. Stimuli that can be controlled in accordance with instructions from a programming device.

Stimulus. Any physical or electrical input applied to a device intended to produce a measurable response.

Test, measurement and diagnostic equipment (TMDE). Any system or device used to evaluate the operational condition of a system or equipment to identify and isolate or both any actual or potential malfunction.

B. LIST OF ACRONYMS

AD - Advanced Development

ATE - Automatic Test Equipment

ATISS - Automatic Test Support System

BIT - Built-In-Test

BITE - Built-In-Test Equipment

DS - Direct Support

ED - Engineering Development

EQUATE - AN/USM-410 Automatic Test Equipment

GFE - Government Furnished Equipment

GS - General Support

ILS - Integrated Logistic Support

IOC - Initial Operational Capability

LCSS - Land Conduct Support System

LOA - Letter of Agreement

LRU - Line Replaceable Unit

LSI - Large Scale Integration

MATE - MICOM Automated Test Equipment

MSC - Material Systems Command

MTBF - Mean Time Between Failure

MTBR - Mean Time Between Removal

MTTR - Mean Time To Repair

PCB - Printed Circuit Board

PM - Product Manager or Project Manager

RDT&E - Research, Development, Test & Evaluation

RF - Radio Frequency

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RGS - Restructured General Support

SAIE - Special Acceptance and Inspection Equipment

SRA - Shop Repairable Assembly

TMDE - Test, Measurement and Diagnostic Equipment

TPS - Test Program Set

UUT - Unit Under Test

VAST - Versatile Avionics Shop Test

WRA - Weapon Replaceable Assembly

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