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A COMPARATIVE ANALYSIS OF DEVELOPMENTAL TEST AND EVALUATION IN THE UNITED STATES ARMY

by

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The purpose of this thesis is to explore and identify key problems in Developmental Testing and Evaluation (DT&E) in the United States Army. A comparative analysis of several programs is conducted to determine common developmental testing problems. These problems are analyzed and a set of conclusions and recommendations for future testing is developed. The thesis provides the reader with a current understanding of the Department of Defense (DOD) test structure, its relationship to the acquisition process, and the Department of the Army test agencies involved in Developmental Test and Evaluation. The agencies identified five common categories of problems across seven systems. These systems included: the Abrams Main Battle Tank Block II upgrade (M1A2); the Javelin, a man portable antitank weapon, (AAWS-M); Enhanced Position Location Reporting System (EPLRS); the Avenger, a mounted Air Defense system, the Kiowa Warrior, an armed scout helicopter; the Maneuver Control System (MCS), a command and control system; and the Family of Medium Tactical Vehicles (FMTV). The thesis concludes by providing recommendations to help future testers, evaluators and program managers to better prepare for DT&E in the acquisition life cycle.

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A Comparative Analysis of Developmental Test and Evaluation

in the United States Army

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The purpose of this thesis is to explore and identify key problems in Developmental Testing and Evaluation (DT&E) in the United States Army. A comparative analysis of several programs is conducted to determine common developmental testing problems. These problems are analyzed and a set of conclusions and recommendations for future testing is developed. The thesis provides the reader with a current understanding of the Department of Defense (DOD) test structure, its relationship to the acquisition process, and the Department of the Army test agencies involved in Developmental Test and Evaluation. The agencies identified five common categories of problems across seven systems. These systems included: the Abrams Main Battle Tank Block II upgrade (M1A2); the Javelin, a man portable antitank weapon, (AAWS-M); Enhanced Position Location Reporting System (EPLRS); the Avenger, a mounted Air Defense system, the Kiowa Warrior, an armed scout helicopter; the Maneuver Control System (MCS), a command and control system; and the Family of Medium Tactical Vehicles (FMTV). The thesis concludes by providing recommendations to help future testers, evaluators and program managers to better prepare for DT&E in the acquisition life cycle.

TABLE OF CONTENTS

I. INTRODUCTION

A. PURPOSE

The purpose of this thesis is to explore and identify key problems in Developmental Testing and Evaluation (DT&E) in the United States Army. A comparative analysis of several programs is conducted to determine common developmental testing problems. These problems are analyzed and a set of conclusions and recommendations for future testing is developed. The thesis provides the reader with a current understanding of the Department of Defense (DOD) test structure, its relationship to the acquisition process, and the Department of the Army test agencies involved in Developmental Test and Evaluation. The thesis concludes by providing recommendations to help future testers, evaluators and program managers to better prepare for DT&E in the acquisition life cycle.

B. BACKGROUND

Test and Evaluation (T&E) is required in the acquisition life of any Department of Defense system. Developmental testing is critical to a program moving on in the acquisition process. Developmental testing, like the entire acquisition process is subject to budget cycles, agency conflicts, turf battles, congressional influence and other political factors all of which can cause problems. Problems in developmental testing have caused schedule delays, inadequate or useless data and unplanned expenditures of large amounts of money and other resources to resolve the situations. In the current environment of declining budgets, such problems can result in program slowdown or even cancellation.

There are two major categories of test and evaluation: (1) Developmental Test and Evaluation (DT&E) and (2) Operational Test and Evaluation (OT&E). Operational Testing as well as other types of testing are described, but the focus of this thesis is DT&E.

Developmental Test and Evaluation (DT&E) is conducted throughout the acquisition process to ensure the acquisition and fielding of an effective and supportable system. Early DT&E is normally conducted by the sub-contractors and the prime contractor. The sub-contractors test the components as they are developed and the prime is interested in testing the total system as the components are integrated. The Government test agencies are more involved during the later acquisition phases to demonstrate how well the weapon system meets its technical requirements.

There are several key players involved in DT&E in the U. S. Army. DT&E is normally planned, coordinated, conducted and monitored by the United States Army Test and Evaluation Command (TECOM), a sub command of the Army Materiel Command (AMC). The test design, evaluation and analysis role of DT&E is conducted by the United States Army Materiel Systems Analysis Activity (AMSAA). Other critical players include the future users or Combat Developers from the United States Army Training and Doctrine Command, (TRADOC), and the Program Management Office (PMO) charged with the overall acquisition of the system including testing.

C. OBJECTIVES OF THE THESIS

The objective of the thesis is to explore and identify common problems of developmental testing in the United States Army from the perspective of the different agencies involved. The agencies or groups focused on were: the Program Management Office (PMO), the testers and their facilities, the analysts/evaluators, the contractors, and the users.

The Program Management Office (PMO) is ultimately responsible for all aspects of any program including testing. The PMO normally maintains a section whose functions include test coordination. The Army's Test and Evaluation Command (TECOM) provides most of the resources -- testers and facilities -- for DT&E in the Army today. Analysis and

evaluation for Army DT&E is normally conducted by the Army Materiel Systems Analysis Agency (AMSAA). This agency impacts the analytical and statistical side of the DT&E. The contractor or builder plays a significant role in the test, fix, retest scenario of the early stages of a weapon system development. Finally, the users provide the need and request the capabilities that the system under test will hopefully provide. The user or Combat Developer is usually represented by a TRADOC Systems Manager (TSM) or by a combined TRADOC organization such as the Combined Arms Center at Fort Leavenworth, Kansas.

The organization and basic DOD test process is described followed by the Army test structure down to the agencies and offices that are the focus of the data collection. Data are presented and once the developmental test problems are identified, they are analyzed and a set of recommendations is developed from this information. The recommendations can then be used by program managers, testers and evaluators to help them assess and prepare their system for developmental testing.

D. RESEARCH QUESTIONS

The primary research question for this thesis is:

What is the most significant problem in conducting developmental testing?

The following are subsidiary research questions to help develop and define the primary research question.

1. What are the common developmental test problem areas across agencies?
2. What are the common developmental test problem areas across types of systems or acquisition strategies?
3. To what extent do these problems endanger program success?
4. To what extent do these proolems impact cost and schedule?
5. What can be done by program managers, testers and evaluators or others to improve the preparation and conduct of developmental testing?

E. SCOPE AND LIMITATIONS

The scope of the research is limited to Acquisition Category (ACAT) I and II systems tested at United States Army Test and Evaluation Command (TECOM) facilities within the United States. Seven programs under test or tested in the past 10 years are researched and analyzed. The systems include the Abrams Main Battle Tank Block II upgrade (M1A2); the Javelin, a man portable antitank weapon, (AAWS-M); Enhanced Position Location Reporting System (EPLRS); the Avenger, a mounted Air Defense system, the Kiowa Warrior, an armed scout helicopter; the Maneuver Control System (MCS), a command and control system; and the Family of Medium Tactical Vehicles (FMTV). These programs represent different types of systems from electronic communications and software to major weapon systems and represent different types of acquisitions from system upgrades and Non-Developmental Items (NDI) to full scale development. Other information will come from literature searches and interviews as indicated below.

F. RESEARCH METHODOLOGY

Research investigation included a literature search of After Action Reports from Test and Evaluation Command (TECOM), lessons learned reports of major systems, General Accounting Office Reports, Congressional Subcommittee Reports, Developmental Test and Evaluation Reports and technical and professional journals. Developmental testing does not normally receive the public scrutiny of operational testing and therefore much of the information was gathered through the interview process. Interviews were conducted with program office personnel, program test officers, analysis personnel, Combat Developers and contractors who participated in developmental testing of the major programs already mentioned. Supervisors from AMSAA and TECOM with years of DT&E experience in the Army were also interviewed. Interviews were conducted in person, over the phone and through the use of video teleconferencing.

G. ORGANIZATION OF THE STUDY

The thesis is organized into the following chapters.

Chapter II: Background -- This chapter contains historical information on DOD testing and describes the current DOD test structure within the acquisition process. The chapter then describes the test structure in the U. S. Army focusing on DT&E and the key players in Army DT&E.

Chapter III: Methodology and Data Summary -- This chapter explains the methods used for executing the research design and structure of the analysis. The chapter then presents the data that were used for the analysis. Most of the data are in the form of interviews.

Chapter IV: Results and Analysis -- This chapter analyzes the data and indicates their implications.

Chapter V: Conclusions and Recommendations -- This chapter contains a summary of the principal findings of the thesis and offers recommendations for future use.

II. BACKGROUND

A. INTRODUCTION

This chapter provides a basic history of testing in the Department of Defense (DOD) with emphasis on the last twenty years. The chapter describes the four major categories of testing namely Development Testing, Operational Testing, Joint Testing and Multi-Service Testing. The chapter then describes testing within the acquisition process and concludes with the description of the Developmental Testing function within the United States Army.

Test and Evaluation (T&E) is a critical part of the acquisition process. "Test" denotes the actual testing of hardware or software to obtain data. These data are valuable in developing new capabilities, managing the process, or making decisions on the allocation of resources. "Evaluation" denotes the process whereby data are logically assembled and analyzed to aid in making systematic decisions. "Test and Evaluation is the process by which a system or components are compared against requirements and specifications through testing." [Ref. 1]

The planning and conducting of T&E exists throughout the acquisition cycle. There is the need for thorough, logical, systematic, and early test planning and the feedback of well documented, unbiased test and evaluation results to system developers, users, and decision makers. The purpose of Test and Evaluation in a defense system's development and acquisition program is to identify the areas of risk to be reduced or eliminated. During the early phases of development, T&E is conducted to demonstrate the feasibility of conceptual approaches, to minimize design risk, to identify design alternatives, to compare and analyze tradeoffs, and to estimate operational effectiveness and suitability. [Ref. 2]

B. HISTORY

1. World War II to 1960's

Equipment testing has been a part of the procurement process throughout the nation's history. For decades testing remained informal, generally "ad hoc" and evolved along with the procurement process. During World War II the procurement process began to take on a more formalized management approach. As the procurement process evolved so did testing. Testing was conducted throughout World War II. There were engineering tests to test engineering and scientific characteristics and Service tests conducted by the various branches to determine if the equipment was sufficient for field use. Testing was basically sequential, lengthy and dependent on the need of the equipment.

The war ended with much equipment still in testing and a recognition that research, development and evaluation must continue to be a peacetime effort. Those involved in testing during the war determined that testing could be greatly simplified under more completely integrated development agencies. The development and continued testing of the atomic bomb offered a ready example of such an integrated and expedited effort. An R&D Division was developed in the Army General Staff in 1946, however it soon fell victim to demobilization and by 1948 the functions of the R&D division were assigned to a subgroup in the Logistics Division. [Ref. 3]

Following the war most of the research, development and testing conducted in DOD dealt with rockets and missiles. During this time the procurement process was evolving and terminology like systems engineering, operations research, project offices and contracted engineering support started to come into play.

2. 1960's and 70's

The 1960's saw the formalization of the acquisition process and subsequently the formalization of the testing process. Initially Secretary of Defense McNamara took a business approach to the acquisition process fostering total package procurement, strong

centralized civilian control and concurrency. In the early 1970's, Secretary of Defense Laird and his deputy, David Packard, promoted decentralization and a "fly before buy" mentality. The Department of Defense (DOD) test policy within the acquisition system became more formalized and placed greater emphasis on Test and Evaluation (T&E) as a continuing function throughout the acquisition cycle. The policies stressed the use of T&E to reduce risk and provide a continuous estimate on the system's effectiveness and suitability. To meet these objectives it was important that appropriate test activities be fully integrated into the overall development process. [Ref. 4] It was also during this time that both the Army and the Air Force were given a congressional directive to establish independent operational test agencies.

3. 1980's

Early in the 1980's the acquisition system was again reviewed and revised. Test and Evaluation was further refined in DOD Directives and Military Standards documents and was becoming a major concern of the Pentagon and The Congress. In 1983 Congress directed the establishment of the Director Of Operational Test And Evaluation (DOT&E). In 1983 the Assistant Secretary Of Defense made the following statement:

> . . . the criterion should not be how quickly we can field any new weapon, but rather how quickly we can field a new weapon that works. The only weapons that would be significantly delayed would be the ones that operational testing shows to be unsuitable for combat, and I cannot believe that any of us would advocate saddling our fighting forces with any of those. In fact, the most likely effect of operational testing is not to delay, but to accelerate the development process. Trying to fix a faulty weapon after it's in the field -- if it can still be fixed -- is a far slower process than fixing the design before it goes into production. [Ref. 5]

Testing continued to be a target of discussion and reform from outside as well as inside the Pentagon throughout the 1980's along with the acquisition process.

4. DOD Acquisition Revision

Defense Management was again looked at in 1985 by a Presidential Blue Ribbon Commission on Defense Management and there were still other revisions of the acquisition

process in 1987 and in 1991. The focus of each of these revisions was an attempt to make the acquisition process less costly, less time consuming, and more responsive to the needs of the operational community. [Ref. 6] The result of these latest revisions is our current acquisition system, a system that is again under review. Among the many initiatives of the latest revisions was the push to consolidate documentation. In the testing arena, DOD Directive 5000.3 "Test and Evaluation" was canceled along with other 5000 series Directives and integrated into DOD Directive 5000.2, February 1991, part 8. Other affects on testing include the requirement of live fire testing of major weapon systems before the production phase and the inclusion of test information in various reports, the Selected Acquisition Report (SAR) for example. [Ref. 7] The acquisition process is again under review and almost any revisions to the acquisition process will likely impact on testing.

C. TYPES OF T&E

There are four major types of testing, DT&E (Development), OT&E (Operational), Multi-Service Test and Evaluation and Joint Test and Evaluation. The types of testing which fall into the realm of DT&E or at least Director, Test and Evaluation (DTE) oversight include qualification testing, Live Fire Test and Evaluation (LFT&E) and Production Acceptance Test and Evaluation (PAT&E). The following sections describe these various types of testing. [Ref. 8]

1. Development Test and Evaluation (DT&E)

Development Test and Evaluation (DT&E) is an iterative process of design, build, test, identify deficiencies, fix, retest, and repeat. DT&E is conducted throughout the acquisition process to ensure the acquisition and fielding of an effective and supportable system. It is performed in the factory, laboratory and on the proving ground by contractors and the Government. DT&E includes test and evaluation of components and subsystems at all Work Breakdown Structure (WBS) levels, it includes modifications, hardware/software

iterations, related software and qualification testing. Contractor and Government testing may be combined into one integrated program test and conducted to determine if the technical development of the acquisition process has been met as well as provide data to the decision authority. [Ref. 9] DT&E involves the use of simulations, models, breadboards, brassboards, and test beds, and full scale engineering development models or prototypes of system components or the system itself. DT&E is conducted throughout the acquisition process as described in the "Testing and the Acquisition Process" section of this chapter.

a. Qualification Testing

Qualification testing is performed to verify the design and manufacturing process and provide a baseline for subsequent acceptance tests. These tests include Production Qualification Tests (PQT), First Article Tests (FAT) and other down line production qualification tests performed to verify process control. The Production Qualification Test is conducted at the unit, subsystem (component) and system level on production items and completed before production decisions. The First Article Tests (FAT) consist of a series of formal contractual tests conducted to ensure the effectiveness of process, equipment and procedures. The FAT is conducted on a random sample from the first production lot. [Ref. 10]

b. Live Fire Test and Evaluation (LFT&E)

Live Fire Testing was mandated by Congress in November 1986. The law stipulates that major acquisition programs may not proceed beyond Low Rate Initial Production (LRIP) until realistic survivability (or lethality for some systems) testing has been completed. This testing requires the Services to Live Fire test their weapon systems as early as possible before Milestone III. [Ref. 11] LFT&E is its own type of testing and while it is not truly DT&E, the Congress recognized the importance of keeping the Live Fire Program coupled closely to the development process and affirmed this by requiring the Director, Live Fire Testing to report directly to the USDA. [Ref. 12] LFT&E is also

sometimes associated with OT&E. However, there are significant differences between LFT&E and OT&E. OT&E is further described in the section "Operational Test and Evaluation" of this chapter. Figure 1 highlights the main differences between LFT&E and OT&E.

LIVE FIRE	OPERATIONAL
Full-Up Destructive Testing	Typically Nondestructive
Instrumented To Gather Vulnerability /Lethality Data	Instrumented So As Not To Interfere With Tactical Realism
Typically One On One	Typically Few On Few
Oversight, Director, Live Fire Testing	Oversight, Director, OT&E

FIGURE 1. Live Fire Testing Versus Operational Testing

c. Production Acceptance Test and Evaluation (PAT&E)

The Production Acceptance Test And Evaluation (PAT&E) is conducted on production items to demonstrate that those items meet the requirements and specifications of the procuring contracts so production may continue. PAT&E also ensures that production line systems demonstrate the same performance characteristics and capabilities of the preproduction models. Such testing is normally conducted by the Program Office quality assurance section, often at the contractor's plant and may involve operational users. [Ref. 13]

2. Operational Test and Evaluation.

The purpose of Operational Test And Evaluation (OT&E) is to assess operational effectiveness and suitability at each stage in the acquisition process. Operational effectiveness is a measure of the contribution of the system to mission accomplishment under actual conditions of employment. Operational suitability is a measure of the

maintainability and reliability of the system, the effort and level of training required to maintain, support, and operate it, and any unique logistic or training requirements of the system. OT&E may also provide information on tactics, doctrine, organization and personnel requirements and may be used to assist in the preparation of operating and maintenance instructions and other publications. OT&E's most important aspect is that it provides an independent evaluation of the utility of the system and the feasibility of employing it. [Ref. 14]

For major systems, OT&E is normally planned and conducted by a major OT&E field agency located within the DOD component. This Operational Test Agency (OTA) must be separate and independent from both the developing/procuring agency and the using agency. The OTA is responsible for managing operational testing, reporting test results and providing its independent evaluation of the system being tested directly to the Military Service Chief or Defense Agency Director. [Ref. 15] Like DT&E, OT&E also occurs throughout the acquisition process. OT&E's role in this process is described in the "Testing and the Acquisition Process" section of this chapter. Figure 2 highlights the major differences between DT&E and OT&E. [Ref. 16]

3. Multi-Service Test and Evaluation

Multi-Service Test and Evaluation is T&E conducted on a system being acquired for more than one Service. All Services involved participate with one designated as the lead Service. At the conclusion of Multi-Service T&E, each participating OT&E agency submits an independent evaluation through its normal channels. The Lead Service then prepares a single report that reflects the system's operational effectiveness and suitability for each Service. This report goes forward to the Defense Acquisition Board (DAB) for review, recommendations and decision. [Ref. 17]

DT&E	OT&E
Controlled by Program Manager	Controlled by Independent Agency
One on One Tests	Many on Many Tests
Controlled Environment	Tactical Environment with Operational Scenario
Component/sub-system	Complex System
Contractor Involvement	No Contractor Involvement.
Test to Specification	Test to Requirements
Trained Experienced Operators	Troops Recently Trained on Equipment
Development Test Article	Production Representative Test Article.
Precise Performance Objectives and Threshold Measurements	Performance Measurement of Operational Effectiveness and Suitability.

FIGURE 2. Differences Between DT&E and OT&E

4. Joint Test and Evaluation

Joint Service Test and Evaluation is a specific program activity sponsored by the Office of the Secretary of Defense (OSD). JT&E Programs are not primarily acquisition oriented. Rather, they are means of examining Joint Service tactics, doctrine and systems' interoperability. JT&E provides information on system requirements or improvements and for force structure planning. There are both Joint Development T&E and Joint Operational T&E. Joint Developmental T&Es focus on obtaining information on system requirements, performance, reliability and other technical aspects. Joint Operational T&Es are conducted to obtain data pertinent to operational doctrine, tactics and procedures. [Ref. 18]

D. TESTING AND THE ACQUISITION PROCESS

Testing is critical throughout the life cycle of any system. Both DT&E and OT&E events occur throughout the acquisition process which consists of the following phases:

- Concept Exploration and Definition - Phase 0
- Demonstration/Validation - Phase I
- Engineering and Manufacturing Development - Phase II
- Production and Deployment - Phase III
- Operations and Support Phase IV

Figure 3 depicts these phases and illustrates that the phases are separated by key decision points or milestones. These decision points occur throughout the program life when a decision authority reviews a program and authorizes it to advance to the next phase in the cycle. The following section describes the acquisition process and testing events normally occurring during the respective phase.

1. Concept Exploration and Definition Phase - PHASE 0

The defense system acquisition process begins with the submission of a Mission Need Statement (MNS) with the Service's Program Objective Memorandum (POM). The MNS documents major mission deficiencies (or improvement opportunities) in a Service's ability to meet its mission requirements. The Concept Exploration and Definition Phase (C/E) follows the Milestone 0 approval for concept studies. During the (C/E) Phase alternative approaches for satisfying the requirement(s) are investigated. Concept Exploration/Definition phase assists in selecting preferred alternative system concepts, technologies, and designs. Documents for the Milestone I review are the MNS, the Acquisition Decision Memorandum (ADM) which provides the exit criteria, the Operational Requirements Document (ORD) which delineates the qualitative and quantitative system parameters and the Test and Evaluation Master Plan (TEMP) which identifies the objectives, responsibilities, resources and schedule for the T&E effort.

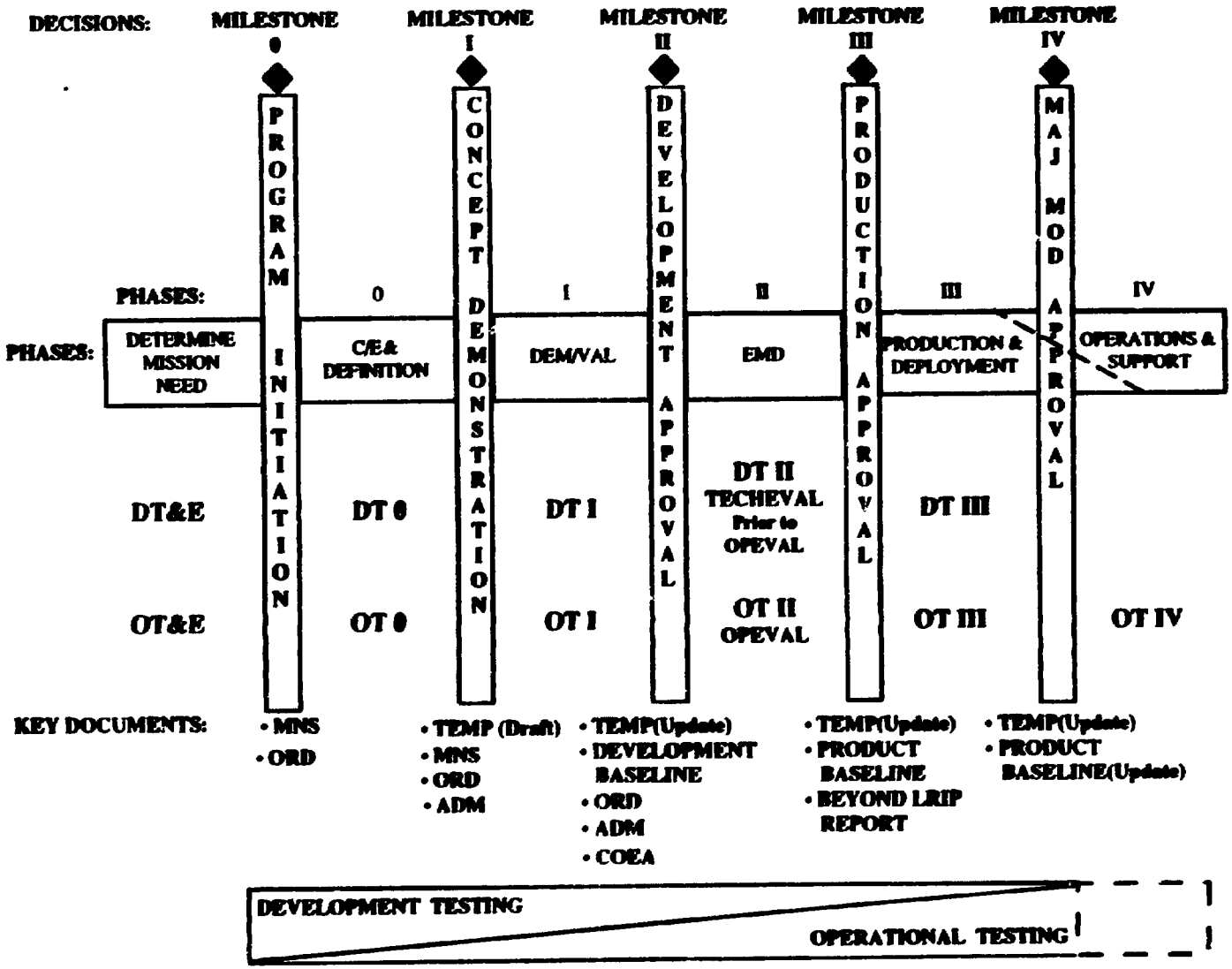

FIGURE 3. Testing and The Acquisition Process

a. DT 0

Early in this phase a review of historical tests and existing systems is conducted. Preferred alternative system concepts are selected and a draft Test and Evaluation Master Plan (TEMP) is started. The TEMP defines test phases, schedules and resource requirements. Prior to the Milestone I decision, laboratory testing, modeling and simulations are conducted by the contractor and/or the Government development agency to demonstrate and assess the capabilities of key subsystems and components. [Ref. 19]

b. OT 0

The operational test agency (OTA) estimates military utility and assesses operational impact of candidate technical approaches. The operational test agency also monitors C/E Test and Evaluation for future test planning. OT&E conducted during this phase supports developing estimates of the need for the new system, a sound physical basis for the new system, the system's affordability and the impact of the system on the force structure. [Ref. 20]

2. Demonstration/Validation Phase - PHASE I

After the Milestone I decision, the program enters the Concept Demonstration/Validation (DEM/VAL) Phase during which selected concepts, typically brassboard or early prototype, are refined through study and analysis. [Ref. 21] This phase ends with the Milestone II decision to either enter into Engineering and Manufacturing Development (EMD), conduct more research and development and delay the decision or terminate the program. Documents of particular interest to the T&E manager at the time of the Milestone II review include the ADM, an updated TEMP, the updated ORD, the Cost and Operational Effectiveness Analysis (COEA), which is a cost and operational analysis of the alternative systems, and the Development Baseline.

a. DT I

During this phase DT&E is accomplished to ensure that engineering is reasonably complete, demonstrate technical risk areas have been identified and can be reduced, identify the best or preferred technical approach and that the concept can meet operational requirements. DT I includes T&E of components, subsystems, and prototype development models. Testing also includes functional compatibility and interoperabilty with existing and planned equipment. DT conducted during this phase is most often conducted at the contractor's facility with Government oversight. [Ref. 22]

b. OT I

In OT I the OT&E agency prepares independent early operational assessments to identify the best design, indicate the risk level of performance for this phase of development, and estimate potential operational effectiveness and suitability. The operational aspects of the technical approaches is examined and information on tactics, doctrine, organization, personnel requirements and critical issues are identified. The OTA also identifies needed modifications or other issues that need to be resolved before the next phase is initiated. Typical operational and support personnel are used to obtain an estimate of the user's capability to operate the system. The OT&E assessments provide a record of testing, an audit trail, test data, recommendations and conclusions. Testing normally includes components, subsystems, brassboard configurations or advanced development prototypes. [Ref. 23]

3. Engineering and Manufacturing Development Phase - PHASE II

The objective of the Engineering and Manufacturing Development (EMD) Phase is to design, fabricate and test a preproduction system that closely approximates the final product. This phase may include Live Fire Testing if required. The information from the DT and OT along with other documents such as the Updated TEMP, the Beyond-Low Rate Initial Production Report (LRIP) and a Live Fire Test Report (The Beyond LRIP Report

and Live Fire Test Report are required by law of the Director, Operational T&E) provide the information to the decision makers for determining whether to enter production or not and what level of production. [Ref. 24] Data obtained during EMD test and evaluation are used to assist in evaluating the system's maintenance training requirements and in evaluating the proposed training program. Test results generated during EMD also support the user in refining and updating tactics. [Ref. 25]

a. DT II

DT II must demonstrate that engineering is reasonably complete, that all significant design solutions to problems are in hand, and that the design meets its required specifications within the range of environmental limits designed for the operational employment of the system. DT II also must verify "fixes" from DT I and assess the survivability, vulnerability and logistic supportability of the system. Vulnerability (or lethality) may require live fire testing.

The final phase of DT II is the TECHEVAL. The TECHEVAL is the formal demonstration that the design meets specifications and it provides the major source of data for certification of readiness for the OPEVAL. The TECHEVAL provides information relative to the technical performance of the system. It is the qualification of components and an assessment of compatibility, inter-operability, vulnerability, lethality, transportability, etc. The technical evaluation also determines performance limitations and safe operating parameters, insures the effectiveness of the manufacturing process and confirms readiness for operational testing. [Ref. 26] Typical test models for this phase include pre production prototypes or pilot production models.

b. OT II

OT II is conducted to demonstrate performance of the program objectives. It estimates operational effectiveness and suitability as well as identifies operational

deficiencies. OT II is used to determine adequacy of publications and support equipment and to provide information to refine operations and support (O&S) cost estimates.

The final phase of OT II is the OPEVAL. The Operational Evaluation (OPEVAL) occurs a minimum of 90 days after the TECHEVAL. It assists the developers by providing information relative to operational performance, doctrine, tactics, training and logistical issues. It assists the decision makers on the overall suitability of the system to be delivered as well as influences either a low rate initial production or a full-rate production. The OPEVAL also assesses the user's viewpoint on the system's desirability. [Ref. 27] Typical test models for this phase include preproduction prototypes or pilot production models.

4. Production & Deployment - PHASE III

The objective of this phase is to produce and field the system. Production Acceptance Test and Evaluation (PAT&E) is conducted on production items to ensure the effectiveness of the manufacturing process, equipment, and procedures. Follow-on Operational Testing (FOT&E) may be conducted to verify operational effectiveness and suitability. [Ref. 28]

a. DT III

After the Milestone III (Production and Deployment) decision, Developmental Testing remains an integral part of the development, validation, and introduction of system changes undertaken to improve the system or to reduce life cycle costs. [Ref. 29] DT III verifies corrections of deficiencies in the TECHEVAL, verifies specification compliance and completes any testing not completed during EMD. DT III is also used to conduct the major elements of the PAT&E. The PAT&E ensures that production line systems demonstrate the same performance characteristics of the preproduction models. PAT&E will continue throughout the production life cycle of the system Testing conducted in this

phase is conducted under controlled conditions, provides quantitative and qualitative data and is normally monitored or conducted by a Government representative. [Ref. 30]

b. OT III

OT III is used to verify correction of OPEVAL deficiencies and to evaluate performance not tested during earlier tests. OT III is conducted on the OPEVAL model with fixes. OT III takes the form of Follow-on Test and Evaluation (FOT&E) and is conducted with production articles in operational organizations. This testing verifies the production system, tests operational effectiveness and suitability under realistic operational conditions and demonstrates reliability and maintainability improvements. [Ref. 31]

5. Operations and Support - PHASE IV

The function of this phase is to ensure that the fielded system continues to provide the capabilities required and to identify the actions and resources needed to maintain operational readiness and support objectives. This phase ends with a Major Modification Approval to identify the actions and resources needed to achieve and maintain operational readiness and support objectives. The Major Modification Approval encompasses a review of a system's operational effectiveness, suitability, and readiness to determine whether major upgrades are necessary or deficiencies warrant consideration of replacement. In preparation for this milestone the TEMP, and product baseline are updated to describe program status, changes and issues. [Ref. 32]

a. DT

Development testing during this phase ensures previous test deficiencies are corrected. DT evaluates proposed production improvements, Engineering Change Proposals (ECPs), upgrades and determines if the resources are available to maintain readiness and support objectives throughout the system's acquisition life cycle. As the system completes its useful life, DT is used in an engineering aspect to help modify the system for new threats or with new technology or to help in system disposal.

b. OT IV

A major function of OT during this phase is to evaluate post production logistic readiness and support and to validate effectiveness and suitability of modified systems. Follow-on Test and Evaluation (FOT&E) are used to assess logistics readiness, sustainability, and the implementation of the Integrated Logistics Support Plan (ILSP). Finally as a system approaches the end of its usefulness, OT monitors the system's current state of operational effectiveness, suitability and readiness to determine whether major modifications are necessary or deficiencies warrant consideration of replacement. [Ref. 33]

E. DT&E IN THE UNITED STATES ARMY

This section describes the testing structure starting from the Office of the Secretary of Defense (OSD) down to the key players involved in Army DT&E.

1. DOD Test Structure

The organizational structure of the DOD concerning acquisition and testing is depicted in Figure 4. T&E oversight is performed by two offices: the Director, Test and Evaluation (DTE) and the Director, Operational Test and Evaluation (DOT&E). The Defense Acquisition Executive (DAE), a position held by the Under Secretary of Defense for Acquisition and Technology (USD (A&T)), performs the management of acquisition for the DOD.

The DTE is the principal staff assistant and advisor to the USD (A&T) for T&E matters. The DTE is responsible for all DT&E. The duties of the DTE include: review major acquisition program documentation for DT&E implications, provide management and oversight of the major ranges and test facilities, and develop and implement the Live Fire Test Program.

The DOT&E reports directly to the Secretary of Defense (SECDEF) and has special reporting requirements to the Congress. The DOT&E's responsibility is to provide

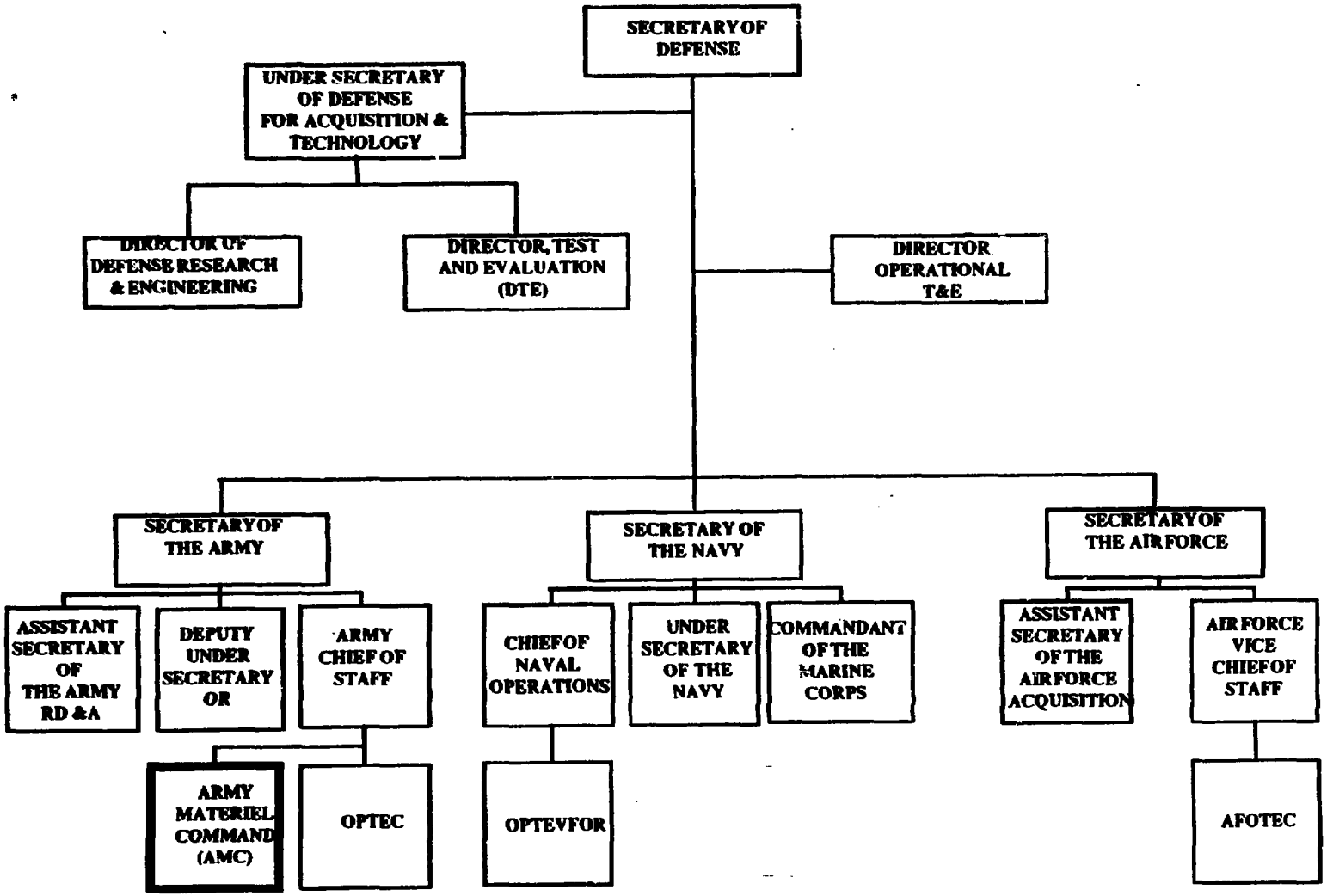

FIGURE 4. DOD Test and Evaluation Oraganization

unbiased insight into the operational effectiveness and suitability of new weapon systems. The duties of the DOT&E include approving test plans on major systems prior to OT&E, approval of OT&E funding for major systems and providing the SECDEF and the Congress with the Beyond LRIP report. [Ref. 34]

2. Army T&E Structure

The Army management structure for T&E is illustrated in Figure 5. The Under Secretary of the Army is the Army Acquisition Executive (AAE). The AAE is responsible for all acquisition T&E (operational and developmental tests) planning, programming, budgeting, developmental test policy and oversight. The AAE performs these duties with the assistance of the Assistant Secretary of the Army, Research, Development, and Acquisition (ASA/RDA). The ASA/RDA is organized to provide technical assessments and program evaluations. He resolves acquisition issues whenever possible and makes recommendations to the AAE on the acquisition of weapon systems. The Deputy Under Secretary of the Army for Operations Research (DUSA(OR)) is chartered to supervise all Army T&E policy and has oversight for all Army T&E. [Ref. 35]

3. Army DT&E

The U. S. Army Materiel Command (AMC) is responsible for the management of DT&E. Under AMC the Test and Evaluation Command (TECOM) has the primary responsibility for conducting developmental tests for the Army and the Army Materiel Systems Analysis Agency (AMSAA) conducts test analysis and evaluation on major systems. TECOM may be designated as the evaluator for non major systems. The Structure of AMC and TECOM is shown in Figure 6.

TECOM is responsible for:

- Planning, executing and reporting the results of technical tests. Technical tests include Development Tests, Technical Feasibility Tests, Production Qualification Tests, Joint Tests, and contractor/foreign tests.
- Providing test facilities and technical expertise in support of the T&E life cycle.

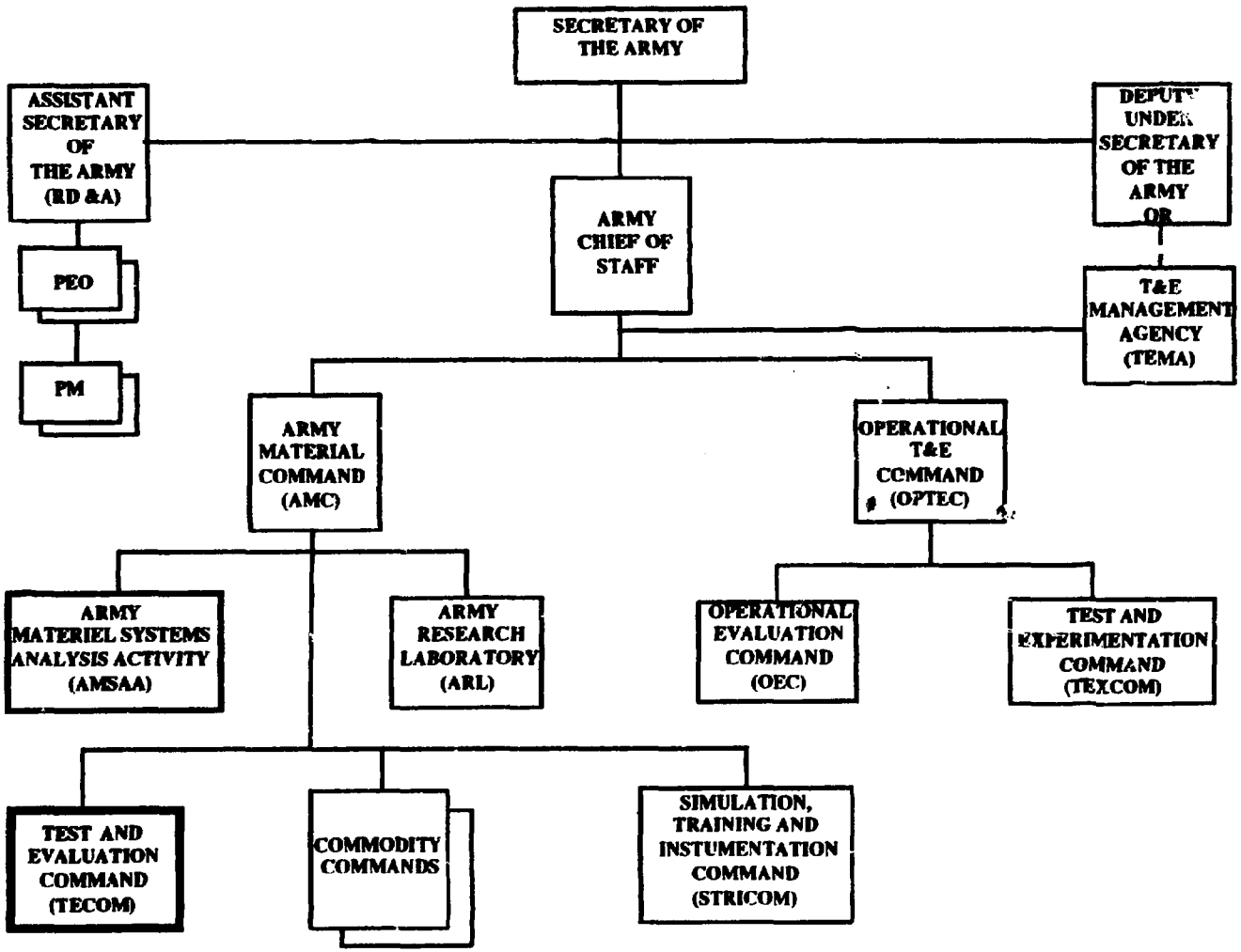

FIGURE 5. Army T&E Structure

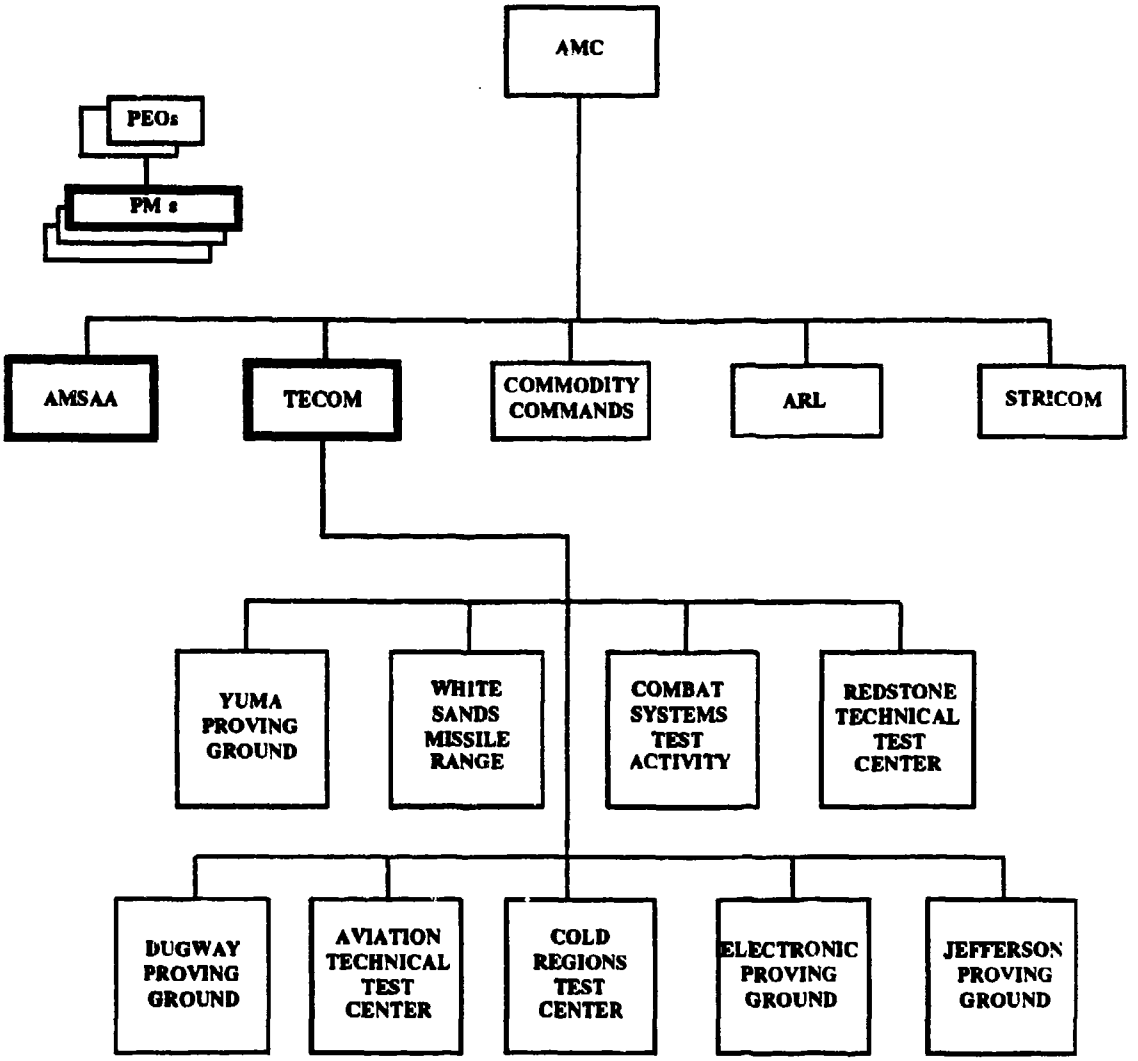

FIGURE 6. AMC and TECOM Structure

(TECOM responsibilities continued)

- Maintaining the Army's T&E data base.
- Maintaining the Army's Major Range and Test Facility Base.
- Researching, developing, and acquiring instrumentation and developing new and improved test methodology.
- Providing safety confirmations. [Ref. 36]

F. OTHER DT&E ORGANIZATIONS IN THE ARMY.

The testing process extends throughout the acquisition cycle of any system. Many agencies play a significant role in the testing process. The Program Management Office (PMO), the Tester and his facilities, the builder or Contractor, the evaluator, the Army Materiel Systems Analysis Agency (AMSAA) in the Army's case and the user or Combat Developer all are a part of DT&E. They meet formally through the Test Integration Working Groups (TIWG) and informally based on other factors such as critical issues or Program Management style.

1. Program Management Office (PMO)

The Program Manager (PM) is ultimately responsible for all aspects of the system development, to include coordinating the total T&E program. The PM normally has a deputy or assistant whose functions include the overwatch of testing as well as writing or inputting into various test documents and reports. The PM and his office are responsible for writing numerous reports and plans such as the Test and Evaluation Master Plan (TEMP). The input to the TEMP is normally influenced by the Test Integration Working Group.

a. Test Integration Working Group (TIWG)

The PM charters and uses the Test Integration Working Group (TIWG) to help coordinate, plan, and discuss the testing and analysis effort. TIWG members include

representatives from the development agency, the user, both developmental and operational T&E agencies, logistics, analysis and training organizations. [Ref. 37]

2. TECOM

The U. S. Army Test and Evaluation Command (TECOM) is the Army's testing agency. TECOM as presented in Figure 6 has facilities throughout the U. S. as well as locations outside of the continental U. S. As sub components of TECOM, these facilities provide the people, equipment, and other resources to conduct various types of DT. TECOM through its various facilities is responsible for the planning, executing and reporting the results of technical tests. Technical tests include Development Tests, Technical Feasibility Tests, Production Qualification Tests, Joint Tests, and contractor/foreign tests. TECOM is charged with maintaining the Army's Major Range and Test Facility Base, maintaining the Army's T&E data base and researching, developing, and acquiring instrumentation and improved test methodology.

3. Prime Contractor

The Prime Contractor is the Company who is responsible to provide the Government with the needed product. The Prime Contractor plays a significant role in DT&E. The contractor conducts his own testing prior to Government tests and demonstrates that he is prepared to enter into Government conducted or at least Government observed testing. The contractor's testing during the initial phases of the acquisition cycle is likely to impact testing conducted by the Government during the EMD Phase. The contractor may even conduct some DT, observed by the Government, within his facility.

4. AMSAA

The Army Materiel Systems Analysis Agency is AMC's independent evaluator for the DT process often referred to as the "honest broker." AMSAA is responsible for the Independent Evaluation Plan (IEP) as well as advising the tester and the program office on

analytical issues, testing and test documentation. AMSAA's greatest influence is on the statistical process controls of the tests such as sample size and confidence levels and test design. AMSAA conducts the analysis and/or evaluation of the testing and provides members to the TTWG.

5. Combat Developer

The Combat Developer is usually the "user" or the organization that represents the user and identifies the need for the system being developed. In the Army this is usually a Training and Doctrine Command (TRADOC) basic Army branch such as the Field Artillery or the Armor School. These agencies develop the doctrine and training for their respective branches based on overall Army tactics, doctrine and guidance. They also help to determine the needs of that particular branch presently and into the future. These organizations provide the Mission Need Statements that may grow into development of a new system or modification of an old system. In some cases the user may be The Combined Arms Center (CAC) or The Combined Arms Service Support Center (CASSC). These agencies integrate the training, doctrine and needs of the various branches they represent and function as an overall user for a system needed by all the combined branches. The Combat Development agency is the organization where the acquisition process begins and where the final product arrives.

G. POTENTIAL ISSUES AND PROBLEMS

There are potentially many issues or problems that can affect Developmental Testing and many issues that are affected by DT&E. This chapter provided a basic history of testing in the Department of Defense, described testing within the acquisition process and the Developmental Testing function within the United States Army. The structure of the testing within the DOD and within the Army is effected by legislation, policy, both formal and informal guidance and a continuous reform effort. The management and conduct of

DT&E impacts upcoming milestone decisions and may hold the key to a program's success and continuation or its cancellation. The problems that occur in DT&E impact on cost, schedule and performance of the system and are very important to both the Government agencies and the contractors involved. The next chapter identifies those issues that are considered the most prevalent according to the major players in a number of programs.

III. METHODOLOGY AND DATA SUMMARY

A. INTRODUCTION

This chapter presents the methodology used and data gathered to answer the primary and subsidiary thesis questions. An overview of the systems investigated is presented along with a summary of those data. Research investigation included a literature search of After Action Reports from Test and Evaluation Command (TECOM), lessons learned reports of major systems, General Accounting Office Reports, Congressional Subcommittee Reports, Developmental Test and Evaluation Reports and technical and professional journals and manuals. Interviews were conducted with program office personnel, program testers, analysis personnel, user representatives and contractors who have participated in the developmental testing of the major programs selected. Interviews were also conducted with personnel who had years of experience in the area of developmental testing. Interviews were conducted in person and over the phone.

B. METHODOLOGY

The focus of the literature search and the interviews was to address the primary thesis question. The primary thesis question was:

What is the most significant problem in conducting developmental testing?

1. Basic Interviews

Interviews were the primary method of addressing the research question. A scope and limitation for the interviews were developed in order to organize the information. About a dozen systems were considered, this was reduced to seven. The main Government agencies dealing with DT&E were interviewed. These interviews included representatives from the Program Office, the tester, the analyst from AMSAA, a user

representative or the Combat Developer and the Prime Contractor. A basic set of questions was developed and reviewed by students and instructors with test and evaluation backgrounds. The initial format was general for all potential interviewees and looked at these areas:

- What do you consider the primary problem or issue in Developmental Testing?
- What can your agency or any of the others you work with do about the problem? To ascertain the "work with" relationship of the various agencies and offices, the questionnaire also focused on:
- How do you (your office) interface with the other agencies? Is this sufficient?

The questions further evolved into five separate formats, similar overall, but tailored to the particular agency being addressed. For example a PM office was asked how a particular problem affected schedule or cost. AMSAA would be asked instead how the problem affected their analysis or reporting. In most cases the interviewee was given a draft of the questionnaire or allowed to thoroughly answer all questions before any direct questioning. A copy of the questionnaire for the Program Management Office is provided in Appendix A.

2. Special Interviews

Other interviews were conducted to gain insight from people with background and experience in DT&E. These people were supervisors, branch and division chiefs at the test facilities, at AMSAA, at TECOM and within the TRADOC System Management (TSM) Offices. Using the same questionnaire format and focusing on the primary thesis question these individuals were also interviewed. Again, they normally had time to prescreen the questions or responded in writing when time was limited.

C. SYSTEMS RESEARCHED

The systems researched were Acquisition Category (ACAT) I and II systems tested at United States Army Test and Evaluation Command (TECOM) facilities within the United

States. Seven programs under test or tested in the past 10 years were researched and analyzed through interviews and reports. The systems include the Abrams Main Battle Tank Block II upgrade (M1A2); Anti Armor Weapon System Medium (AAWS-M),"the Javelin;" Enhanced Position Location Reporting System (EPLRS); the Avenger, a mounted Air Defense system, the Kiowa Warrior, an armed scout helicopter; the Maneuver Control System (MCS), a command and control (C2) system; and the Family of Medium Tactical Vehicles (FMTV). These programs represent different types of systems from electronic/data communications and software to major weapon systems. They also represent different types of developments, from system upgrades and Non-Developmental Items (NDI) to full scale developments.

1. Abrams Tank Block II Improvement (M1A2)

The M1A2 is the M1A1 (main battle tank) with improvements referred to as the Block II Improvement Program. The improvements to the main battle tank consist of an Improved Commander's Weapon Station (ICWS); Commander's Independent Thermal Viewer (CITV); Position Navigation System (POS/NAV); and the core tank. The core tank includes the turret, hull, fire control electronic units, a data bus to interconnect the new mission hardware; dual stabilization of the gunner's primary sight head mirror; the Single Channel Ground Airborne Radio System (SINCGARS); Inter Vehicular Information System (IVIS); and onboard built-in test equipment. The M1A2 is designed to provide Armor and Mechanized units with improved mobility, protection and both internal and external C3I. [Ref. 38]

2. Kiowa Warrior (OH-58 D)

The OH-58D is a modernization of the OH-58A airframe. The modernization included a four blade main rotor system, an advanced cockpit display system and a mast mounted sight to provide day/night targeting capability. Armament was added to some of these helicopters for a special mission and eventually resulted in a modification program to

for all OH-58Ds. The Kiowa Warrior was designed to provide reconnaissance, security and target acquisition functions. It is used with Divisional aviation, in support of armor assets as well as against threat armor as part of a "Tank Killer Team" and employed by special operations units. [Ref. 39]

3. Family of Medium Tactical Vehicles (FMTV)

The new Family of Medium Tactical Vehicles is being designed to replace the Army's aging fleet of Two and a half (2.5) ton and Five (5) ton vehicles. These types of vehicles are used for tactical mobility, supply and support operations. The vehicles will include a 2.5 ton cargo model, a 5 ton cargo model and special purpose vehicles such as tankers, dump trucks and wreckers. Its expected improvement over the current fleet of vehicles includes greater horsepower and speed, increased towing capability, higher reliability and a high commonalty of parts among the various versions. [Ref. 40]

4. Enhanced Position Location Reporting System (EPLRS)

EPLRS provides the Army with data communications and ranging information. EPLRS reports position location and identification data on ground and airborne units to the radio station operator in near real time. Its performance advantages include rapid response times and effective data throughput, Communications Security (COMSEC), resistance to Electronic Countermeasures (ECM), and Electronic Support Measures (ESM), low levels of mutual interference, transmissions for ranging measurement and freedom from voice data contention. EPLRS will normally be deployed in the Division and Corps areas and operated by Army Signal Corps personnel. [Ref. 41]

5. Anti Armor Weapon System -Medium (AAWS-M),"The Javelin"

The Javelin is a man portable antitank weapon system. It consists of a round, a Command Launch Unit (CLU), training devices and test equipment. The Javelin has the capability to defeat the current and projected armor threat in all battlefield environments to include electronic and electro optical countermeasures and the electromagnetic

environments. The system provides the gunner with increased survivability by having a greater range, a reduced signature and increased lethality. [Ref. 42]

6. Pedestal Mounted Stinger (PMS), "The Avenger"

The Avenger is an Air Defense Weapon that has the requirements of protecting friendly critical assets and inflicting maximum attrition on threat aircraft. It consists of a fire control unit module that includes a turret with vehicle mounted launchers and a heavy machine gun. The system is mounted on a High Mobility Multipurpose Wheeled Vehicle (HMMWV) but can be operated remotely. The Avenger has a Forward Looking Infrared (FLIR) sensor, a laser range finder and an onboard computer which provides the gunner with displays to engage the target, monitor the system, and receive and display command and control C2I data. The Avenger is designed to protect the rear areas of the Corps, the Divisions and Regiments. [Ref. 43]

7. Maneuver Control System (MCS)

MCS is a combination of hardware and software intended to provide commanders of all maneuver elements (corps through battalion/squadron and selected companies) a single command and control (C2) system. It is one of five C2 systems that make up the Army Tactical Command and Control System (ATCCS). It includes a Lightweight Computer Unit (LCU), Large Scale Printer Plotter (LSPP), Large Screen Display, Tactical Scanner (TACSCAN) and software. MCS will enhance decision making and synchronization among maneuver elements and as a part of ATCCS help integrate and coordinate other battlefield functions such as Artillery, Air Defense and support functions. [Ref. 44]

8. System Categories

The systems listed above could be broken down by various criteria. To enhance analysis and address the thesis question they were broken down by type of system, namely

ground vehicle, aircraft etc. The systems were also broken down by acquisition or development strategy such as upgrade or NDI.

a. Type of System

The systems above include one rotary wing aircraft, the OH-58D; one man portable missile system, the Javelin; three ground vehicle systems including a tracked vehicle, the M1A2; a small wheeled vehicle with a Air Defense missiles, the Avenger; and family of wheeled vehicles in different configurations, FMTV. The systems above also include two communication/data and information systems, MCS and EPLRS.

b. Type of Development

From a development standpoint the M1A2 Abrams is an upgrade to the M1A1 tank. The Kiowa Warrior is also an upgrade to the OH-58A scout helicopter. Both the Avenger and the FMTV are considered Non-Developmental but for slightly different reasons. The Avenger is using mostly developed technology designed for the military use while the Family of Medium Tactical Vehicles is pushing the use of commercial components and parts. The Javelin is full scale development weapon system as are the software and electronic intensive MCS and EPLRS.

D. DATA SUMMARY

The data summary includes information from both interviews and literature searches. The interview data will be broken down by program and further broken by agency or office. In order to obtain answers beyond the "party line" some interviews were conducted under the premise that the interviewee by name would not be associated with a particular program or agency. Therefore the data are presented by system but will not identify which system specifically. The person or office making the response about that system will only be identified as a representative of that agency or office who played a role in the system's DT&E. While few people actually requested anonymity, a single name or the name of the

system would easily divulge almost every person's identity to someone who is familiar with the agency or system described. Each of the following sections will summarize the respondents' answers to the questionnaire, specifically:

- What do you consider the primary problem or issue in Developmental Testing?
- What can your agency or any of the others you work with do about the problem?
- How do you (your office) interface (work with) with the other agencies?

1. System t

a. Program Management Office

This program management representative stated that one of the major problems entering a Developmental Test was meeting the test start milestone with all compliant system hardware, software and support to conduct the testing. Delays in getting to the test start point (caused by various factors) cause a test delay and "all delays impact cost."

The program manager representative determined that to deal with this problem, the PMO, particularly the PM, require intensive proactive management at all levels. Issues need to be identified before they happen and alternative plans developed. He indicated that the tester "...needs to make sure resource requirements are on hand, plus be in a positive position to adjust to changes." Finally he noted that all the entities involved in DT&E need to be more proactive and timely with their input into the test planning and development effort.

The program manager representative described the interaction between his office and the other agencies as adequate and recognized each of the other agencies as having an important role to play in not only testing but the entire development process.

b. Tester

This tester considered the scheduling of DT&E the primary problem. He credited PM over optimism and the budget/funding process as the causes. He stated that by

the time a system is supposed to enter DT&E, events have occurred that have caused the test window to be reduced and or delayed. The tester may often be left to prioritize the various tests, getting as many in as possible (but not all) before a report is required and decisions need to be made.

This tester asserted that it was the tester's job to deal with the situation as best they can. If anything could be done about this it would probably be the PM being a little more realistic about when DT&E will occur and how long it will take. The tester also stated that despite this and some other problems " overall, the system works, especially for full scale development systems." [Ref. 45]

The tester for "system t" believed there was a good relationship among the agencies and a "fantastic working relationship" between his office and that of the PM. He attributed the system's overall success to this interface.

c. AMSAA

The analyst saw scheduling as the primary problem with DT&E. Specifically he noted that on this program as well as others there was usually not enough time to test, collect data, compile data, analyze data, make preliminary reports and briefings and final reports and briefings. His analysis team often found itself working with incomplete data sets from which they were expected to make final reports required by the schedule. His primary concern was that key decisions were often made prior to completion of final reports.

To help alleviate this problem he believed that AMSAA should be more realistic when signing up to a schedule and find ways of reducing their internal processes. He said that his agency was addressing the problem by working on methods to shorten their response time. He thought that the best way for the PMO to deal with this issue was to consider all that is involved in the evaluation portion of Test and Evaluation. He said the testers do the best they can given the environment in which they must test.

The lead analyst for "system t" considered the interface between his office, the tester and PMO as good. There were regular TIWG meetings, monthly reviews, ad hoc meetings and special working groups. He said there was little interface between his office and those of user and the contractor but did not see this as an issue.

d. User Representative

The user representative for "system t" indicated that the most significant problem with DT&E was that the PM pushed the schedule rather than product readiness. He believed this problem was a result of the funding and budget cycles. The consequences of this schedule push was an early "bad name" for the system. He said that this system initially received a bad reputation because it went into a testing functionally unprepared for the test.

The user representative thought that his office should have been more involved in the product design. He believed that the contractor and his office needed a closer and earlier interface. He indicated that the contractor's engineers still do not understand the "real" operational environment.

The user representative for this program interacts with the other agencies through action officers and through the PMO. The user representative believed that for this system the interface along with the TIWG is normally adequate but recommends more frequent TIWGs and a more definitive TIWG schedule.

e. Contractor

The contractor believed obtaining the necessary resources to conduct a successful DT&E was the major problem in entering DT&E. Namely, needed activities were delayed, not accomplished or shortcuts taken. Also, resources such as funding were tight and schedules were compressed to the point that completing the test by a specific date became more important than conducting the test according to the test plan. Subsequently tests became more difficult to conduct and results harder to understand. The contractor

stated these types of practices early in the program development tended to push problems into later phases where they were more expensive in terms of both cost and schedule.

The contractor thought that all the agencies involved could help alleviate this problem. All agencies should provide better estimates of resources in terms of time and money. The PM should allow for contingencies and not assume perfect and complete success at every step along the way. The contractor stated that long term stable funding would be the greatest help in overcoming schedule and resource problems, but that means legislative action.

The prime contractor for "system t" was very positive about the contractor/Government PM relationship "for this program." He made the point that his experience with other programs between his company and the Army were not as cooperative. His interaction with the other agencies was mostly through the TIWG process. The contractor thought for this program the working relationships were good and provided an "easy flow" of information and good cooperation.

2. System u

a. Program Management Office

The PMO representative said the most significant problem was that technical tests were conducted before the PMO and the contractor had sufficient time to do their own "checking out" of the system. This led to surprises during DT&E impacting test schedule and costs. The PM representative believed this happened because of inflexible budgets, changing Operational Requirements Documents (ORDs) and because the PM was locked into an inflexible success oriented schedule.

He suggested that the PM, through management, should be able to work these issues. First, the PMO should get all the players involved early, including testers and evaluators, and concentrate on making realistic estimates. Then, the PM needs to ensure

that the ORD remains solid and realistic. He also said that PMs should view the tester as part of the team and not the "bad news messenger."

The Program Management Office from "system u" was very pleased with the working relationships that were established within the program. Besides the formal TIWG interface, the PMO had established other semi-formal groups to address numerous issues including testing. The PM representative believed these working groups and their efforts enhanced the TIWG meetings as well as other aspects of the program.

b. Tester

This tester believed that the schedule was a major DT&E problem for this program. He said early involvement from the tester and the analysts is key to helping minimize this problem. The tester suggested that the PMO ensure testers and analysts are involved early on and that they actively scrutinize test and evaluation schedules before they are finalized. The tester for "system u" was satisfied with the interface and coordination that occurred for this program.

c. AMSAA

The AMSAA representative for "system u" identified the changing of software /hardware requirements as the biggest problem or issue in entering Developmental Test. Requirement changes often occurred after estimates were made and therefore affected the test plans and analysis. This changing test environment reduced confidence in the tests and impeded analysis.

The AMSAA representative indicated that his agency can help with this problem by working with the PMO to help identify problems early in development. He also stated that AMSAA, the testers and the contractors must do a better job of controlling test costs.

The analyst for "system u" said the interface between his office and that of the PM started as adversarial but improved over time. He believed he had a good working

relationship with the tester and with the contractor. The analyst was not satisfied with the contact that he had with the user representative and believed that the analysis people should obtain more feedback from the troops.

d. User Representative

This user representative thought that the major problem in entering a DT&E was the flow of critical paper work. Namely, he pointed out those documents (TEMP, Detailed Test Plan) which are needed to make things happen. When these documents are late, it impacts and often delays the test schedule. The user representative believed for their part they should concentrate more on the war fighting capabilities and enhancements rather than technical issues. This may help reduce the paper delays.

The user representative stated that his contact with the various agencies was frequent and provided for a good flow of information. The only interface that did not have regular communication was that with AMSAA. There was only minimal contact with AMSAA and it was usually formal in nature. He thought the TIWGs provided an adequate single forum to bring the key players together.

e. Contractor

The contractor cited unanticipated problems that delayed test completion within schedule and increased test costs as the major issues for DT&E. He ascertained that these occur because proposed estimates for cost and schedule usually assume no technical difficulties will be encountered. Subsequently overly optimistic estimates become the standard to meet.

This contractor representative saw ways for his office, the PM and the Tester to address this issue. One way in which the contractor believed that his company could help deal with this problem was to use actual schedule information from historical records to create more accurate future test estimates. He said the tester also needs to track test program costs and schedule variances and document these historical data so that it can be

used when estimating future testing. He said the PM should identify potential problems to be encountered during testing and formulate contingency plans with cost and schedule impact acknowledged in the original estimates.

The prime contractor for "system u" noted that the contract office and the Government PMO had a very good working relationship. The interface with other agencies like AMSAA and the test facility was more formal, less frequent, but sufficient. Concerning DT&E, he does not recall involvement with the Combat Developer.

3. System v

a. Program Management Office

The program representative for "system v," an NDI Program, identified the primary problem in conducting DT&E as the belief that the PM has plenty of money for test. He stated that testers and analysts tended to want to test extensively to reduce their risk and increase their confidence. However, the PM, like all PMs, had a limited budget and it was for more than testing alone. He attributed the problem to the acquisition process and the congressional funding system.

Because the PM representative determined the root of the problem to be the acquisition process, he suggested that the problem was beyond the scope of the agencies and offices targeted for research. He did suggest that the PM bring in all the key players early, particularly AMSAA.

The PM representative described his working relationship with the other agencies as regular and productive. Most of the interface is formal but gets more familiar and frequent as major tests or milestone reviews approach.

b. Tester

The tester indicated that the primary problem in conducting Developmental Testing was reactive involvement by the PMO instead of proactive involvement. The tester believed that the PMO and the contractor often saw DT&E as an area to maybe save some

time or funds. The PM failed to put emphasis on DT&E until after something went wrong and both cost and schedule were negatively impacted.

The tester believed that the test community as a whole should educate PMs to the various test capabilities available. Also, testers should demonstrate that the test facilities are more flexible than ever in packaging programs for the PM. He stated the main action a PM can do to avoid such a problem is to get the tester and the analysts involved early. The analysts for their part need to become flexible in packaging the analysis and evaluation. The analysts (AMSAA) must also realize that money no longer exists for huge sample sizes and that other methods are needed to analyze and design tests.

The tester for "system v" believed his interface with the other agencies was adequate and was particularly good with AMSAA. Face to face coordination is easily achieved due to the close proximity to most of those agencies. He stated that good communication between the tester, the PM and AMSAA is important for successful DT&E.

c. AMSAA

The AMSAA representative for "system v" described the primary issue in DT&E as the Non-Developmental Item (NDI) status of the system. It was assumed for NDI programs, because they are "non developmental," that testing and analysis would be faster and easier. However, any type of a problem during DT&E or any other area in such a program can be costly. Problems in DT&E brought public scrutiny and possibly jeopardized the entire system development. This system, although NDI, still required extensive testing and data collection. The task of data reduction, analysis, and report preparation was reduced to a shorter time frame because of the NDI status.

The analyst suggested some things that could be done by the various players to mitigate this problem. The AMSAA representative said that AMSAA is using different methods of analysis and evaluation to try to speed up the evaluation process. These methods include the physics of failure and the reliability growth model. The physics of

failure is the method of using more current electronic failure analysis instead of standards and specifications derived from early electronic hardware. The reliability growth model tracks the increasing reliability of a system through its development and projects and plans for levels of reliability at system maturity. The analyst stated that the PM needs to recognize how non developmental a system truly is and develop realistic schedules. The PM should also ensure that NDI is not automatically associated with easier testing and evaluation. Finally, the analyst thought that the NDI test environment requires AMSAA, the tester, the PM and the contractor to have a "team" approach to the test.

The analyst from AMSAA for "system v" was very pleased with the working relationships that had been established among the various agencies. The communication with both the test facility and the PMO was positive and frequent. There was little interaction with the user representative and the contact with the contractor was limited to formal forums such as scoring conferences or TIWGs.

d. User Representative

The Combat Developer addressed the changing of program timeline as the major problem on entering a Development Test. Specifically he referred to the compressing of the DT&E schedule and an unplanned DT&E and OT&E overlap in order to make up lost schedule time. For example, the PM and the contractor prepared for OT I, conducted DT I during the preparation and tried to correct DT I deficiencies before the start of OT I. The Combat Development Office believed that this problem "was driven by the desire to always present the program in a positive light (otherwise risk funding cuts)." [Ref. 46]

The user representative office suggested the best way to deal with the issue internally was to stake out a performance issue such as reliability and stick to it. This gives the PM at least one solid perspective as to the system's readiness for test. The user representative also said the PM should realistically assess performance and system readiness based on the user's requirements and the system's performance, not on "what it

will take to get to the next hurdle." As for the other agencies and personnel involved, the user suggested that they need to be prepared to make the tough decisions, e.g. stop and fix the test process if needed.

The user for "system v" said the interface with the other agencies is generally adequate but requires more intense coordination. He stated that the various conferences and working groups both formal and informal normally achieve their intent but often fail to resolve major conflicts.

e. Contractor

The contractor considered the biggest problem or issue in entering Development Testing the question of "how well a system made of many commercial parts will perform under rigorous military testing?" The problem stems from the Government's desire to have non-developmental systems yet maintain military specifications and standards. In some cases the commercial parts cannot hold up to the stringent military tests and standards.

The contractor suggested that everyone, especially the PM should be more aware of the complexities in buying commercial items for military use. Tradeoffs have to be made when buying under the commercial use concept (time versus cost versus performance). He believed contractors should challenge the various military specifications and ascertain if a lesser performance level would be acceptable. The tester, who has knowledge and experience should be involved in contract specifications review for (NDI) contracts. Finally, the contractor recommended that the Combat Developer should help assess tradeoffs and delete unnecessary requirements.

The Contractor for "system v" described different levels of interaction among the agencies. There was regular communication between the contractor's program office and the Government program office. There was also regular interface between the contractor and both AMSAA and the tester. The contractor had support personnel at two

test facilities attend meetings and facilitate good communications. The interface with the Combat Developer was less frequent but increased as the system prepared for another test.

4. System w

a. Program Management Office

The program representative stated that his major problem in conducting DT&E was that you test regardless of how ready you are, "...it's a mark on the board you must meet." The office also said there needs to be more control over the testing. Some tests are conducted to satisfy an evaluator's need but may add little to the overall analysis of the system. AMSAA particularly is not required to test prudently. All this non value added testing just makes completing DT&E within a very optimistic schedule that much harder.

The Program representative suggested some actions for the various offices to deal with these problems. First, the PM should have everyone involved early -- about the time of the Statement of Work (SOW). The test and evaluation participants need to reduce and justify tests, and budgets accordingly. He also stated that test facilities have recently become aware of this situation and have responded, but the evaluators were not as responsive. The PMO believed the Combat Developer should play a more definitive role in testing. A strong combat development office, that knows the system's background and the doctrine, could help decrease testing that adds no value to the system.

The program office responded that they had a good interface with the other agencies. They believed the formal interface of the TIWG was good but attributed the positive working relationship between agencies to the fact that all the agencies were brought in early.

b. Tester

The tester for "system w" regarded the "lack of concrete requirements" as the most significant problem in conducting DT&E. This led to difficulties in test planning and resulted in schedule and cost overruns.

The tester admitted that his office could do better at coordinating the test effort with the PM, AMSAA, and the Combat Developer, but that the PM is the one who must bring these groups into harmony concerning the test requirements. As for the Combat Developer, the tester said he needed to define the requirements, learn and understand the system and appreciate the impact that changing requirements have on the test process. AMSAA should also try to better understand the system under test.

The tester was pleased with the interaction and working relationships with the other agencies. The one exception he noted was that his interface with the Combat Developer was limited to the formal meetings such as TIWGs. He said that the working relationship was good but needed to be more frequent.

c. AMSAA

The analyst from AMSAA indicated that the biggest problem with DT&E was its uncertainty. That is, did the tester have adequate control to complete all testing on schedule and within budget? He further explained that some tests were not performed due to lack of time, funding or both. This creates "data voids" and makes the evaluation more difficult.

The AMSAA representative believed that all the agencies can help at least mitigate the problem, but also asserted that it will take legislative action to get testing "event driven rather than schedule driven." He stated for AMSAA's part, they should prioritize testing and work closely with both the PM and tester to design tests that fit within the given schedule and budget. The analyst also suggested that the PM fund the tester "as needed" rather than by fiscal year. The tester must learn more about the system under test and try to anticipate potential test control problems. The contractor should work closer with the tester to integrate the test item and the instrumentation. Finally, the analyst said that the Combat Developer should provide more explicit guidance on test set up and installation procedures.

The AMSAA representative concluded that the interface with the other agencies was normal and in most cases sufficient. The TTWG, the most common forum, was adequate for keeping the test community abreast of the status and latest developments in the program, but lacked in solving detailed, lower level issues.

d. Contractor

The contractor for "system w" said that the biggest problem in conducting DT&E was the lack of adequate coordination between the tester and the contractor especially when integration checkout was needed between the test instrumentation and the system under test. This can severely impact both schedule and cost if restarts and retests are needed.

The contractor indicated that he is limited to bringing the issue to the attention of the PM and explaining its potential effect on the test and test data. He believed closer coordination with the tester and a better technical understanding by the tester would help alleviate the problem, but the PM needs to influence such a relationship. He also suggested that the Combat Developer establish realistic and unchanging requirements that will give the other agencies a foundation to develop tests and evaluation plans.

The contractor described his interface with the other agencies as regular and sufficient. Contact with the PM was both formal and informal and contact with AMSAA and the tester usually in relation to reviews or technical documentation. He said there was very little contact with the Combat Developer.

5. System x

a. Program Management Office

The Program Management Office stated that "The major problem entering this developmental test program was the compressed test schedule." The test schedule was laid out with no flexibility and testing continued throughout the program. When problems with

design or other areas were encountered, delays and slips occurred. The slips in turn delayed and or compressed DT&E as well as affected other areas such as OT&E.

The Program Management Office had recommendations for the various agencies in addressing this problem. For the Program Management Office itself, the representative believed the PM must recognize the importance of the test schedule early and make a concerted effort to hold the line on design reviews, hardware deliveries and costs. The PM representative saw the tester as being left to complete testing within many constraints. He suggested that the tester try to be innovative and find ways to expedite testing. He believed the contractor could help by delivering hardware on time and committing sufficient resources to support the test. The PM representative suggested AMSAA should be open minded to problems, potential solutions and be able to make quick decisions. The Combat Developer also needs to respond to questions and issues in a timely manner.

The PMO for "system x" characterized the working relationship with the other agencies as frequent, direct and both formal and informal. The PM representative considered this interface sufficient.

c. AMSAA

The analyst for "system x" indicated limited sample size as the major problem in developmental testing and evaluation. A limited sample size causes data analysis to be more difficult and increases risk. The analyst recognized that smaller sample sizes were becoming the norm as funding continues to decrease.

He recommended that AMSAA rely more heavily on models and take part in building reliable models. AMSAA also should consider modeling and simulation in test design.

6. System y

a. Program Management Office

The Program Management Representative for "system y," an NDI program, stated that people have great expectations of NDI programs and so the testing schedule for such a program is very intensive. Trying to fit in all the testing that is required becomes difficult and is the primary DT&E issue for this type of program.

The PM representative for this system believed NDI type programs will continue to be tested in an accelerated fashion and suggested ways that the PM and other agencies could deal with this issue. He asserted that the PM should hold "conclusive" TIWGs. That is, "Make the TIWG important and ensure that the other agencies send representatives that can make decisions and can speak for that office." [Ref. 47] The PM also should have the tester and analyst on board early. He indicated that the tester should coordinate the test effort and start as early as possible. The analysts should accept some risk and the Combat Developer should develop a good set of requirements and then stick to them. Changing requirements severely impact the already intensive test schedule. The contractor should dedicate the right people to the test and concentrate on putting them at the right place during the key test events.

This person indicated that the interface with the other agencies was good, but that the PM could improve the results through better management of the TIWG process as previously cited.

b. AMSAA

The analyst considered the use of contractor test plans and test data for evaluation and analysis as the major issue. Due to shrinking Government resources, the use of contractor data is becoming more common.

To address this problem the analyst suggested that AMSAA should be more vigilant in reviewing test information provided by the contractor and the contractor should

be more receptive to some of the unique oversight required by the Government. The analyst also stated that the PMO should build safeguards into the TEMP to deal with using contractor testing and data. Finally the analyst concluded that even if the Government does not conduct the test in a certain case, the expertise of the tester will still be needed as will some of the Government test facilities.

The analyst for this system believed that the working relationship between her office and that of the other agencies was sufficient. The contact between the various groups was conducted through both formal and informal means and conducted frequently. The analyst noted that the proximity of AMSAA to TECOM Headquarters was a positive contributor to the good exchange of information.

c. User Representative

The Combat Developer for this system considered the decreasing funds for RDT&E as the most significant problem in conducting DT&E as well as other types of testing. The decreased funding has caused compromised and reduced testing and increased risk. This reduced T&E and increased risk environment could be acceptable. However, typically when problems occur with a system, the program suddenly becomes a target for inquiry, funding reductions or even elimination because "...the Army failed to properly test." [Ref. 48]

The Combat Developer conceded that decreasing funding is a reality and believed it will continue for the next few years. The best way that his office can deal with this problem is to actively participate in the TTWG process and insure the TEMP supports the ORD and the requirements in the ORD are valid and realistic.

d. Contractor

The contractor for "system y" stated that the major problem in conducting DT&E was the inconsistency between the ORD and the contract requirements. The

inconsistencies increased test cost and test time. Schedule was regained but at additional cost to both the Government and the contractor.

The contractor suggested some actions to be taken if the inconsistency occurs and also actions to prevent the problem in the first place. First, in order to resolve an existing problem, the TIWG members did an extensive cross match of the contract, the ORD and the TEMP. This created an overall, though not complete, consensus among the TIWG members. Additionally, continuous tracking of the test issues by the PM helped resolve the problems. To avoid variation between the ORD, the contract, and the TEMP in the first place the contractor suggested that the PM and the Combat Developer thoroughly review the contract and verify that it corresponds to the ORD.

The contractor described the relationships between his office and the various agencies as both formal and informal and as sufficient. He further stated that he did not believe the program testing would have gone as well if they had strictly relied on the formal interface of the TIWG alone. The informal working relationships were a key to the overall test success.

7. System Z

a. Program Management Office

The Program Management Office representative for this program cited the Government's changing requirements as the biggest problem in conducting a DT&E. Changing requirements are difficult for any program test, but with software intensive programs it's "really tough." [Ref. 49] When unplanned and unfounded requirements keep coming, none of the documentation is solidified. The detailed test plan, the software test plan, the Independent Evaluation Plan (IEP) and the TEMP are all affected by the changing requirements as is the test schedule.

The PM representative saw some ways to address this problem. First, he said that the tester had to be involved early and be kept up to date on system changes that could

affect the test. Next, the tester should realize the complexities of software testing. Finally, the various agencies including the contractor need to make a team effort. He thought for "system z" that AMSAA took on an antagonistic role and that the contractor was not up front with bad news. A "team member spirit" might have helped avoided these problems.

b. AMSAA

The AMSAA spokesperson for this system believed that the major problem in conducting DT&E was that DT&E was a target for cutting costs. He suggested that this occurs because PMs are cost and schedule driven and that by the time DT&E rolls around many programs have cost and schedule overruns. PMs start looking for ways to save and they cut out some development type tests. Cutting tests impacts data, data analysis and creates more risk and development uncertainty.

He recommended that the PM and the contractor should "realize the value of DT&E." They needed to "accept testing instead of seeing it as a burden." He also said that the contractor should be up front with potential problems, especially software problems.

He described the interface between his office and the other agencies as changing. Originally it was formal, mostly TIWGs and teleconferencing, but this has improved by becoming more frequent and including other forums and less formal working relationships.

c. User Representative

The user representative for "system z" regarded the lack of regulation and guidance for software testing to be the primary problem in conducting DT&E. This made the development and fielding of multiple versions of software extremely difficult.

To resolve this problem the Combat Developer suggested that the PM office push for quicker fielding decisions, and the testers and analysts lobby for changes to the regulation and process for testing software.

The Combat Developer indicated that the interface between his office and the others was generally sufficient and that the TTWG was an adequate forum which served the purpose for which it was designed. He noted that the geographical location between the agencies; particularly between his office and the former contractor made that working relationship insufficient.

8. Other Interviews

A number of interviews were conducted with people who through their position and experience provided insight to the thesis questions. These people represented supervisors, branch and division chiefs at a TECOM test facility, TECOM Headquarters itself and AMSAA. These interviews focused on the following:

- What do you consider the primary problem or issue in Developmental Testing?
- What can your agency or any of the others you work with do about the problem?

a. TECOM I

This project engineer said that schedule compression was the major problem in entering or conducting DT&E. He referred to the continuous pressure to conduct Developmental Testing in considerably less time than originally estimated. He believed that the funding and budget process drove this compressed schedule and caused major decisions to be made with only partial data. He also said that the budget process caused the PM to focus on budget and Initial Operational Capability (IOC), therefore risking system quality. He suggested the best way to deal with this issue is for the PM to understand early on what the capabilities are in the test and evaluation community and to work closely with the tester and analyst.

b. TECOM II

This representative from TECOM thought that "success oriented testing" was the major problem in entering or conducting DT&E. This unrealistic and optimistic attitude makes the tester a "bad guy or gal" when a test reveals a problem with the system. It also

fails to allow the contractor the time he should have to improve his design. Because problems are not planned for, it negatively impacts both cost and schedule when they do occur. PMs, contractors and everyone else should anticipate and identify potential problems. To alleviate this problem he thought that all the agencies should simply be more realistic about developing a test schedule.

c. AMSAA I

This senior analyst said the problem in entering developmental test was that in many cases we launch into testing with hardware or software that in reality is not ready for test. He believed that PMs do not always receive a realistic test status picture from their staffs. No one wants to deal with bad news, even potentially bad news. The analyst suggested that PMs insure that their staff representatives for T&E have some test experience and coordinate closely with the testers and evaluators.

d. AMSAA II

Another senior analyst from AMSAA considered the schedule driven environment versus an event driven environment as the primary problem in conducting developmental testing. From the analysis point of view this causes problems with data collection, analysis and reporting. He feels this problem is not easily resolved by any agency or even all the agencies, because program funding is also schedule or calendar driven and all the participants know that. He suggested that early coordination, team work and realistic estimates by all the participants could minimize the effects of this problem.

e. AMSAA III

The next analyst said the most significant problem was trying to obtain an adequate sample size, one large enough to analyze and yet not so large that it is cost prohibitive. He believed his agency must move to using more simulation and modeling and validate that information with a small number of actual tests. He also stated that more

positive incentives for contractors would be valuable. Rewarding the contractor early, for good designs that pass early basic testing would be an excellent investment.

f. Tester I

This tester stated the PM attitude about Developmental Testing was the most significant problem in entering or conducting DT&E. He said that PMs are more worried about the cost and schedule of testing than on using it as a tool. PMs often see DT&E as an area to try to make up cost or schedule overruns. This attitude is created by the process that emphasizes getting everything right the first time. Testing often surfaces failures or problems that the PM or contractor had not anticipated. Such failures can drastically impact a success oriented schedule.

The tester determined that to improve this situation testers should educate PMs as to their testing capabilities. Also, the decision makers need to be realistic in their expectations and let the "test, failure, fix, retest" model do its job.

g. Tester II

Another senior tester saw the lack of early tester involvement as a primary problem in conducting DT&E. He believed even under an unrealistic schedule, the tester, if involved early and kept informed could bring the test resources needed for the PM's requirements. Early participation by the tester and the analyst can help the tester customize the test program to satisfy the various data and analysis requirements as well as reduce costs. His bottom line was "bring the testers into the program early."

h. Tester III

The next tester thought that the acquisition process itself was the major problem in conducting DT&E. The acquisition process causes PMs to be proponents of the system instead of proponents of the user. The emphasis is on program success instead of user factors. He believed it is the acquisition process that causes the unrealistic schedules, the adversarial relationships and systems that are fielded needing modes and retrofits almost

immediately. To fix this problem, the decision makers at very high levels (DA, DOD, the Congress for example) need to reward PMs that are critical and objective about their systems instead of fire them. [Ref. 50]

9. Recent Studies and Initiatives

Several recent studies have made recommendations that apply to the problems identified in this thesis. These recommendations include streamlining the T&E process; better risk management and increased acceptance of risk at all levels; testing smarter; acquisition reform; and early user involvement in the test process.

Streamlining T&E or reducing the amount of actual testing and evaluation needed was a common theme throughout the studies. In the previous era (Cold War), test designs and test plans called for enough data generation to practically make evaluation a misnomer. Despite PM resistance to extensive testing, it usually still occurred. In the Post Cold War environment testers, evaluators and decision makers will no longer have the luxury of an unlimited amount of test data. [Ref. 51] The recommendations for reducing actual testing is to use modeling and simulation, integrate OT&E and DT&E where feasible and to increase decision risk analysis. The increase in risk applies to testers, evaluators as well as decision makers. Instead of a zero tolerance mode for development testing, a limited number of test criteria should be selected and an acceptance of test event risks outlined. [Ref. 52]

Throughout the studies and initiatives, the emphasis was on testing smarter and cheaper. The testing community in the Army; AMSAA, TECOM, OEC, and TEXCOM recognized the need for T&E efficiency and reduction and have started to formally meet, discuss and even implement some of the ideas. One example is the "improvement of requirements" determination. The emphasis is to develop realistic requirements that meet the user's needs and can be efficiently tested. The following example illustrates the concept of improvement of requirements.

> A user had mandated that a system with a Mean Time Between Failure (MTBF) of 80 hours increase to a MTBF of 150 hours at system maturity. After evaluating and scrutinizing the requirement it was determined that a MTBF of 150 hours made no significant impact on mission success but increased program risk and would take a lot of time to test. After a realistic analysis, the MTBF was increased to 114 hours at maturity. This took less test time, reduced program risk and improved the system within realistic terms. [Ref. 53]

An area mentioned by many respondents in the interviews was testing within the acquisition process itself. The respondents normally suggested ways to resolve problems within the system believing the acquisition process too difficult to change. However, unlike other reform efforts in the recent past, there is anticipation that an opportunity truly exists to improve the process. The Cold War is over and DOD resources are very limited and agencies like the GAO argue that this is an ideal time to change the system.

> Changes of the type needed will not come easily. They must be directed at the system of incentives that has become self-sustaining and very difficult to uproot. The incentives that motivate the participants must be realigned with better program outcomes. If we expect program sponsors to be forthright about program alternatives, costs and risks, such candor must be rewarded, and parochialism and undue optimism penalized. Ultimately, change will occur only through the collective action of the acquisition participants, particularly within the Department of Defense and the Congress, for it is their actions that dictate the incentives that drive the process. [Ref. 54]

Early user involvement is another recommendation cited by the various studies. The studies state that the users can help the tester and evaluator focus in on those areas that are critical to mission success and system performance rather than just specifications. Early user involvement also should make users more familiar with the test environment so that they can help the tester and other decision makers determine the value and utility of future technologies. It should also give the user an appreciation for the test process and the impact of changing requirements.

Today may in fact be the best opportunity the Government has ever had to improve the overall acquisition process. Such an idea is politically popular and it appears more agencies than ever are looking into the "how" of changing the process. Any changes

to the acquisition process will likely affect testing and testing, in fact, continues to be one of the focus areas of the present reform effort.

IV. RESULTS AND ANALYSIS

A. INTRODUCTION

This chapter discusses the results and analysis of the data presented in the previous chapter. The focus for the analysis was on the primary thesis question: "What do you consider the most significant problem in conducting Developmental Testing?" After analyzing the agency responses it was determined that five problems areas were commonly noted across agencies. The responses were then categorized into one of the five common problem areas. The categories included: (1) Schedule problems, (2) Problems with the Acquisition Process, (3) Test Culture Problems, (4) Resources Management and (5) Changes in Requirements. The problems were analyzed by system, by agency as well as by the type of system and its development strategy. This analysis led to a unique finding in reference to a system's development strategy and discussed in the "Other Observations" section of this chapter.. The categories are explained below and Table I presents a simplified summary of the results.

1. Schedule

This category describes problems or issues related to test schedule and insufficient test time. The various respondents described these problems with "schedule crunch or squeeze," "lack of time for proper testing," or "schedule push."

2. Acquisition Process

The Acquisition Process category describes the responses that focused on testing problems that are a consequence of the overall acquisition process. These responses concentrated on the processes that create problems for DT&E as well as other areas. Common answers included: "the process creates unrealistic optimism and expectations,"

"congressional funding does not allow for good long term planning," or "the process overburdens both the Government and the contractor with bureaucracy."

TABLE I

INTERVIEW RESULTS

PROBLEM / *AGENCY*	Schedule	Acquisition Process	Test Culture	Resources Management	Change in Requirements
PMO	XX	XXX	-	X	X
TESTER	XXXX	X	XXXX	-	X
AMSAA	XXX	XX	XX	XX	X
*CD**	XX	XX	-	X	-
*Kr***	X	X	X	X	X
TOTAL	12	9	7	5	4

X - A single agency whose responses applied to that particular category.
*** - Combat Developer**
**** - Contractor**

3. Test Culture

The next type of problem identified was described as test culture. This category consists of the responses which indicated that negative attitudes and stereotypes exist toward testing, testers and analysts. This "culture" is blamed for many of the problems including the adversarial relationships and inadequate communication and cooperation between the test community and other agencies. Responses included comments such as "late tester involvement," "lack of coordination due to adversarial role of the tester," "tester/analyst the bad news messenger," "DT - a place to make up lost schedule or dollars" or "DT as an inconvenience to the program."

4. Resources Management

Resource management relates to problems noted by the respondents such as lack of funds, instrumentation, hardware or software. It also refers to the failure by one or more agencies to ensure that those same types of resources are at the right place, at the right time to conduct the proper testing.

5. Change In Requirements

Change in Requirements is the final problem area in which responses were categorized. Problems of this nature occur when changes in the requirements in turn impact the TEMP, test conduct and or the evaluation. This problem was also mentioned by many of the respondents, but usually as an aside and not as the most significant problem.

B. ANALYSIS

This section summarizes the findings from the responses by category. The categories are further divided into findings across systems and findings across agencies. Each of these areas summarizes what the respondents determined as the cause(s) of the problem. Finally, for each category, recommendations are provided for problem minimization, avoidance or prevention.

1. Schedule

a. Findings Across Systems

Schedule was the most frequent problem mentioned in the interviews. Five of the seven systems represented had at least one respondent describe schedule type problems. In addition, of those who stated that the acquisition process (next category) was the major problem, many pointed to the negative impact on schedule caused by the acquisition process. The process appeared to encourage unrealistic schedule estimates from all agencies. The respondents generally concluded that extremely optimistic management was the primary reason for schedule problems. Schedules were developed months, even years

in advance, always anticipating success along the way, but failing to take into account historical test information or previous test experience. If the test completion date could not be adjusted, test reduction and compression resulted in order to meet the schedule.

b. Findings Across Agencies

Across agencies, at least one representative from each agency described schedule as a significant problem. The testers and AMSAA believed that schedule problems were a product of unrealistic estimates. Testers and analysts were either not involved in early estimates or they signed up to an overly aggressive test schedule. The Combat Developers and PM offices cited over optimism and fear of funding cuts as the causes for schedule problems. The responding contractor in this category focused on estimates that assume no technical difficulties as cause of the problem.

c. Recommendations

The following is a summary of respondents' recommendations to minimize or prevent schedule problems:

- PMs should push for early involvement of all the participants including the testers and evaluators.
- More realistic estimates should be made by all agencies involved with less optimism from the PM.
- The PM should make the testers and evaluators part of the team and not the bad news messengers.
- The Combat Developer should be actively involved in test planning from the beginning.
- Historical information and data from previous tests should be used to better estimate future tests costs and schedule.

Schedule was the most common problem mentioned in the interviews. The respondents generally cited PM optimism and unrealistic estimates as the cause of schedule problems. Overall early agency involvement and participation and realistic estimates were recognized as the best methods to prevent or minimize schedule problems.

2. Acquisition Process

a. Findings Across Systems

Across systems, six of the seven systems had at least one respondent describe the acquisition process as the most significant problem. The major causes for this problem were the funding process and PM over-optimism. The annual control of funds forces PMs to be optimistic and show positive progress in cost, schedule and performance on a regular basis. If not, the PM faces possible funding cuts.

PM optimism forces other agencies to plan and schedule based on the PM's extremely optimistic plans. Thus, testers and analysts sign up to try to meet aggressive schedules. The respondents concluded that these optimistic plans and schedules were unrealistic and based on meeting the schedule, not on historical test information or test experience.

b. Findings Across Agencies

Every agency identified the acquisition process as a problem. The PM representatives focused on the fear of losing funding and support as the cause of the problem. One tester indicated the acquisition process was the major problem. He believed the main cause was the current incentive system that rewarded PMs for being unrealistically optimistic. Two AMSAA representatives stated that the acquisition process was the major problem area and pointed to unrealistic early estimates as the cause. Two Combat Developers also determined the process was the major problem. One believed the cause was the layers of bureaucracy and paperwork. The other Combat Developer regarded inconsistencies within the process as the cause. The contractor also determined the inconsistencies as the cause of problems. For example: the military is told buy "off the shelf items," but the items must still meet rigid requirements and standards that some "shelf" items cannot possibly meet.

c. Recommendations

The assumption for most of the respondents was that the acquisition process will not or cannot be changed or reformed enough to impact DT&E. The recommendations to improve acquisition process problems were based on that assumption and include:

- PMs should push for early involvement of all participants including the testers and evaluators.
- PMs should hold participative and conclusive TIWGs to address test plans and schedules.
- The Combat Developer should be involved early and play a definitive role.
- The analysts should utilize more efficient methods of evaluation, more modeling and simulation and accept more risk.
- Senior decision makers should find a way to reward PMs who are critical and objective.

The acquisition process was considered a major problem in conducting DT&E. The acquisition process was also cited as the cause of some of the other categories of problems identified in this thesis. Early and definitive involvement from the tester, the analyst and the Combat Developer were common recommendations for addressing this problem.

3. Test Culture

a. Findings Across Systems

The Test Culture category had the third most responses overall. The representative causes noted for this problem included 1) the acquisition process itself, 2) lack of PMO understanding of test and analysis capabilities and constraints, and 3) the assumed reputation of testers and analysts as wanting to overtest. The respondents believed the acquisition process drove PMs to focus on cost and schedule and regard DT&E as an opportunity to make up time and money. Interviewees also indicated that PM Offices may not realize what the testers and evaluators can or cannot do within the constraints of the budget and the schedule. Therefore, unless the PMO involves the tester

and analyst early, PM offices could develop unrealistic test plans. Finally, some testers and analysts have earned poor reputations among Program Offices by conducting tests or pursuing additional data that a appeared to add no value to the process. This practice has caused increased costs and affected the credibility of testers and analysts.

b. Findings Across Agencies

The majority of the responses for this category were represented by test agencies. Four of the seven respondents in this category were testers; AMSAA and one contractor were also represented. The PM representatives and the Combat Developers as agencies did not respond in this category. The testers, three of whom were supervisors within TECOM, believed that test culture was root of many cost and schedule problems. They pointed to the acquisition process as the cause of this culture. The process encourages the PM to move through testing quickly. If problems occur in testing, the testers and the analysts are usually the presenters of the bad news. Bad test news can mean rescheduling tests, may bring into question system need and validity from outsiders, and affect other cost and schedule issues for the PM. Two AMSAA representatives had responses that fit into this category. Both pointed to lack of funding and the funding cycle as the cause of the problem. The current funding system does not allow the PM efficient long term planning and in turn does not allow the testers and analysts to execute long term planning. One contractor representative believed that the acquisition process was the major cause of this negative approach to testing experienced in many PM Offices. He said that the process causes PMs to focus on cost and schedule and regard reducing DT&E reduction as an opportunity to make up for schedule and cost overruns.

c. Recommendations

The recommendations presented by the respondents for fixing, mitigating or preventing problems in Test Culture include:

- PMs should push for early involvement of all the participants including the testers and evaluators.
- PMs should ensure that AMSAA, the tester and the contractor closely coordinate the test effort.
- PMs and contractors should realize the value that DT&E provides to development.
- Testers should educate PMs on their capabilities and demonstrate more flexibility in packaging test programs.
- Testers should become more familiar with the systems under test.
- Combat Developers should develop and stick to solid, realistic requirements.
- The PM must make the testers and evaluators part of the team and not the bad news messengers.

Test Culture problems were generally recognized by testers and analysts. The causes noted for this problem included the acquisition process itself, lack of PMO understanding of test and analysis capabilities and constraints, and the assumed reputation of testers and analysts as wanting to overtest. To prevent or minimize this problem most respondents determined that PMs should make the test community (testers, analysts) part of the team and the test community should better educate PMs, contractors and Combat Developers of their respective DT&E capabilities and limitations.

4. Resources Management

a. Findings Across Systems

Resource management was mentioned as a problem by three of the seven systems. Respondents indicated that the causes of this problem included short term funding and limited resources (hardware and software) for DT&E. A system entering DT&E awaiting funding may not receive the resources in the lead time needed for proper test conduct. Lack of funding could delay test setup, delay instrumentation/equipment checks, cause inconclusive or even useless early test results and reduce needed test support personnel. Short term funding also causes PMs to desire and plan for perfect success in the test process. Anything other than perfect success could impact future funds.

Systems under development are often constrained by limited prototypes, test models, versions of software, and other components. Other required events of a system's development could cause these limited resources to be spread across the country and not at the test facility in time for proper test preparation. The lack of resources at the right place at the right time could severely affect test schedule, the test conduct or the evaluation and reporting process.

b. Findings Across Agencies

All agencies were represented in this category except the testers. The PM representative indicated that resources management was the major problem and believed the cause was the lack of aggressive management by the PMO. The two analysts from AMSAA believed that limited funding was the cause for this problem. The prime contractor pointed to reduced funding and compressed schedule as the cause of resource management problems. The Combat Developer believed the problem existed because of the increasing use of software in modern systems. Software testing, like the entire software management issue, lacks in information, experience and guidance as is a new environment and creates many problems for testing as well as other functio.

c. Recommendations

The actions recommended by the respondents to resolve or at least minimize Resource Management problems include:

- The PM should require intensive, proactive management at all levels.
- PMs should plan for contingencies and not assume perfect success in the test process.
- PMs fund testing to insure test resources are on hand when needed so that testers can be in a position to adjust to change.
- All those involved in the DT&E process need to be timely with their input into the test plan.
- Agencies should provide solid, realistic estimates of resources in terms of both time and dollars.

- Testers should become more familiar with the systems under test especially software intensive systems.

Resources Management was another common problem area. The lack of proper resources at the right place, at the right time could severely affect the test and evaluation of a system. Short term funding and limited resources for DT&E were noted as the causes of this problem. The recommendations that addressed this problem included: fund testing to insure test resources are on hand when needed; tester familiarity with systems under test, especially, software intensive systems; and incorporating more realistic estimates of test resources required by all agencies.

5. Change In Requirements

a. Findings Across Systems

Change in (technical) Requirements is the final problem area in which responses were categorized. Four of those interviewed described this as the major problem or issue in conducting DT&E. These four responses represented four different systems. They indicated that the causes of this problem were the lack of coordination and or communication between agencies and the lack of understanding of DT&E process among the Combat Developers. Lack of communication and coordination results in major documents such as the ORD, the TEMP, and the contract, not matching up with requirements. It causes difficulties in defining test requirements and makes test plans and conduct more difficult and expensive than originally estimated. Combat Developers who may not be familiar with the test process may not realize the impact that a requirement change could have on the test and evaluation process.

b. Findings Across Agencies

Across agencies there was one response for each of the agencies except from the combat developers. None of the five Combat Developers or user representatives determined that change in requirements was the biggest problem in DT&E. This is notable

since these agencies are most likely to generate changes that impact the PM, the testers and the evaluators. The PM representative believed the lack of good communication and cooperation among agencies was the cause of the problem. The tester and the AMSAA representative believed the lack of coordination and lack of understanding of the T&E process on the part of the user representative was the cause. The contractor representative pointed to both coordination and communication as the basis for this problem.

c. Recommendations

The recommendations for reducing requirement changes include:

- The PM should insist that a solid, stable and realistic ORD be maintained.
- PMs should hold participative and conclusive TIWGs.
- The PM should establish a better working relationship among the agencies in defining test requirements.
- The Combat Developer should appreciate the impact that changing requirements has on the system and the test process.
- The PM should ensure that the major documents, to include the contract, are closely coordinated.

Change in Requirements was the fifth category of significant problems. The respondents cited the lack of coordination and/or communication between agencies and the lack of understanding of DT&E process among the Combat Developers as the causes of this problem. Overall, the agencies believed that strong PM management of people, resources and critical documents was the best way to prevent problems associated with change in requirements.

C. OTHER OBSERVATIONS

Analysis was also conducted to determine if the type of system or its development strategy influenced the problems that occurred. This analysis used information gathered from the seven systems and did not include responses from the interviews conducted with supervisors at AMSAA and TECOM. Analysis by type of system (one aircraft, three

ground vehicles, one antitank weapon and two communication/data and information systems) revealed little relationship between the categories of problems and the type of system. This could imply that the problem areas identified in this thesis are generally applicable to Army systems regardless of type of end item. It also indicates that the recommendations that address these problems may be applicable to various Army systems.

Responses were then analyzed by the development strategy of the systems against the categories of problems. The development strategies for the systems reviewed were: full development, major upgrade to an existing system and Non-Developmental Item . The results are depicted in TABLE II.

TABLE II

DEVELOPMENT VERSUS PROBLEMS

PROBLEM *Development*	Schedule	Acquisition Process	Test Culture	Resources Management	Change in Requirements
Full Development	XX	XX	XX	X	XX
Upgrade	XXX XXX	X	-	XX	X
NDI	X	XX XXX	X	X	X

X- A single agency whose responses applied to that particular category.

TABLE II appears to indicate that overall, the type of development strategy may have minimal influence on the DT&E problems experienced by a system. However, there are two areas where a relationship may exist (shaded): 1) Schedule problems and upgrades in development and 2) the acquisition process and NDI developments.

1. Schedule and Upgrades

Two systems, both representing upgrades in development, had at least three of the agencies for their respective systems indicated that schedule was the major problem in conducting DT&E. This indicated that a relationship may exist between schedule type problems and upgrade type developments. The cause for this relationship may be that "upgrades" are often seen as simply integrating new components and subsystems. DT&E schedules are developed to focus on the upgrade. Upgrades however, may be extensive and incorporate the latest technology and the "simple integration" may prove more difficult than anticipated. The early test schedule and planning for the upgrade probably does not anticipate the impact of new technologies and the significance of the integration on the old system.

2. Acquisition Process and NDI

Problems with the acquisition process and NDI developments also seem to be associated. There were two systems in the NDI spectrum of development. Most of the respondents, including both the PM representatives, for these systems indicated that the acquisition process was the major problem in conducting DT&E. The likely cause of this relationship is that NDI developments are often seen by senior leaders and the Congress as a kind of panacea acquisition model. NDI should be a more expedited process, to include DT&E. However, the acquisition process, as previously mentioned, already proliferates over optimism which is accentuated for NDI developments. This creates an environment of extremely high, unrealistic expectations for NDI developments. When these expectations are not realized within the original cost and schedule estimates, the system becomes the target of scrutiny and question.

3. Recommendations

The recommendations that address these two relationships include:

- PMs, as well as others, should avoid underestimating the DT&E process for NDI and system upgrades.
- Historical test and analysis information and data from components and subsystems should be used to better estimate future tests costs and schedule.
- PMs should hold participative and conclusive TIWGs to address test plans and schedules.
- More realistic estimates should be made by all agencies involved with less optimism from the PM.
- PMs should push for early involvement of all the participants including the testers and evaluators.

Overall, the type of development strategy may have minimal influence on the DT&E problems experienced by a system. However, there are two areas where a relationship may exist: 1) Schedule problems and upgrades in development, and 2) the acquisition process and NDI developments. Both relationships may be the result of the high expectations of these types of development efforts. Many of the previous recommendations for schedule problems and acquisition problems hold true for these two relationships. In addition PMs, as well as others, should avoid underestimating the DT&E process for NDI and system upgrades simply because they are "supposed to be easier."

V. CONCLUSIONS AND RECOMMENDATIONS

A. INTRODUCTION

The primary purpose of this thesis was to explore and identify recurring problems in developmental testing in the United States Army, analyze the problems and make recommendations to prevent and or minimize these problems. As a result of this comparative analysis, it appears that Developmental Test and Evaluation is subject to many of the same problems that occur in the acquisition process. This chapter presents the conclusions and recommendations derived from the analysis of the previous chapter.

B. GENERAL CONCLUSIONS

This thesis concludes that five significant problem areas exist in conducting Developmental Test and Evaluation. In order of significance these problems are: 1) Schedule Problems, 2) Problems with the Acquisition Process, 3) Test Culture Problems, 4) Resources Management Problems and 5) Problems with Changing Requirements. The thesis also concludes that the type of development strategy may influence which of these problems is most prevalent. Finally, the thesis concludes that the most recognized method to alleviate or prevent these problems is for the PM to involve the tester, the analyst and Combat Developer early in development.

C. SPECIFIC CONCLUSIONS

1. Schedule

Schedule problems were the most common and the most significant problems in conducting DT&E. Schedule problems are caused by the acquisition process which encourages over optimism, unrealistic schedule estimates and emphasizes completing the test on schedule over conducting the test according to plan. The process may cause the PM

and his staff to develop early estimates without considering historical test information or the experience of the tester or analyst.

2. Acquisition Process

The acquisition process itself presents a significant problem to conducting DT&E as well as being a cause of other related problems. Nearly every agency addressed the acquisition process as a major problem. The causes for this problem included the funding process and PM over optimism. The funding process rewards PMs for being on schedule, under budget and meeting the criteria of the next milestone, but not for being critical and objective about their system and not for taking a user perspective. Over optimism by the PM in his planning and scheduling, forces other agencies in turn to sign up to unrealistic plans that are based on meeting an aggressive schedule not based on the system's readiness for testing.

3. Test Culture

This thesis concluded that a negative test culture exists and this culture was the basis of many DT&E problems. PMs, their staffs, and sometimes contractors have a negative attitude toward testing, testers and analysts. The representative causes noted for this problem included: 1) the acquisition process itself, 2) lack of PMO understanding of test and analysis capabilities and constraints, and 3) the assumed reputation that testers and analysts require excessive testing.

The acquisition process drives PMs to focus on cost and schedule and regard DT&E as an opportunity to make up time and money. PM Offices may not realize what the testers and evaluators can or cannot do for the PM unless the PMO involves the tester and the analyst early. Some testers and analysts have earned poor reputations among Program Offices by conducting tests that appeared to add no value to the process.

4. Resources Management

Resources management of critical test assets was another major problem in conducting DT&E. The causes of this problem included short term funding and limited resources (hardware and software). A system entering DT&E without adequate test funding may not receive the resources in the lead time needed for proper test conduct. Lack of funding could delay test setup, delay instrumentation/equipment checks, and reduce needed test support personnel. Short term funding also caused PMs to desire and plan for perfect success in the test process. Systems under development are often constrained by limited prototypes, test models, versions of software, and may be spread across the country. The lack of resources can severely limit effective testing evaluation and reporting.

5. Change in Requirements

Changes in requirements were a major problem for DT&E. The causes of this problem were the lack of coordination and/or communication between agencies and the lack of understanding of DT&E process among the Combat Developers. Lack of communication and coordination resulted in documents such as the ORD, the TEMP, and the contract, not matching in terms of requirements. It caused difficulties in defining test requirements and made test plans and test conduct more difficult and expensive than originally estimated. Combat Developers, the agency where most changes come from, may not be familiar with the test process and may not realize the impact that a requirement change has on the test and evaluation process.

6. Other Conclusions

a. Developmental Strategy

This thesis also concluded that a system's development strategy may be related to the type of problems a system encounters. Two particular areas which reveal strong relationships were 1) Schedule problems and upgrades in development and 2) the acquisition process and NDI developments. The main cause for both these relationships

was that these types of developments tend to promote very high expectations among PMs, senior decision makers and other agencies. It has often been anticipated that there should be minimal problems in the DT&E of such developments (although the contrary is more likely). Therefore, when cost and schedule overruns occur prior or during DT&E, the senior decision makers, other agencies and even the Congress scrutinize and reassess the system.

b. Early Involvement

Early involvement of the tester, the analyst and the Combat Developer is critical to minimizing and or preventing DT&E problems. Having the PM bring these agencies in early to help estimate, plan, and coordinate the test effort was the most common recommendation made. This recommendation was observed across systems, agencies, and all categories of problems.

D. RECOMMENDATIONS

To improve Developmental Test and Evaluation, Program Managers, testers, analyst, Combat Developers and contractors should review and address the DT&E problems identified in this thesis. Specifically they should be prepared to address and account for problems involving: 1) Schedule, 2) the Acquisition Process, 3) Test Culture 4) Resources Management and 5) Changing Requirements, in that order.

1. General Recommendations

The PM should bring in all agencies for early planning, especially the tester, the analyst, and the Combat Developer. The PM's DT&E effort should concentrate on realistic estimates of test cost and schedule, make the test community part of the team, aggressively manage test resources, and foster a working relationship between agencies that emphasizes cooperation and communication. The following is a list of general recommendations to prevent or minimize the problems identified in this thesis:

- PMs should push for early involvement of all the participants including the testers, analysts and Combat Developers.
- The PM must make the testers and analysts part of the team and not the bad news messengers.
- Agencies should provide solid, realistic estimates of resources in terms of both time and dollars.
- Testers should educate PMs on their capabilities and demonstrate more flexibility in packaging test programs.
- Combat Developers should develop and stick to solid, realistic requirements.

2. Specific Recommendations

The following recommendations are made to address each of the specific categories noted in the thesis.

a. Schedule

- Starting with the PM and his staff, more realistic schedule estimates should be made by all agencies involved
- PMs should hold participative and conclusive TIWGs to address test plans and schedules.
- Historical information and data from previous tests should be used to better estimate future test schedules.

b. Acquisition Process

- The analysts should not promote excessive testing and should integrate other and more efficient methods of evaluation including modeling and simulation.
- Senior decision makers should reward PMs who are realistic and objective about the development of their system.

c. Test Culture

- PMs should ensure that AMSAA, the tester and the contractor closely coordinate the test effort.
- PMs and contractors should realize the value that DT&E provides to their development effort.
- Testers should educate PMs on their capabilities and demonstrate more flexibility in packaging test programs.

- The PM must make the testers and analysts part of the team and not the bad news messengers.
- Testers and analysts should become more familiar with the systems under test to better understand, "What to test?"

d. Resources Management

- The PM should require intensive, proactive management at all levels.
- PMs should plan for contingencies and not assume perfect success in the test process.
- PMs should fund testing to insure test resources are available when needed for proper test conduct.
- Testers should become more familiar with the systems under test especially software intensive systems.

e. Change in Requirements

- The PM should insist that a solid, stable and realistic ORD be maintained.
- The PM should establish a better working relationship among the agencies in defining test requirements.
- The Combat Developer should appreciate the impact that changing requirements has on the system and the test process.
- The PM should ensure that the major documents, to include the contract, are closely coordinated.

f. Other Recommendations

The following recommendations focus on upgrade and NDI type developments.

- PMs, as well as others, should avoid underestimating the DT&E process for NDI and system upgrades.
- Historical test data and analysis information from components and subsystems should be used to better estimate future tests, costs, and schedule.
- PMs should hold early TIWGs to address unique testing requirements, plans and schedules.

E. AREAS FOR FURTHER RESEARCH

The following areas should be investigated for potential benefit to the DOD:

- **Developmental Strategy and Test Problems** - One of the findings of this thesis was that the type of development strategy influenced the number of test problems a system encountered. Further research on the effect of development strategy on test programs could provide insight for better tailoring of programs.

- **Test Culture** - Developmental Test and Evaluation could be significantly improved if the relationship between the test community (testers and analysts) and the PM Office were improved. Further research into the causes of this adversarial relationship with emphasis on preventing or minimizing its impact on testing could provide valuable information to the DOD.

- **PM Incentives and the Acquisition Process** - Researching the feasibility of incorporating an incentive system for PMs which encouraged them to be "event driven and user oriented" should be conducted. A meaningful and quantifiable rating and evaluation system for PMs that stressed good management techniques vice political maneuvering should be developed.

APPENDIX A (PROGRAM MANAGEMENT OFFICE QUESTIONS)

Name: *Location:*
Title or Job *Date:*

Thank you for taking the time to meet/talk with me. I am conducting this research for my master's thesis at the Naval Postgraduate School. The focus of my thesis is to identify **problems in developmental testing** from the perspective of the various agencies involved in DT&E. In my final product I hope to make some recommendations to correct the problems or at least minimize the impact of these problems for future programs. I am examining a number of systems and interviewing the key players in the developmental test process of those systems as well as some others. My questions to you will primarily address your interface with these other agencies, what you perceive as the major problem in DT&E and how can you or the other agencies solve or alleviate the problem? I would also welcome any additional comments that you have about any aspect of the developmental test process. The information I collect will be confidential if you request. I will consolidate and summarize all interview data so that your name will not be identified in any way.

PROGRAM MANAGERS

1. How do you interface with these agencies:

   -Test facility

   -AMSAA

   -The contractor

   -The Combat Developer (user representative)

2. Is this sufficient?

3. What do you consider the most significant problem or issue in entering a Developmental Test?

4. Does this problem effect the cost and or scheduling of the DT?

5. What rules, regulations or policies exist that try to alleviate this problem? What rules, regulations or policies only feed the problem?

6. Does the problem impact future testing - DT or OT? How?

7. What could you the **PM** do to deal with this problem?

8. What could be done by the **Tester** to deal with this problem?

-Are they aware of the problem?

9. What could be done by the **Contractor** to deal with this problem?

-Are they aware of the problem?

10. What could be done by the **Combat Developer** to deal with this problem?

-Are they aware of the problem?

11. What could be done by **Agencies** like AMSAA to deal with this problem?

-Are they aware of the problem?

12. What could be done by **Legislative action** to deal with this problem?

13. What do you consider as **other** key problems or issues in Developmental Testing?

14. What impact do these problems have on the cost and schedule of the test?

15. What could be done by **who and how** to deal with these problems?

APPENDIX B (LIST OF ACRONYMS)

AAE	Army Acquisition Executive
ACAT	Acquisition Category
ADM	Acquisition Decision Memorandum
AMC	Army Materiel Command
AMSAA	Army Materiel Systems Analysis Activity
ARL	Army Research Laboratory
ASA (RDA)	Assistant Secretary Of The Army (Research, Development & Acquisition)
ASD	Assistant Secretary of Defense
ATCCS	Army Tactical Command and Control System
CE	Concept Exploration (Phase)
CLU	Command Launch Unit
CITV	Commander's Independent Thermal Viewer
COEA	Cost and Operational Effectiveness Analysis (Report)
COMSEC	Communications Security
DA	Department of the Army
DAB	Defense Acquisition Board
DAE	Defense Acquisition Executive
D&V	Demonstration and Validation
DDT&E	Director, Defense Test and Evaluation
DEMVAL	Demonstration and Validation Phase
DOD	Department of Defense
DODD	Department of Defense Directive
DODI	Department of Defense Instruction
DOT&E	Director Operational Test and Evaluation
DT	Development Test
DTE	Director, Test and Evaluation
DT&E	Development Test and Evaluation
DUSA (OR)	Deputy Under Secretary Army (Operations Research)
ECP	Engineering Change Proposal
ECCM	Electronic Counter-Countermeasures
ECM	Electronic Countermeasures
EMD	Engineering and Manufacturing Development
ESM	Electronic Support Measure
EW	Electronic Warfare
FAT	First Article Test
FLIR	Forward-Looking Infrared
FMTV	Family of Medium Tactical Vehicles
FOT&E	Follow-on Operational Test and Evaluation
GAO	General Accounting Office