LESSONS LEARNED
M1 ABRAMS TANK SYSTEM

DEPARTMENT OF RESEARCH AND INFORMATION
DEFENSE SYSTEMS MANAGEMENT COLLEGE
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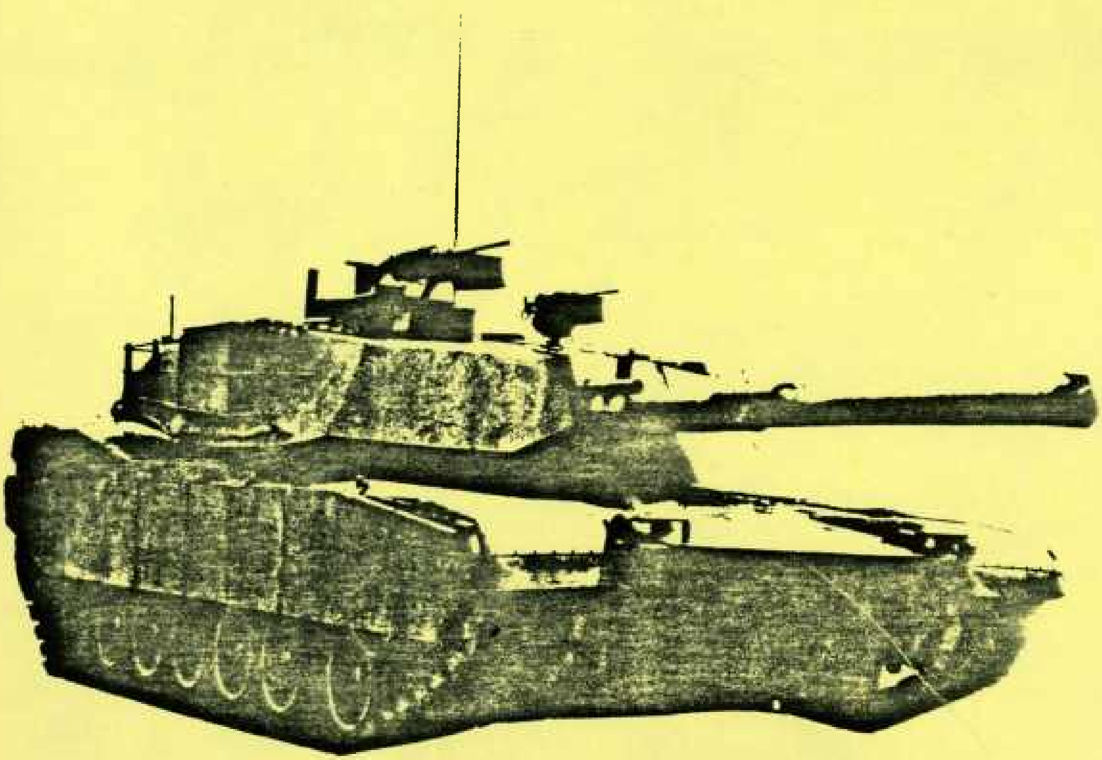

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FINAL REPORT
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M1 ABRAMS TANK SYSTEM

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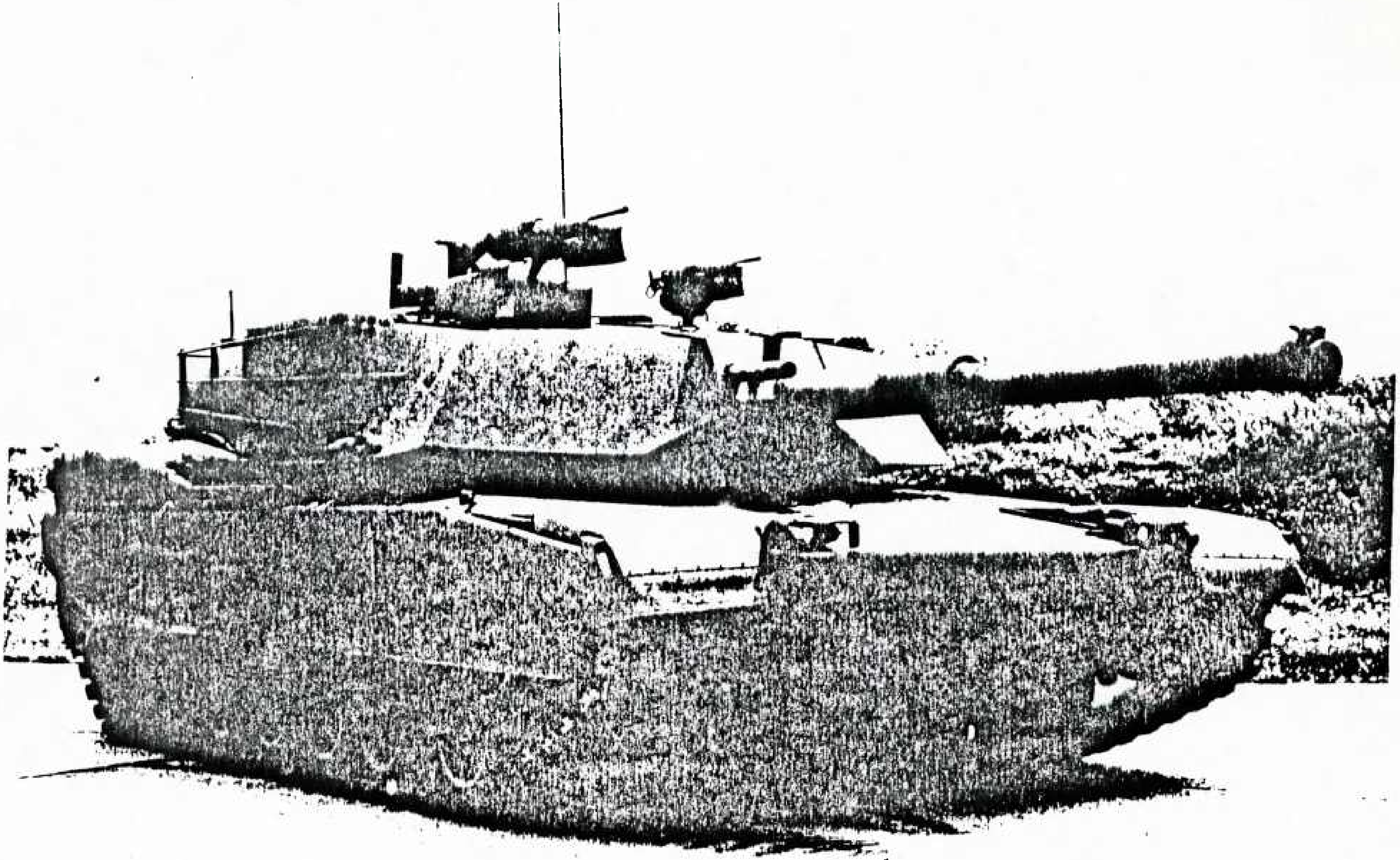

M1 ABRAMS . . . MAIN BATTLE TANK

GENERAL DYNAMICS
Land Systems Division

EXECUTIVE SUMMARY

A. <u>BACKGROUND.</u> This report was prepared in response to a 1980 request from the Assistant Secretary of the Army (Research, Development, and Acquisition). The Deputy Chief of Staff for Research, Development, and Acquisition through the Chief, Policy, Plans, and Management Division, tasked the Defense Systems Management College to document the lessons learned during the acquisition of major Army Systems. To date lessons learned reports have been published on the Multiple Launch Rocket System (MLRS) and the Advanced Attack Helicopter (AAH) program. As part of a continuing effort, this report documents the lessons learned during the acquisition of the M1 Abrams Tank System and covers the period from initial concept of the tank through early production.

B. <u>PURPOSE</u>. The purpose of this study was to document the lessons learned based on a review of the acquisition management practices used on the M1 Tank Program. For the most part, the study team concentrated on those areas which were impacted by the use of competition, accelerated schedules, budget constraints and international collaboration. The study focuses on the success of the M1 program office in coping with the problems and issues in such areas as technology, technical risks, business management, configuration management, test and evaluation, integrated logistics support, international collaboration, transitioning to production, and production.

C. <u>FINDINGS AND PRESENTATION</u>

1. The M1 Abrams Tank System has demonstrated the Army's ability to acquire and field a technically advanced weapon system. The study team identified several basic factors which have contributed to the success of the M1 Abrams Tank program to date.

- o Continuing high level support of the program as an integral part of the Army's force modernization program.
- o Continuity of key civilian personnel.
- o Economics, national pride, and differing national requirements are obstacles to major weapon system collaboration with our allies.
- o Good concept definition and statement of user requirements.
- o Innovative planning and effective management through the acquisition of a system.

2. The review of the acquisition management practices used on the Army's M1 Abrams Tank System program revealed that numerous lessons could be learned in such areas as business and technical management, production management, test and evaluation, integrated logistics support and international collaboration. The following is a synopsis of the principal lessons learned contained in this report.

- o Consideration should be given to using a range of values for DTUHC thresholds to allow Government and contractor flexibility.
- o Development Commands should sponsor R&D efforts to design, develop and test components for use in future systems.
- o Provisions should be made for system hardware availability to test set designers and major contractors.
- o There needs to be a "find and fix" period in the transitioning to production and a recognition of the costs associated with start-up so that these costs do not become part of the early production model costs.
- o During testing, on-site Government and contractor teams should consist of top quality, highly knowledgeable contractor and Government personnel.
- o The LSA effort should be initiated early.
- o Requirements for logistics development must be recognized early in the program and detailed planning began before release of the Validation Phase RFP.
- o MOU's should be written so as not to jeopardize the national sovereignty of the United States.

- International agreements should be made at sufficiently high levels to allow for an assessment of the impacts against national objectives, cost, and force effectiveness.

D. CLOSING REMARKS. The M1 Abrams Tank System Study Team recognizes that there are numerous challenges to be faced throughout the remainder of the program. However, to date, the Army has produced a tank that has demonstrated its superiority over existing tanks, that has had only a small real cost growth, that has met the production schedule, and has received favorable support from the users in both CONUS and in Europe.

FOREWORD

One of the contributors to the successful management of any defense systems acquisition project/program might well be the application of lessons learned from previous projects. The best sources for lessons learned are generally the personnel from the material development commands, project management offices user community, contractors, and supporting organizations. The team that prepared this report on the Ml Abrams Tank System spoke with the personnel from these sources and recorded their observations and summarized the lessons learned for consideration by both present and future defense systems acquisition project/program managers and their staffs. The team realizes that to be effective, the lessons learned must be available to those who have a need to know and applicable to present or future projects/programs. Therefore, it is the hope of this team that its efforts and the experience gained on the Ml Program will be helpful to future defense systems acquisition project teams. If these teams learn from the Ml Program experience the preparation of this report will have served a useful purpose.

The members of the team responsible for the preparation of this report are:

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The team is grateful to the Ml Program Manager, MG Duard D. Ball, the Deputy Program Manager, Col William R. Sowers, Jr. and the other personnel on

the program team, as well as to the many Army and contractor personnel who provided the information and insights required to make this report of lessons learned possible.

The information and data contained herein are based upon the input available up to the time of its preparation in October 1982. This report represents the observations of the study team and the government and industry program/project management teams associated with the M1. No inferences, either pro or con, should be drawn from the wording of the observations regarding the M1 PMO performance in the activity discussed. How the particular event/activity was handled by the PMO is discussed in the "Background" section of each appendix. The report should not be construed to represent the official position of the DSMC, the U.S. Army, or the M1 Program Office.

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I. INTRODUCTION

A. GENESIS OF THE M1 ABRAMS TANK SYSTEM

In 1963, the United States and the Federal Republic of Germany (GE) entered into an agreement for the joint development of a main battle tank (the MBT-70). This new tank was envisioned to be a highly mobile, heavily armored vehicle with substantial protection against nuclear radiation. In December 1969, after six years of effort, the joint program was terminated due to the extremely high unit hardware cost of the system, then estimated at $850,000 (in FY 69 dollars). At the direction of the Deputy Secretary of Defense (DEPSECDEF), the Army proceeded with development of the XM-803, an "austere" version of the MBT-70, which would not exceed a unit hardware cost of $600,000. In December 1971, Congress terminated the XM-803 program because the tank was still considered to be unnecessarily complex, excessively sophisticated, and too expensive. However, Congress also proposed that the Army use 20 million dollars to initiate conceptual studies for a New Main Battle Tank (NMBT).

On 20 January 1972, the Vice Chief of Staff assigned the responsibilities for the Material Need (MN) development phase of a NMBT development program to the Commanding General, U.S. Army Combat Development Command (USACDC). On 25 January, the CG, USACDC, directed the organization of the Main Battle Tank Task Force (MBTTF) to be chaired by the Commanding General, U.S. Army Armor Center. Initially, the mission of the MBTTF was to produce a Draft Proposed MN with the following associated considerations:

- o Evaluate the need for a new tank to include the Initial Operational Capability (IOC) date.
- o Prepare and outline a development schedule.

- o Determine the proper interface with the M60 tank series.

A Department of the Army (DA) Steering Group was formed to review the MBTTF progress and provide guidance.

On 28 March, the Chief of Staff, U.S. Army, directed that the tank development program be accomplished in six years, with the first unit being equipped by 1978. Based on this decision, and guidance received from the DA Steering Group, the mission of the MBTTF was revised as follows:

- o Prepare an MN(Engineering Development)
- o Prepare outline development schedule.
- o Determine the proper interface with the M60 series tank.
- o Prepare as complete a concept formulation package as possible.
- o Provide recommendations to DA by 1 August 1972.

The MBT Task Force Report was published in August 1972 and presented three alternatives for the Development Concept Paper (DCP):

(1) Alternative 1: Conduct a program to develop and procure a new MBT based on optimum product improvement of the M60A3 (M60A4).

(2) Alternative 2: Conduct a program to develop and procure an entirely new MBT designed to meet user requirements (MN).

(3) Alternative 3: Procure a new foreign tank or an adaptation of new foreign tank.

Following nearly three months of Army/Office of the Secretary of Defense (OSD) evaluation of the MBTTF report, the three alternatives were presented in November to the Defense Systems Acquisition Review Council (DSARC). No agreement was reached at the review. A second DSARC was held on 2 January 1973, and based on their recommendations, the Secretary of Defense signed off on an amended DCP approving the NMBT tank program, known for a short time as the XM-815.

The causes for the delay in approving the new tank program are covered in detail in Appendix D. A summary of the major events of this phase is shown in Figure I-1.

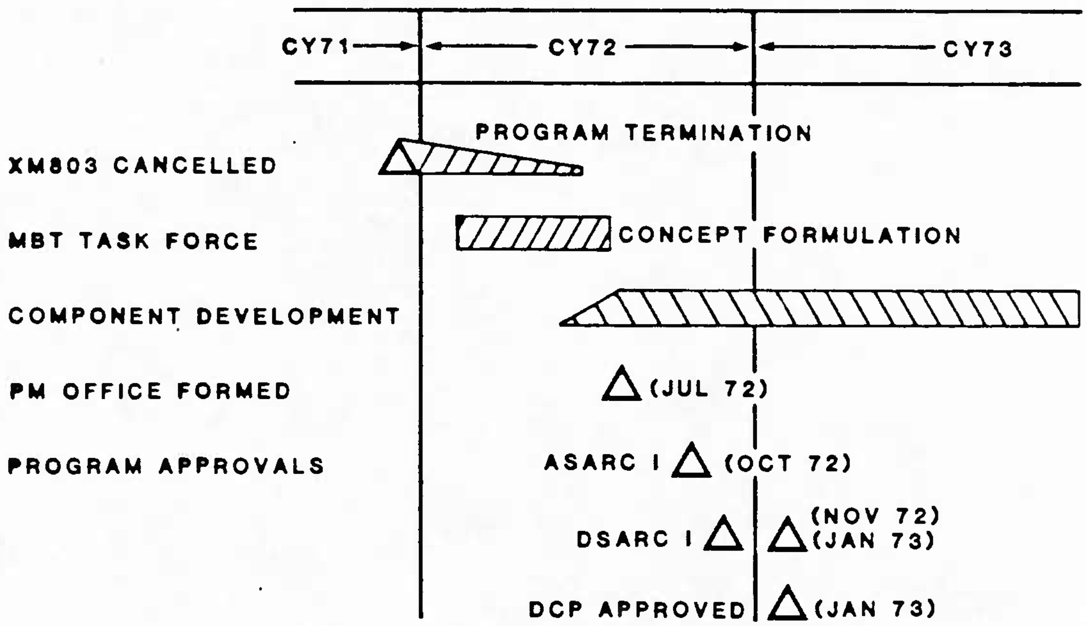

Figure I-1
PROGRAM DEFINITION

B. THREAT

In formulating the draft DCP for a NMBT, the MBT Task Force justified the need based on the threat and the operational deficiencies of the existing M60A1 tank. The following is an extract of the threat as defined in the 1972 MN document: [1]

[1]Main Battle Tank Task Force, Part 2, Volume 1 Materiel Need (ED), 1 August 1972.

"The Soviet Union and its Warsaw Pact allies give every indication of designing a future ground force which will be oriented around a large number of medium tanks. This armored force will adhere to "blitzkrieg" doctrine and will be capable of conducting rapid and deep penetrations of opposing forces....The Soviets are now beginning to field a new model medium tank. Improvements are expected in armor protection and mobility to include speed, cruising range and engine efficiency. Future Soviet tanks will also incorporate improved CBR defensive systems to include radiation shielding. In addition, significant improvements can be expected in target acquisition, fire control and gun stabilization systems. The Soviets possess great superority in numbers of tanks...The natural and cultural features of the West European continent pose serious restrictions to cross-country movement and visibility...The area of confrontation indicates the need for a vastly improved ground movement capability in the MBT."

The following M60A1 (then the current MBT) operational deficiencies were identified in the MN:

- o Large silhouette, both height and width--larger than any other tank in the world.
- o Inadequate acceleration and cross-country speed.
- o Unacceptable reliability of mobility and firepower systems.
- o Lack of adequate firepower on the move.
- o Insufficient ballistic protection against hypervelocity kenetic energy munitions.

The MN acknowledged that product improvement of the M60A1 could provide for certain levels of increased performance and capability, and that such a program should be pursued in that the M60A1 tank will be in the inventory well into the 1990s. However, that approach was not considered to be a total solution to the decreasing survivability and effectiveness of an MBT in the face of the Warsaw Pact threat. In order for the necessary qualitative advancements to be made, a new MBT was required.

C. SYSTEM DESCRIPTION

1. General

The M1 Abrams Tank--initially called the XM-1 and renamed for General Abrams, Chief of Staff of the Army, after his tragically early death--provides increased performance over the M60 tanks in the areas of surivability, tactical mobility, fire-on-the-move capability and high hit probability, and night fighting capacity. The M1 Abrams Tank is designed to provide for the increased reliability, availability, maintainability, durability, and fightability required to meet the postulated threat.[2] The characteristics and significant features of the M1 Abrams Tank are shown in Figures I-2 and I-3, respectively.

The tank uses a 1500 horsepower AVCO Lycoming regenerative turbine engine coupled with an Allison X1100-3B hydrokinetic transmission to provide four forward and two reverse speeds. Turbine engine use has significant potential advantages over the diesel tank engine in performance, durability, and reduced maintenace. The turbine engine is nearly one ton lighter than a comparable diesel engine. At maturity, the turbine is expected to operate up to 12,000 miles without requiring overhaul nearly 2 1/2 times greater than the diesel engine used in the M60. Furthermore, the turbine never requires an oil change and has the capability of operating on a wide range of fuels, including diesel, jet fuel, and gasoline. Approximately 70 percent of the engine accessories and components can be removed without removing the powerpack from the tank. When required, the M1 Abrams Tank power pack can be removed and

[2] IBID

MOBILITY

Acceleration	
0 to 32 km/h	7.0 seconds
Speed	
Maximum	45 mph (72.4 km/h) (Governed)
Cross Country (Average)	30 mph (48.3 km/h)
10% Grade	20 mph (32.2 km/h)
60% Grade	4.5 mph (8.0 km/h)
Obstacle Crossing	
Vertical Wall	49 inches (1.24 m)
Trench	9 feet (2.74m)
Cruising Range	275 miles (475 km)
Water Fording Without Preparation	4 feet (1.22m)
Power Plant	1500 HP Multifuel Turbine, Air cooled
Transmission	Automatic, mechanical lock-up
Gear Ratios	4 Forward 2 Reverse
Braking System	Hydro-mechanical
Power/Weight Ratio	25 HP/ton

DIMENSIONS

Overall Length, Gun Forward	384.5 inches (9.77m)
Width	143.8 inches (3.65m)
Ground Clearance	19 inches (0.48m)
Height, Turret Roof	93.5 inches (2.38m)
Ground Pressure	13.3 psi
Combat Weight	60t

CREW

Commander
Gunner
Loader
Driver

ARMAMENT

Main Gun	105 mm (M68E1)
Ammunition	55 Rounds
Turret Capability	120mm Gun
Elevation	-9° to +20°
Commander's Weapon	12.7mm MG
Ammunition	1000 Rounds
Field of Fire,	
Azimuth	360°
Elevation	-10° to +65°
Coaxial MG	7.62mm
Loaders MG	7.62mm
Ammunition	11400 Rounds
Smoke Grenades	24 Rounds

FIRE CONTROL

Stabilization	Day/Night Line Sight and Laser Rangefinder are stabilized
Gun/Turret Drive	Electro-hydraulic. Gunner or Commander can fire the main gun
Night Vision	Thermal Imager
Computer	Digital
On-Board Testing	Computer Controlled
Rangefinder	Laser, 200m to 7990m
Tubebend Correction	Muzzle Reference System
Commanders Sight	Day/Night 360°, Electric Drive
Auxiliary Telescope	Magnification 8x

OTHER EQUIPMENT

Driver, Passive Night Vision
HALON Electro-Optical Fire Suppression
Crew Heater
CBR Protection
Bilge Pump
Radio Communication
650 Ampere Alternator, Oil Cooled

Figure I-2

CHARACTERISTICS OF M1 ABRAMS TANK

SURVIVABILITY

Improved Armor Protection
Compartmentalization of Fuel and Ammunition
Agility
Low Silhouette
Fire Suppression System
Smokeless Exhaust
Reduced Engine Noise
Passive Night Sight

FIREPOWER

Digital Ballistic Computer
Miniaturized Laser Rangerfinder
Thermal Imaging Day/Night Sight
Improved 105mm Ammunition
High Fire-on-the-Move First Round Hit Probability

MOBILITY

Improved Acceleration and Performance
Advanced Suspension
1500 HP Turbine Engine
Hydrokinetic Transmission

MAINTAINABILITY

Onboard Malfunction Detection System
Modular Engine Design
Ease of Engine Accessory Replacement
Semiannual Scheduled Maintenance Services

Figure I-3

SIGNIFICANT FEATURES OF THE M1 ABRAMS TANK reinstalled in less than 60 minutes. In comparison, it takes four hours for the same operation in the M60 Tank.

The M1 fire control system has been designed to enhance the first round hit probability. This complex fire control system integrates the 105mm cannon, laser range finder, solid state digital computer, and the stabilized day/night thermal sights. The tank stabilization system is designed to permit accurate firing-on-the-move.

Survivability has been improved by the use of advanced armor materiels and techniques, and by the separation of the crew fighting compartment from the fuel tanks and the on-board main gun ammunition storage by armored bulkheads and sliding armored doors. The tanks secondary weapons consist of a .50 calibre machine gun and two 7.62mm machine guns.

In an effort to further the standardization and interoperability of tanks with our NATO allies, an improved M1 tank, the M1E1, will integrate the German-designed 120mm smooth bore gun and other block improvements into the M1 (see Figure I-4).

The M1 Abrams Tank will be produced until 1985 with the standard M68 105mm cannon. The M1E1, now in Full Scale Engineering Development (FSED), is scheduled for production commencing in August 1985.

2. Organizational and Operational Concept

As the Army's primary assault weapon system the M1 will satisfy the Main Battle Tank requirements during the 1980s and beyond. Capable of

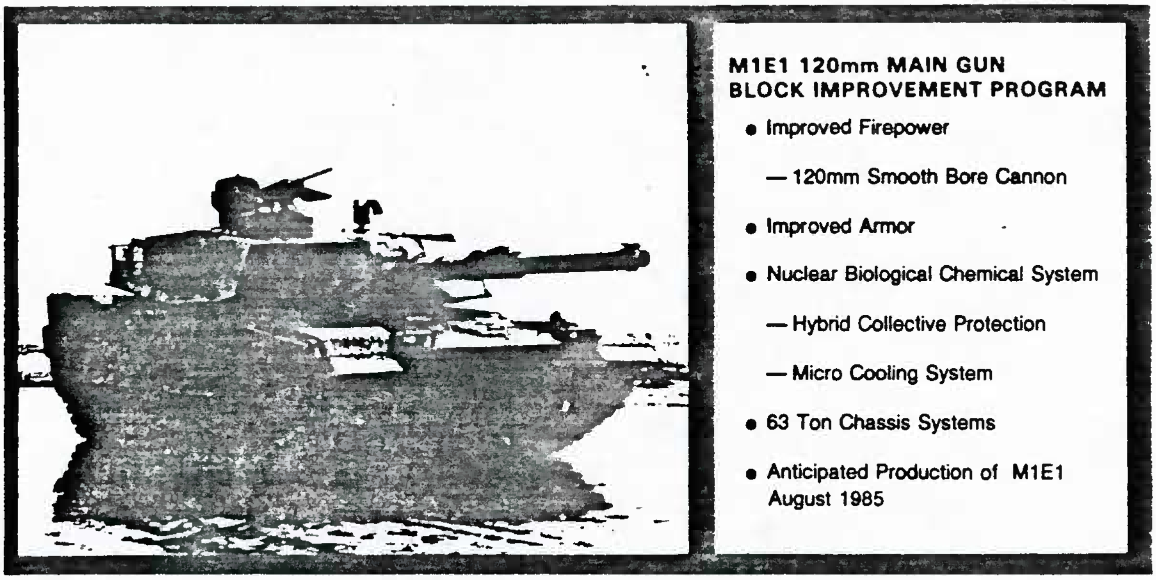

Figure 1-4
M1E1 120mm MAIN GUN BLOCK IMPROVEMENT PROGRAM

sustained offensive and defensive combat, the tank is designed to close with and destroy the enemy using shock action, firepower, and mobility in coordination with supporting ground and air systems under all battlefield conditions and levels of combat.

The tanks will be issued to separate tank companies and to tank companies organic to tank battalions of divisions and separate brigades. Under the Division 86 concept, battalions will be comprised of four companies of four platoons with three tanks each.

3. Support

The M1 has been designed to minimize the requirements for specialized support and test equipment. Maintainability was designed into the tank to allow 70 percent of the engine maintenance to be performed without removal of the powerpack. In the event that the powerpack must be removed, electrical connections and hydraulic quick disconnects have been grouped to ease the operation. Built In Test Equipment (BITE) helps the crew diagnose engine and transmission problems.

II. PROJECT STRATEGY

A. OVERALL PLAN

During the preparation for DSARC I, the Army considered several development and production options for the acquisition of a NMBT based on the MBT Task Force Report. The development options considered were:

- o Development Option 1 - Single contractor for validation and FSED.
- o Development Option 2 - Two competitors in validation and single contractor (winner) in FSED.
- o Development Option 3 - Two competitors, both in validation and FSED.

The Army Systems Acquisition Review Council (ASARC) eliminated Option 1, based on congressional interest in competitive prototyping shown at the time of the XM-803 termination. The production options considered by the ASARC were as follows:

- o Production Option 1 - Non-competitive, sole source decision at DSARC IIA.
- o Production Option 2 - Non-competitive, sole source decision at DSARC III.
- o Production Option 3 - Competitive decision at DSARC III.

The ASARC eliminated Production Options 2 and 3 due to cost considerations; therefore, only Option 1 was retained for inclusion in the DCP. This option called for a limited production decision (DSARC IIA) at the end of Engineering Tests and Service Tests (ET/ST). The combinations of development and production options shown in Figure II-1 were retained for inclusion in the draft DCP for presentation at the DSARC. The two major alternatives were product improvement of the M60A1 Tank (Alternative 1) or development and production of a NMBT (Alternative 2). The ASARC recommended Alternative 2A as the preferred alternative of the Army because of the increased development cost associated with Alternative 2B and the need for a NMBT, as opposed to an improved M60A1.

Alternative 1A:	Development of M60A3 tank (a product improved M60A1)
Alternative 1B:	Additional product improvement to the M60A3 Tank
Alternative 2A:	Development and production of NMBT Option 2 for development. Option 1 for production. 7 year program.
Alternative 2B:	Development and production of NMBT Option 3 for development. Option 1 for production. 7 year program.

Figure II-1
ASARC/DSARC I ALTERNATIVES

The DEPSECDEF approved Alternative 2A on January 18, 1973, with the following instructions to be included in a revised DCP:

- An absolute ceiling of $507,790 unit hardware cost for the XM-1 tank and total production cost of $4,990M (FY 72 dollars).
- If actual unit hardware cost reaches or threatens to exceed ceiling, Army will examine pertinent trade-off in design or performance characteristics versus cost.
- Any trade-off which reduces the performance characteristics below those stated in the Material Need Document will not be made without approval of Department of the Army.

Figures II-2 thru II-4 reflect the major milestones established for the development of the M1 Abrams Tank and the planned and actual acquisition schedule.

MILESTONES		TARGET DATE	ACTUAL DATE
ASARC I		Jun 72	Oct 72
DSARC I		Jun 72	Jan 73
Validation Phase Contract Awards		Jun 72	Jun 73
ASARC II		Mar 75	Jun 76
DSARC II		Mar 75	Nov 76
Full Scale Engineering Development/Producibility Engineering and Planning Contract Award		Mar 75	Nov 76
ASARC III	(DSARC IIa)	Apr 77	Mar 79
DSARC III	(DSARC IIa)	Apr 77	May 79
Low Rate Initial Production Contract Award		Apr 77	May 79
First Production Tank		--	Feb 80
Full Scale Production Contract Award	(DSARC III)	Apr 79	Sep 81

Figure II-2
M1 ABRAMS TANK PROGRAM MILESTONES

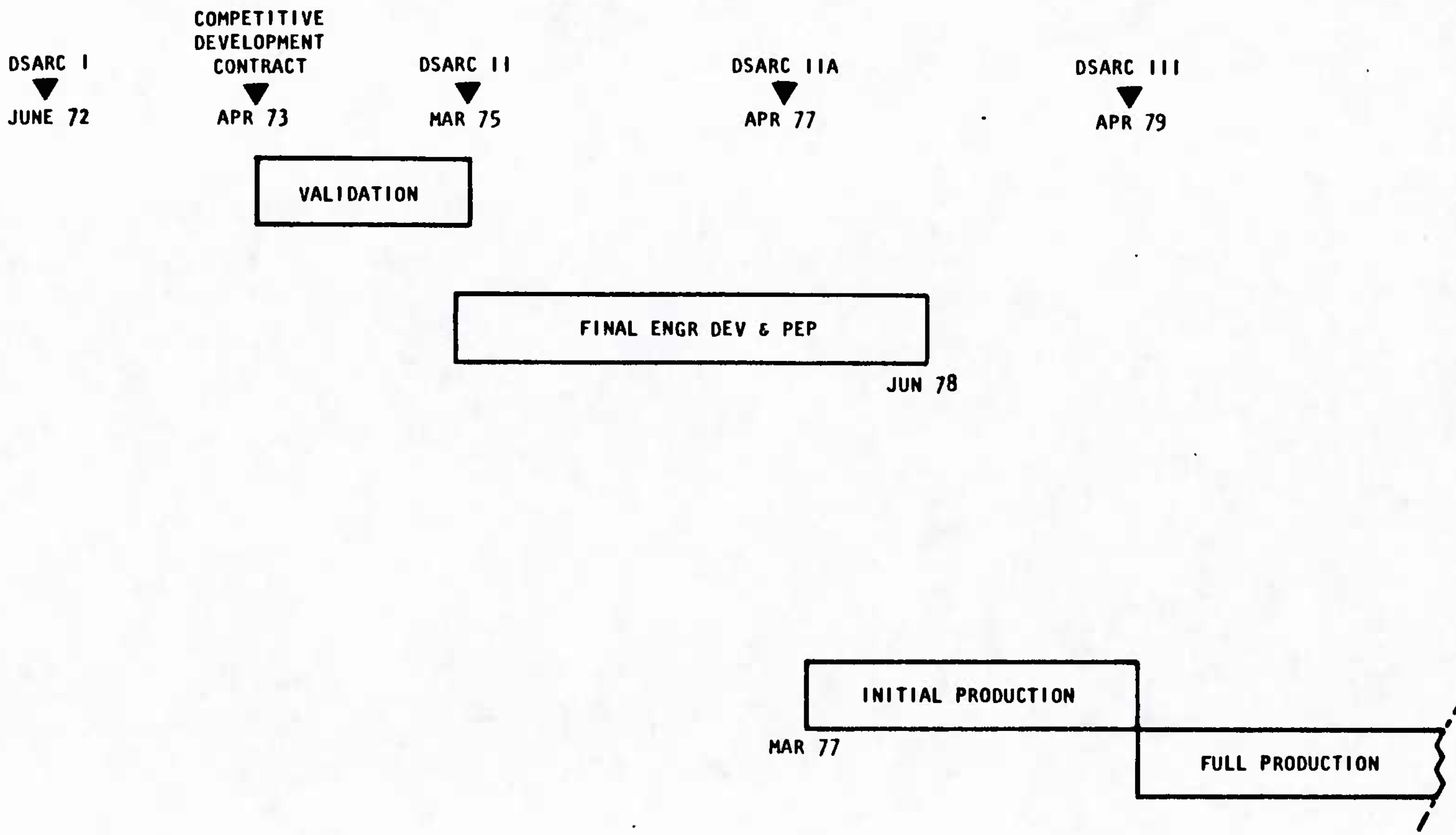

Figure II-3
M1 ABRAMS TANK ACQUISITION SCHEDULE - PLANNED

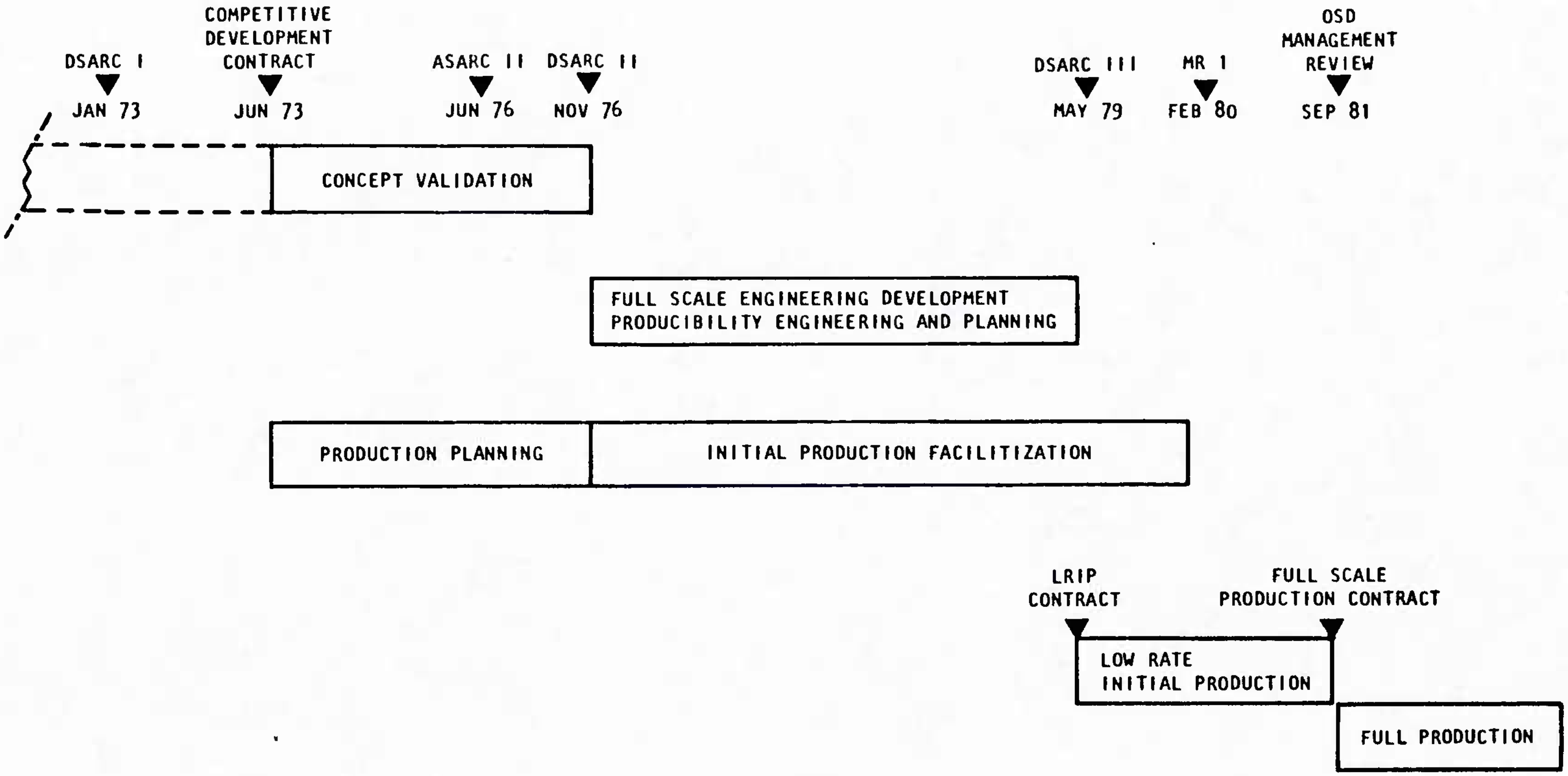

Figure 11-4
M1 ABRAMS TANK ACQUISITION SCHEDULE - ACTUAL

B. ACQUISITION STRATEGY

1. General

Acquisition strategy is the conceptual basis for all planning for accomplishing specified goals and objectives to attain a mature and logistically supportable weapon system or equipment. It gives an overview of management concepts and Program Manager (PM) actions planned to ensure satisfaction of the approved mission need. The acquisition strategy covers every phase of the development of a major weapon system, including operation and maintenance considerations. At any stage of the acquisition process, the strategy must address the remaining life of the program. Because no two programs are exactly alike, each requires a tailored acquisition strategy.[1]

2. Ml Abrams Tank System Program

The Ml Abrams Tank System acquisition strategy reflected guidance concerning competition, international collaboration, accelerated development, an intensive Design-To-Cost (DTC) of for these areas is discussed in the following paragraphs.

a. Competition

Two prime contractors were selected in 1973 for the competitive Validation phase. Development and fabrication of prototypes and scored testing was accomplished between the two competing contractors to facilitate selection of a single prime contractor for the FSED Phase.

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[1]Guide for the Management of Joint Service Programs, DSMC, June 1982.

During the first two years of production, the prime contractor purchased and manufactured all components and materials necessary to fabricate and assemble the M1 Abrams Tank, with the exception of guns, ammunition, smoke grenades and their launchers, driver's viewers, and selected hand tools. Subsequent year production contracts call for the breakout of major components to be procured by the government directly from the manufacturer and provided to the prime contractor as Government Furnished Equipment (GFE).

b. International Standardization

Under the provisions of a 1974 Memorandum of Understanding (MOU) with the Federal Republic of Germany (GE), the United States agreed to evaluate a modified version of the German Leopard 2 Tank against the Army's MN requirements. The goal was to achieve maximum standardization of the American and German tanks. In a 1976 Addendum to the 1974 MOU, both the United States and Germany agreed to identify and specify areas of standardization of their respective tanks to ensure compatibility and commonality of components. The M1E1 tank program was initiated when the decision to use the GE 120 mm weapon system was made.

c. Accelerated Development

The acquisition strategy followed the Chief of Staff's guidance and utilized the flexibility allowed by Department of Defense Directive (DODD) 5000.1, to reduce the time required to develop and field a major weapon system. This was accomplished in part by compression of test schedules. Although Developmental Testing (DT) started several months earlier in order to fill safety release requirements, Operational Testing (OT) for the most part occurred concurrently. The compression of tests schedules contributed to the M1 Abrams Tank entering Low-Rate Initial Production (LRIP) six years after the start of the validation phase.

d. Design-to-Cost

The initial DCP for the M1 Abrams Tank reflected the mandated absolute Design-To-Unit Hardware Cost (DTUHC) threshold of $507,790 in FY 72 dollars. During the Validation and FSED phases, extensive tracking of the DTC was conducted. The government conducted detailed reviews of the contractor reports to establish estimate realism. Contractor incentive was promoted by establishing a DTC Award Fee during FSED. A total award fee of 7 million dollars was available, 5 million dollars of which were paid to the contractor.

e. Production Facilities

Government-Owned, Contractor-Operated (GOCO) facilities are being used for the production of M1 Abrams Tanks and engines. The Lima Army Tank Plant (LATP) fabricate hulls and turrets, provides finish machining, and assembles complete tanks. The Detroit Army Tank Plant (DATP) will support the LATP with component parts and assembly of tanks during the third production year and beyond. The AGT-1500 engine is produced by AVCO at the Stratford Army Engine Plant.

f. Growth Potential

The M1E1 Tank program will integrate the German-designed 120mm smoothbore gun and block improvements of the M1 Abrams Tank System. Planning for the four-point M1E1 Block Improvement Program was initiated in February 1979.

Annex G (Product Improvements) to the MN was approved in May 1982. The program provides for incorporation of armor modifications, a hybrid NBC system with micro-cooling for crew protection, weight reductions, and suspension/transmission/final drive upgrades for the M1E1 Tank System.

III. PRINCIPAL LESSONS LEARNED

A. INTRODUCTION

This section presents the principal lessons learned -- up to October 30, 1982 -- from the study of the M1 Abrams Tank System program. The reader is referred to Appendices A thru K for the complete set of study team observations (lessons learned) and their supporting background discussions.

B. BUSINESS MANAGEMENT

1. Competition and Source Selection

An in-depth validation of contractor cost data by qualified Government personnel is an opportunity for the Government to gain detailed knowledge of the contractor's management, operational practices, and credibility.

2. Cost Management

a. Studies should be contracted with industry early in the competitive phase to receive more timely best estimates for tooling and facilitization costs.

b. Production budgets of major Army programs should have a contingency line or a "TRACE" element just as RDT&E budgets do.

c. When DTUHC thresholds are established, consideration should be given to using a range of values (i.e, $\pm$ 10%) to allow Government and contractor flexibility.

d. The design must be producible at the DTUHC. Design-to-cost is a more viable tool when the fee award is delayed until actual hardware has come off the production line and production cost determined. This is the thrust of DAIP Action 22, Design to Cost Contract Incentives.

C. TECHNICAL MANAGEMENT

1. Deferral of component development has a negative impact on both cost and performance trade-off capabilities and the time to conduct component tests and take corrective action prior to system testing.

2. Service Development Commands should sponsor R&D efforts to design, develop, and test components for use in future systems.

3. Contract specifications must be specific and verifiable with all requirements clearly defined in the System Specifications.

4. Human Factors Engineering must have up-front involvement with design to include the prime contractor, subcontractors, and Government program management.

5. Provisions should be made for system hardware availability to test set designers and to the major contractors.

6. The contractor should be furnished a facility vehicle for testing redesigned components.

7. The completion date for the TDP should be carefully coordinated with provisioning requirements. This is especially critical in a program having a compressed schedule.

D. PRODUCTION MANAGEMENT

1. Initial production cost estimates must be realistic and should provide for unknown contingencies.

2. The Government must be involved in the process of design change during FSED and LRIP. Government approval of design changes is required to assure that the final production product meets the Government's requirements.

3. Production planning should be included as a factor for evaluation of FSED proposals and fee award criteria to ensure that the contractor's planning is sound and sufficient during early stages of development. This also is a motivational factor to enhance the contractor's production planning.

4. It cannot be assumed that the transition to production will be without problems. There needs to be a "find and fix" period in the production process and recognition of the costs associated with start-up so that they do not become part of the early production model costs.

E. TEST AND EVALUATION MANAGEMENT

1. Planning

Realistic times must be allotted for shake-down, experiencing failures, determining corrective actions, making corrections, and retesting prior to official DT/OT tests.

2. Scheduling

Scheduling DT and OT concurrently creates several problems that must be planned for; these include: requirements for more test vehicles and components and the potential for increased risk.

3. On-Site Management

On-site government and contractor teams should consist of top quality, highly knowledgeable contractor and Government personnel. All personnel should be cognizant of the terms of a test participants Memorandum of Agreement and recognize that one person is in charge.

4. Test Player Selection

Operational test player personnel must be typical of the ultimate user in the field and, in a competitive situation, there must be assurance that the teams are equally manned. In addition, the player organization should be manned with the elements normal to the tested unit.

F. INTEGRATED LOGISTIC SUPPORT MANAGEMENT

1. Planning

a. Requirements for logistics development must be recognized early and detailed planning begun before release of the Validation Phase RFP. In addition, resources must be designated for the Validation Phase ILS effort. These ILS resources may be the result of trade-offs among other program requirements.

b. Delay of the entire ILS effort and schedule compression are incompatible actions.

2. Logistic Support Analysis

Ideally, the LSA effort should be initiated early and performed in its entirety. However, it should be realized that some actions can be postponed, without penalty.

3. Fielding

The Army needs to place greater emphasis on the criticality of trained and experienced materiel fielders to meet NETT, fielding team, user, PMO, and staff requirements.

G. INTERNATIONAL COLLABORATION

1. Economics, national pride, and differing national requirements (design, performance, mission, operational and support concepts), to include internal standardization, are obstacles to future attempts at weapon system collaboration with our allies.

2. National restrictions impinging on standardization and interoperability objectives should be waived where the advantages of international standardization and interoperability outweigh national standardization objectives.

3. A MOU should be written so as not to jeopardize the national sovereignty of the United States, e.g., preclude U.S. export rights.

4. International agreements should be made at high levels--sufficient to assess the impacts against national objectives, cost, and force effectiveness.

5. The following guidelines should be considered in future collaborative efforts:

- o Should not disrupt the development program by either increasing costs, reducing performance, or stretching out the schedule.
- o Should lead to demonstratable increases in military effectiveness for the system being developed.
- o Should not impede subsequent U.S. export of that system.
- o Should be reviewed by both countries users, developers, and industry.

H. GENERAL OBSERVATIONS

1. Concurrency is a deliberate and generally worthwhile solution to shortening the acquisition process, however, managers planning concurrent programs should be aware of the implications--the impacts on the ILS program, test and evaluation, and production facilitization planning (to name a few).

2. Program/Project offices are required by several DARCOM publications to submit lessons learned report to HQDARCOM. However, the requirement is not enforced and the benefits to other PMOs that could be realized from timely observations by other program management personnel are lost.

3. The Army has produced a tank that has demonstrated its superiority over existing tanks, that has had only a small real cost growth, that has met the production schedule, and has received favorable support from the users in Europe and in the Continental United States (CONUS).

APPENDIX A

PROGRAM ORGANIZATION

This appendix presents the following M1 ABRAMS Tank System organization charts.

1. Overall Organization for the M1 Abrams Tank System.
2. M1 Abrams Tank System Program Office.
3. Tank Main Armament System Project Office.

*Refer to Glossary for explanation of acronyms

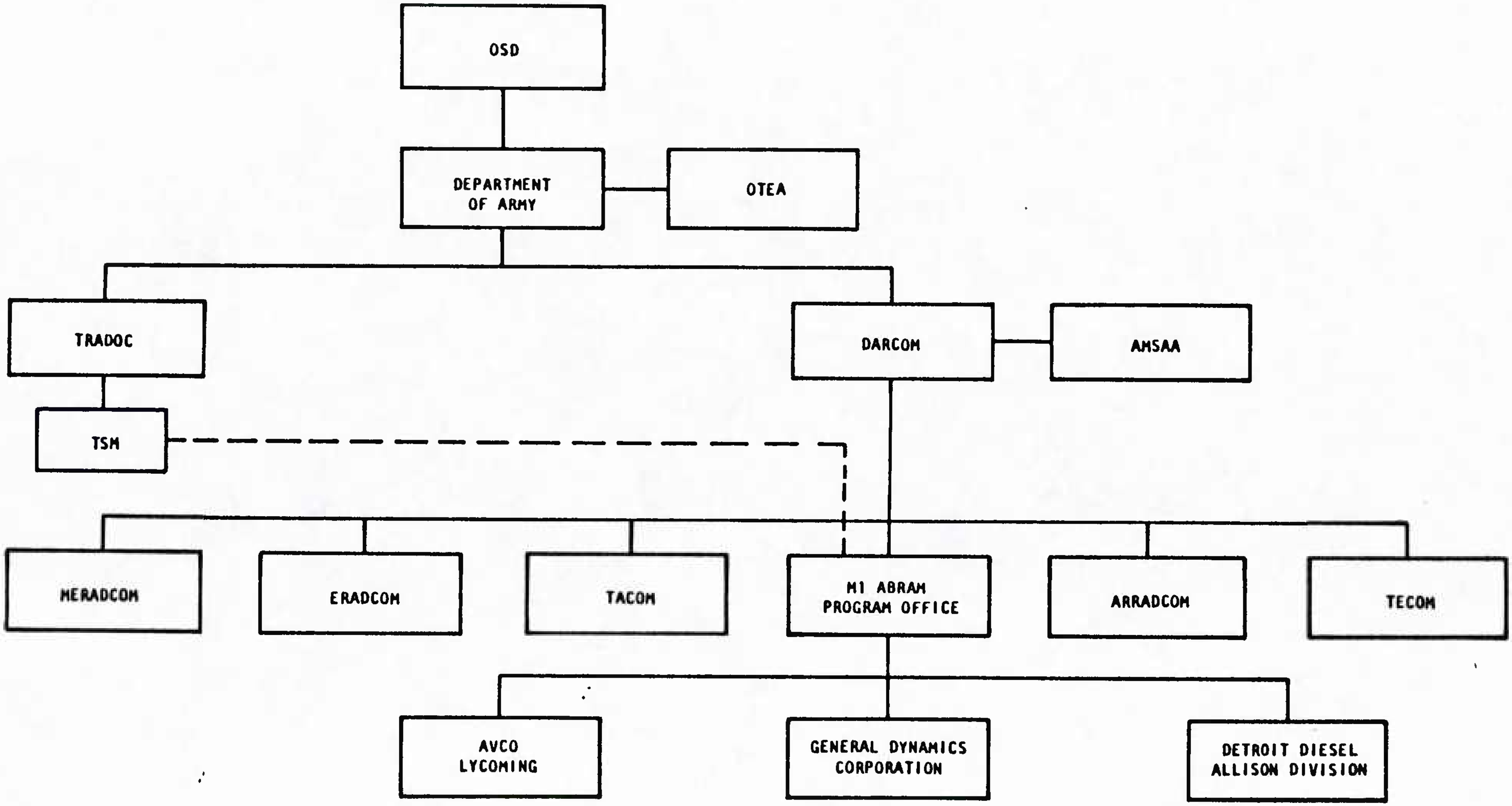
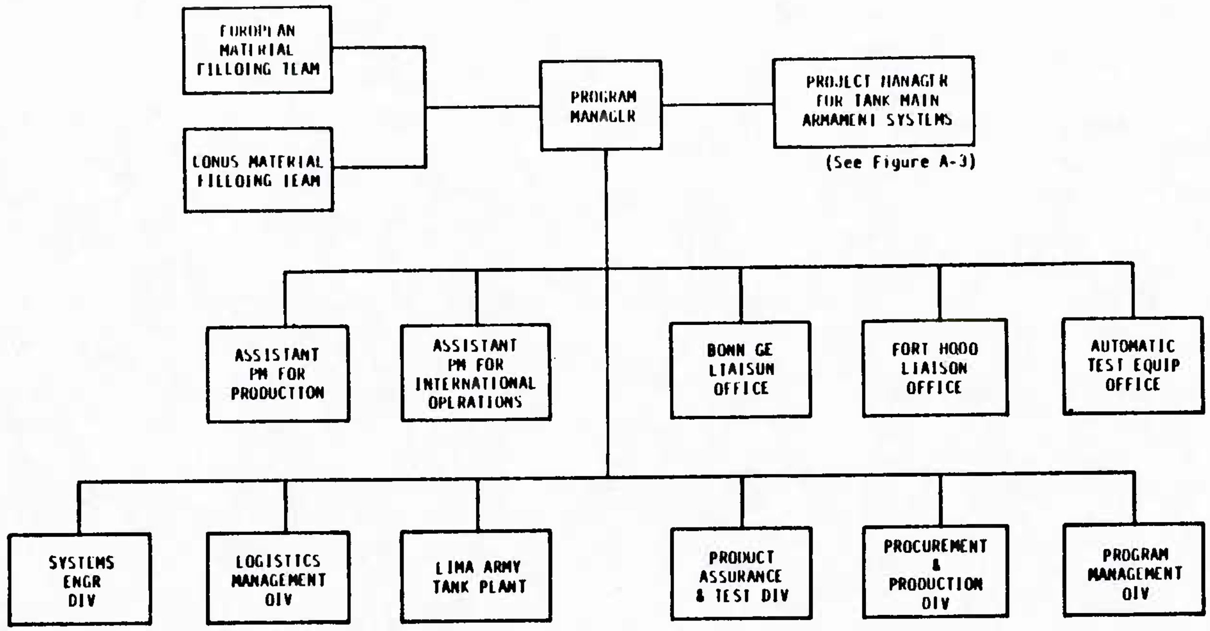
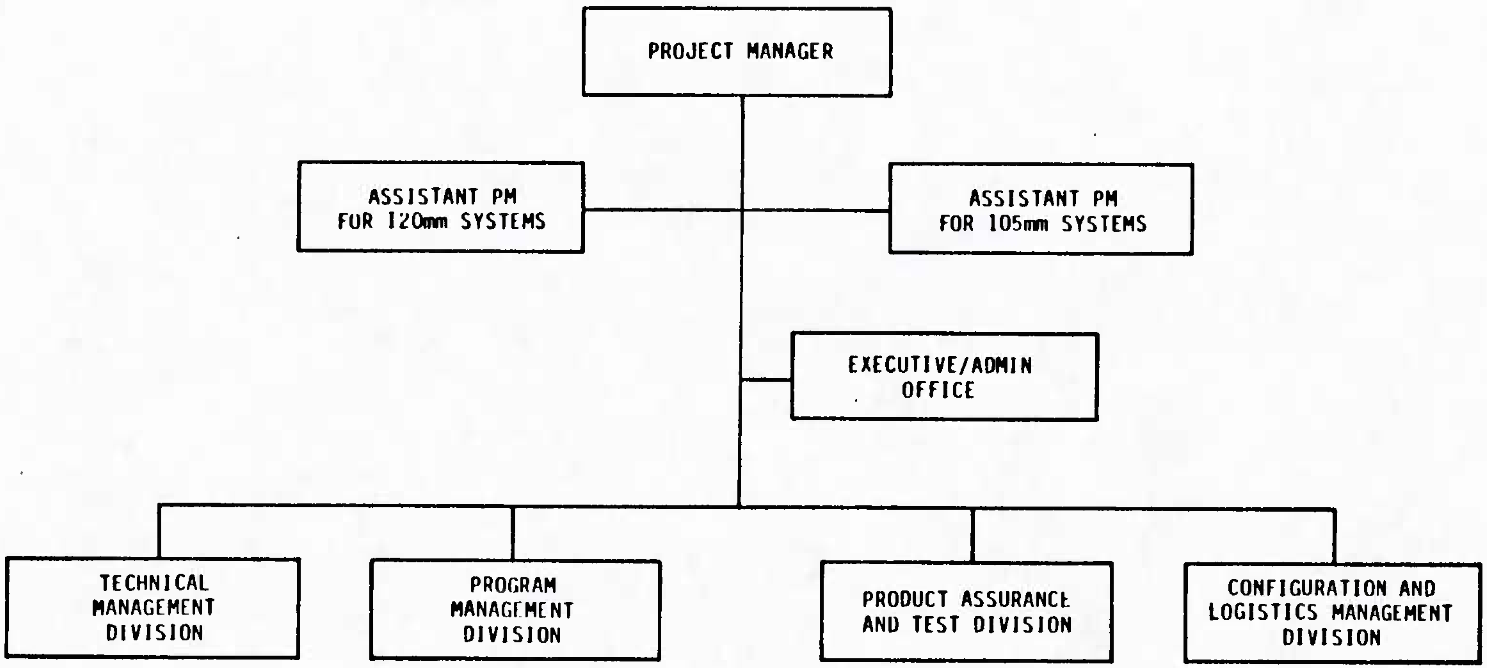


Figure A-1
OVERALL ORGANIZATION FOR THE M1 ABRAMS TANK SYSTEM



(As of SEP 82)

Figure A-2
OFFICE OF THE PROGRAM MANAGER M1 ABRAMS TANK SYSTEM



(As of JAN 82)

Figure A-3
OFFICE OF THE PROGRAM MANAGER TANK MAIN ARMAMENT SYSTEMS

APPENDIX B

HISTORY OF THE M1 ABRAMS TANK SYSTEM PROGRAM

1. 1963 PRINCIPAL EVENTS

In August, the United States and the Federal Republic of Germany (GE) agreed to jointly develop an entirely new tank--the Main Battle Tank 70 (MBT-70). The agreement established a Program Management Board that would be co-chaired by an American and a German representative.

2. 1970 PRINCIPAL EVENTS

a. In January, the U.S.-GE MBT-70 project was formally dissolved due to increasing cost and disagreements over national requirements for the new tank.

b. The U.S. continued development of an austere version of the MBT-70 known as the XM-803.

c. The FRG continued development of their version of MBT-70, the LEOPARD 2.

3. 1971 PRINCIPAL EVENTS

In December, Congress cancelled the XM-803 program due to system complexity and cost. However, $20 million dollars was appropriated by Congress to enable the Army to begin development of a New Main Battle Tank (NMBT).

4. 1972 PRINCIPAL EVENTS

a. In January, DA established the Main Battle Tank Task Force (MBTTF) to formulate the concept for the NMBT.

b. In February, the MBT Task Force, consisting of 22 officers and four civilians, representing the user, trainer, and developer, was organized at Fort Knox, KY. The Commander, U.S. Army Armor Center was designated as chairman.

c. In March, the Chief of Staff of the Army (CSA) directed an NMBT development program of six years to first unit equipped. This action accelerated the MBT Task Force mission.

d. In July, DA established the NMBT Project Management Office (PMO) at the US Army Tank-Automotive Command in Warren, MI. Brigadier General Robert J. Baer was designated the Project Manager.

e. In August, the MBT Task Force Report was published. It included an MN and a draft DCP.

f. In September, at one of several Army Systems Acquisition Review Council (ASARC) meetings--and after considerable discussion regarding mobility, survivability, cost, and weight -- the CSA directed that the NMBT would weigh 58 tons. In addition, the PM was directed to re-examine the cost estimates and find a better way to package the presentation arguing for a NMBT.

g. On 31 October, the ASARC met and concluded that the NMBT program should proceed into a competitive Concept Validation Phase. The winner of the competition would take the program into FSED.

h. In November, the Secretary of the Army redesignated the NMBT, the XM-1.

i. On 14 November, the Defense Systems Acquisition Review Council (DSARC) met to determine the readiness of the XM-1 program to commence the Validation Phase. No decisions were made by the DSARC at this meeting.

j. On 5 December, a DSARC Executive session was held and agreement was reached to support the XM-1 program.

5. <u>1973 PRINCIPAL EVENTS</u>

a. On 2 January, the DSARC met to expedite formal coordination of the XM-1 DCP No. 117.

b. On 18 January, the DCP was signed by the DEPSECDEF. The DCP did not establish performance thresholds but did establish a Design to Unit Hardware Cost (DTUHC) of $507,790 FY72$ based on a procurement quantity of 3,312 tanks produced at the rate of 30 per month.

c. On 23 January, the Requests for Proposals (RFPs) were sent to General Motors, Ford, and Chrysler.

d. In June, contracts were awarded to Chrysler and General Motors for the competitive prototype validation phase. Ford did not submit a proposal.

e. In October the Secretary of the Army approved a detailed management and control plan as presented by the PM.

6. <u>1974 PRINCIPAL EVENTS</u>

a. In March, a Trilateral Memorandum of Understanding (MOU) was concluded among the U.S., GE, and U.K.. The three nations agreed to test and evaluate each other's tank guns. These tests become known as the Tripartite Gun Trials.

b. In December, the U.S. and the GE concluded a second MOU in which the two nations agreed to make all reasonable efforts to achieve maximum standardization between the XM-1 and the LEOPARD 2. The U.S. also agreed to conduct a comparative test and evaluation of an Americanized version of the LEOPARD 2 for its possible purchase by the U.S. if after considering all factors, it proves to be superior to the XM-1.

7. 1975 PRINCIPAL EVENTS

a. The Tripartite Gun Trials were held in the U.K. and in the U.S. during the Winter and Spring.

b. Tank Special Study Group at Fort Knox conducted a follow-on study to the MBTTF of 1972. Their report, User Review and Analysis of XM1 Tank Requirements Documentation, 30 June 1975, resulted in revisions to the MBT MN (ED) in 1976.

c. In August, the results of the trials were published. The GE 120mm smooth-bore gun was determined to be the best suited for meeting the long-term threat.

8. 1976 PRINCIPAL EVENTS

a. In January, the Secretary of Defense (SECDEF) approved the Army's decisions to use the 105mm gun on the XM-1.

b. In February, the Army accepted prototype vehicles from both GM and Chrysler for Developmental Testing and Operational Testing (DT/OT I).

c. In May the DT/OT I was completed and the Army said that subject to SECDEF approval, it would announce the winner on 20 July.

d. On 24 June, the ASARC II met to review the program and the Source Selection Evaluation Board recommendations and to determine its suitability to enter FSED.

e. On 14 July, the U.S. and the U.K. concluded a Letter of Agreement (LOA) in which the two nations agreed to test the U.K.'s new tank ammunition in the U.S..

f. On 20 July, the Army's planned source selection announcement was delayed for one day at the request of SECDEF.

g. On 21 July, the SECDEF announced that there would be a 120-day delay in the XM-1 source selection announcement while the two contractors altered their bids to meet new standardization requirements.

h. On 28 July, the U.S. and the GE concluded an addendum to their 1974 MOU which committed them to an exchange of tank components and included a turret capability to accept either a 105mm or a 120mm weapon system.

i. In August, the Secretary of the Army announced the selection of the Lima Army Tank Plant (LATP) for XM-1 production with the Detroit Army Tank Plant (DATP) as a second production source.

j. On 28 September, the full Armed Services Committee approved the "Hillis Resolution" which threatened the tank gun program.

k. In September, the GE delivered the LEOPARD 2 (American Version) to the US Army for test and evaluation.

l. On 10 November, the DSARC II met to review the XM-1 program. The DSARC recommended that the Army be authorized to proceed to FSED. It also concurred with the turbine engine and dual capability turret decisions.

m. On 12 November, the Secretary of the Army announced that the Chrysler Corporation was selected to enter FSED. During the three-year FSED Phase, Chrysler would fabricate 11 XM-1 pilot vehicles at the DATP.

n. In December, the tests of the Leopard 2 in the U.S. were completed.

9. 1977 PRINCIPAL EVENTS

a. On 12 January, the Department of Defense announced the conclusion of an Addition to the Addendum to the 1974 MOU between the U.S. and the GE. The two nations agreed to focus strictly on the component exchange portion of the 1974 MOU.

b. On 11 April, a special ASARC met to determine tank production quantities. Many unresolved tank issues were deferred to the July DSARC.

c. In April, the Chief of Staff directed that a Special Tank Task Force (STTF) be established to develop a comprehensive review of the Army Tank Program prior to the FY79 Budget development and review.

d. On 12 July, BG(P) Donald M. Babers was assigned as PM XM-1, replacing Major General Baer.

e. On 22 July, the ASARC met to consider the alternatives proposed by the STTF. Among other decisions, an XM-1 procurement quantity of 7058 tanks was decided upon.

f. On 30 July, Public Law 95-79, containing the "Hillis Resolution" was passed.

g. In November, the General Accounting Office (GAO) issued PSAD-78-1, DOD Consideration of West Germany's Leopard As The Army's New Main Battle Tank.

h. During 1977, evaluation of the U.K., GE, and U.S. guns by the DA Tank Main Armament Evaluation Working Group continued as part of the collaborative effort among the three nations.

10. <u>1978 PRINCIPAL EVENTS</u>

a. On 31 January, the Secretary of the Army announced that the FRG 120mm smooth-bore gun would be mounted on future production versions of the XM-1 Tank. This decision established the requirement for a separate program for the M1E1 (with 120mm gun) so that the XM-1 (105mm) program could continue unimpeded.

b. In February delivery of FSED pilot vehicles commenced, and DT II was initiated.

c. In April, the ASARC approved the PM's program for development, testing, and fielding of the 120mm gun as the future XM-1 main armament system.

d. In May, OT II was initiated.

e. On 11 August, the Tank Main Armament System (TMAS) Project Office was established and Col P.B. Kenyon was designated as PM-TMAS, reporting to the PM XM-1. The XM-1 Project Office was redesignated as a Program Office with the PM XM-1 continuing to report directly to CG DARCOM.

11. <u>1979 PRINCIPAL EVENTS</u>

a. In January, OT II was completed.

b. In February, the OSD Power Train Review (Blue Ribbon) Panel was formed. The US government signed a 120mm tank gun and ammunition licensing agreement with Rheinmetal GmbH.

c. On 22 March, the ASARC III met and recommended the following:

- o XM-1 proceed to production and be a type classified Limited Procurement
- o A contract be let with Teledyne for development of a 1500hp diesel engine.
- o Initiation of the 120mm gun system development and integration program with deployment in 1985.

d. On 17 April, the DSARC III met and recommended LRIP for the XM-1 with first-year production quantity of 110 tanks.

e. On 8 May, the SECDEF Decision Memorandum, implementing the DSARC recommendation, was issued. Production rate was limited to 30/ month and FSED testing was extended.

f. In June, the Government entered into a contract with Chrysler to initiate the M1E1 program. OSD informed the Army that it expected the 120mm gun system to be ready for production not later then August 1974.

g. In August, because of threatened weight growth, the Vice Chief of Staff of the Army (VCSA) stated that he would retain approval authority for XM-1 weight growth beyond the addition of the 120mm gun.

h. In September the extended DT-II was completed.

i. In October, the PM XM-1 selected the GE designed breech for the 120mm gun.

j. In November, the complete Technical Data Package (TDP) for the XM-1 was delivered to the government. However, control was to remain with Chrysler through the first two production years.

12. 1980 PRINCIPAL EVENTS

a. In January, the GAO issued PSAD-80-20, XM-1 Tank's Reliability is Still Uncertain. The OSD Blue Ribbon Panel published a recommendation for further powertrain durability testing.

b. In February, the first LATP production tank was delivered.

c. In March, the DEPSECDEF scheduled a management review requirement for 1981 and authorized the Army to obligate FY 81 funds to continue production at not more than 30/month (withheld full-scale production authority). DT III commenced.

d. In April, the first XM256 120mm smooth bore cannon made in the US (Watervliet Arsenal) to GE design was delivered.

e. On 27 July, MG Duard Ball was assigned as PM M1 Abrams Tank Program.

f. In September, OT-III commenced at Fort Knox, KY and Fort Hood, TX.

g. In November, the PM briefed HQDA on potential M1 weight growth. Sixty-three tons was established as the upper Producibility Engineering Planning boundary weight limit for the M1E1.

h. In December, monthly quality reviews of the LATP commenced.

13. 1981 PRINCIPAL EVENTS

a. In January, the Initial Operating Capability (IOC) was achieved at Fort Hood.

b. Also in January, the PM briefed a proposed Block Improvement Program to the Acting Secretary of the Army and later the VCSA.

c. In February, a Special ASARC approved a production goal of 7,058 tanks by FY 88 and Type Classification Standard.

d. In March, the VCSA issued guidance to initiate improvements (Hybrid NBC system, Auxiliary Power Unit (APU), armor modifications, weight reduction improvements) for introduction to 1985 production of the M1E1. (A production date slippage of one year.)

e. Quality reviews with AVCO also commenced in March.

f. In April, quality reviews with the Detroit Diesel Allison Division commenced.

g. In May, OT III was completed at Fort Knox and Fort Hood.

h. In June, a DARCOM Joint PIP Review, in response to the VCSA guidance in March, terminated retrofit plans for 16 proposed improvements to the M1.

i. In September, the VCSA approved M1E1 initial production for August 1985 and eliminated the APU requirement. GAO issued PLRD-81-33, Logistics Planning for the MI Tank: Implications for Reduced Readiness and Increased Support Costs.

j. On 20 August, HQ DARCOM approved conditional release of the M1.

k. In August, the DA Blue Ribbon Panel (an independent task force of technical experts) concluded that the power train would likely exceed required durability and obtain 8500 miles between durability failures in the third year production program.

l. In September, the SECDEF lifted the 30/month production limit and authorized full-scale production.

m. In December, GAO issued MASAD-82-7, Large-Scale Production of the MI Tank Should Be Delayed Until Its Power Train is Made More Durable.

14. 1982 PRINCIPAL EVENTS

a. On 16 March, General Dynamics Land Systems (GDLS) assumed the prime contractor responsibility following its purchase of Chrysler Defense Incorporated from Chrysler Corporation.

b. In March, the first M1 tanks were delivered from the DATP.

c. In May, all DT III testing was completed.

d. In June, quality audits of GDLS and major subcontractors commenced.

e. By August, three battalions had been fielded and trained in Europe, two in the CONUS, and a total of 585 tanks accepted by the Army.

f. In October, combined tank production at the LATP and the DATP was approaching the November goal of 60/month.

APPENDIX C

PROGRAM PLAN BY PHASE

1. COMPETITIVE ENGINEERING DEVELOPMENT (VALIDATION)

a. During the 34-month Validation Phase, two competing contractors and the Army conducted developmental and operational tests to evaluate the prototype vehicles. Validation testing demonstrated the feasibility of the design of the two competing prototypes and their potential to satisfy the system requirements as stated in the MN. The U.S. Army Materiel Systems Analysis Activity (AMSAA) prepared the independent evaluation of the Test and Evaluation Command (TECOM) development tests and the U.S. Army Operational Test and Evaluation Agency (OTEA) conducted the independent operational test and evaluation. The two prime contractors, General Motors and Chrysler, were tasked to design and fabricate the prototype systems for testing. The government was responsible for providing the 105mm gun, ammunition, and driver's viewers. In addition to prototype development, each contractor prepared cost estimates for the first two years of production and the Life Cycle Cost (LCC) for 3,312 tanks produced over a 10-year period.

b. The Validation Phase test program was designed to provide data from two competing systems in order to: (1) determine the degree to which each system met the contract requirements and (2) provide data for the Army's independent evaluation prior to ASARC/DSARC II. Objectives of the tests were to demonstrate system performance, and to determine technical risks associated with proceeding into the FSED Phase with a single contractor. The test programs for the competing systems were identical and consisted of the following:

- o Ballistic Vulnerability Testing
- o Automotive Tests
- o Firepower Performance Tests
- o Operational Tests

c. The Validation Phase test schedule was compressed into three months. DT I and OT I were conducted concurrently. This compression of the test schedule did not enable sufficient part, component, and subsystem testing prior to the full vehicle testing. Furthermore, test assets, e.g., availability of sufficient test sets, were not adequate to support the concurrent testing. Details on the management of the Validation Phase testing program are presented in Appendix H.

2. FULL SCALE ENGINEERING DEVELOPMENT PHASE (FSED)

a. In November 1976, the DSARC recommended that the Army proceed into FSED of the M1 Abrams Tank. On 12 November, the Secretary of the Army announced that Chrysler corporation was selected as the prime contractor. During this three-year phase, Chrysler produced 11 pilot vehicles with associated hardware at the DATP. These vehicles underwent intensive developmental and operational testing (DT/OT II) under most types of climates and simulated battle field conditions. Included in the scope of the FSED contract was the requirement to establish producibility of design and complete the Technical Data Package (TDP). The production baseline was modified near the end of the FSED contract to reflect a total tank buy of 7,058 at a rate of 60 per month.

b. Concurrent with the FSED contract, Chrysler was awarded a production planning and manufacturing engineering contract in November, 1976, and a facilities contract in April, 1977. These contracts provided for tooling design, make/buy analysis, development of standards, machine selection, and plant layout required to produce the M1 tank at a rate of 60 per month on a single eight-hour shift with the capability to surge to 150 per month.

c. During the period 13 November to 14 December 1978, the M1 Tank Production Readiness Review was conducted. The procedures and findings of this independent and objective review to verify that the production design, planning, and associated preparations for the tank system had progressed to a point where a production decision could be made are discussed in Appendix F.

d. The M1E1 is in FSED and has yet to be tested IAW the performance goals in the MN. Improvements to the gun turret drive, final drives, and suspension systems are being made to the M1E1 to the maximum extent possible consistent with minimizing their impact on RAM-D performance.

3. PRODUCTION PHASE

a. Low Rate Initial Production

(1) At the ASARC III held on 22 March 1979, the M1 Abrams Tank was type classified limited procurement. A waiver to defer type classification of the training devices and maintenance test sets was recommended by the ASARC members and approved by the VCSA.

(2) On 8 May 1979, the SECDEF approved the production of 110 M1 tanks during the first year of production. (Actually, only 90 were produced). Subsequent production, leading to a total acquisition objective of 7,058 M1 tanks would be dependent upon attainment of specific performance goals with

particular emphasis on reliability and durability. The production contract, which was an option to the FSED contract with Chrysler, budgeted a "Not to Exceed" FY 76 ceiling price. A second year production option was awarded in September 1980.

(3) The Development Test III was conducted from March 1980 to November 1981 to provide information on contract compliance and quality assurance to assist in making subsequent deployment and production decisions. Included in the DT III were Production Verification Tests by the Contractor (PVT-C) and by the Government (PVT-G). Nine LRIP tanks were used in these tests. Their results of these tests were generally satisfactory with the exception of track life and powertrain durability.

(4) The Operational Test III was independently conducted at Fort Knox, Kentucky and Fort Hood, Texas by OTEA during the period October 1980 to May 1981. The critical test issues for the Fort Knox Phase included mission reliability and compliance with specifications for the powertrain. Conversely, the Fort Hood Phase addressed the issue of system performance, i.e., the FSED M1 versus the initial production model. The results of OT III testing indicated that all test requirements were generally satisfactory with the exception of track life and powertrain durability.

b. Full Production

(1) A special ASARC was conducted on 17 February 1981 to decide on the plan to support third year production and fourth year advance procurement actions. The decision was also made at this time to type classify Standard the M1 Abrams Tank.

(2) Full production was authorized as a result of a 15 September 1981 OSD Management Review. The first production delivery for the DATP occurred as scheduled, and the first two tanks were accepted by the Government in March 1982. In November 1982, the combined production (LATP and DATP) reached the 60/month rate.

(3) Fielding of the M1 Abrams Tank has proceeded on schedule with the first unit equipped in CONUS at Fort Hood, Texas in January 1981 and in Europe in January 1982.

(4) The key production milestones for both the M1 Abrams Tank and the M1E1 tank are shown in Figure C-1.

M1

MILESTONE	DATE
DARCOM Conditional Release	20 August 1981 (Actual)
OSD Management Review	15 September 1981 (Actual)
Full Production Contract (LATP)	15 October 1981 (Actual)
European Fielding Initiated	15 January 1982 (Actual)
1st Production DATP	31 March 1982 (Actual)
TDP Validation	30 June 1982 (Actual)
FORSCOM NET & Fielding Initiated	31 August 1982 (Actual)
Achieve 60 Tanks/Month	30 November 1982
Complete Initial Production Test, DATP	28 February 1983
Full Materiel Release	31 March 1983 (rescinded)
Complete LATP Durability Test	15 April 1983
Extended Conditional Full Materiel Release	15 September 1984
Introduce Armor Modification	31 December 1984
Achieve 90 Tanks/Month	28 February 1985
Surge Capacity at 150/Month	31 August 1985

M1E1

MILESTONE	DATE
Armor Mod TDP Complete	31 May 1982 (Actual)
Initial System Spt Pkg in Place	[illegible] 1982 (Actual)
DA Review Armor Mod	[illegible] 1983
Complete DT II	[illegible] 1984
Complete OT II	[illegible] 84
TDP Accepted	[illegible] 1984
DA Management Review	[illegible] June 1984
First Production Delivery	31 August 1985

Figure C-1
KEY M1 AND M1E1 PRODUCTION MILESTONES

APPENDIX D

PROGRAM REVIEWS AND REDIRECTIONS

This appendix serves to summarize the external forces that have impacted the Ml Abrams Tank Program since 1972. Readers who review the following pages of Army, DoD, and Congressional actions will gain a better perception of the lessons learned from the Ml Tank Program.

The program commenced with an absolute DTUHC threshold of $507,790 in FY72 dollars, a compressed schedule requirement, and several requirements for which no trade-off was allowed (RAM-D, dimensions, weight). It had to be a success oriented program from the start.

There were various pressures and requirements regarding the FRG LEOPARD tank as an alternative to the XM-1 and for the use of the 120mm gun rather than the 105mm gun on the XM-1. It was not until late 1976 that the Leopard II issue was settled and it was 1978 before the main armament issue was settled in favor of the GE 120mm gun and the MlEl tank program established.

Finally, powertrain durability and other RAM-D questions arose, test requirements were expanded, and an alternate 1500hp diesel engine development program directed.

1. Army System Acquisition Review Council

a. ASARC I, 31 October 1972: Concluded that NMBT was ready to proceed into Concept Validation Phase.

b. ASARC II, 24 June 1976: Program review determined suitability to enter FSED.

c. Special ASARC, 11 April 1977: Many unresolved tank issues surfaced requiring establishment of a STTF and a subsequent ASARC.

d. Special ASARC, 22 July 1977: Special Tank Task Force alternatives were reviewed. Recommendations included a production goal of 7,058 tanks from two interdependent plants with surge capability of 150 tanks/month.

e. Special ASARC, 17 April 1978: The program implementing the XM-1 tank 120mm main armament system was reviewed.

f. ASARC III, 22 March 1979: The LRIP decision was made. The tank was Type Classified Limited Procurement. The 120mm gun development and integration program was approved.

g. ASARC Decision Review, 17 February 1981: The classification changed to Standard and production goal of 7,058 by FY88 was approved.

h. ASARC IIIa, 10 August 1981: The production rate was determined and the fielding plan was revalidated.

2. Other Army Reviews/Redirections

a. Army Chief of Staff directs 6 year program, March 1972.

b. MBT Task Force prepares MN and DCP in August 1972.

c. Army Chief of Staff directs 58 ton tank, September 1972.

d. Army decides to equip XM-1 with 105mm gun - January 1976.

e. Army decides to equip XM-1 with the GE 120mm smoothbore gun - January 1978.

f. VCSA instructs that improvement program be initiated - 1980.

3. Defense System Acquisition Review Council

a. DSARC I - 14 November 1972 - no decision.

b. DSARC I - 2 January 1973 - recommended approval of DCP with $507,790 DTUHC.

c. DSARC II - 10 November 1976 - recommended approval of FSED for XM-1.

d. DSARC III - 17 April 1979 - recommended approval of LRIP, 110 tanks first year. Future production was dependent upon test results, the alternate engine plan, a leader-follower approach for the AGT-1500 turbine engine, and other conditions.

4. Other OSD Reviews/Redirections

a. DEPSECDEF Packard, "Fly before you buy" memorandum - 1972.

b. Design to Cost emphasis - Cost Analysis Improvement Group (CAIG) established - 1972.

c. SECDEF arranges U.S. test of GE LEOPARD 2 tank - 1973.

d. SECDEF requires Trilateral Gun Trials - 1974.

e. SECDEF approves Army's decision to equip XM-1 with 105mm gun -1976.

f. SECDEF delays Army's source selection announcement - 1976. Proposals to be resubmitted to include new standardization requirements.

g. Army directed to develop back-up 1500hp diesel engine - 1979.

h. In 1979 OSD informs Army that it expects 120mm gun system to be ready for production by August 1984.

i. OSD Administrative Review Army directed to conduct more durability tests - 1980.

j. OSD Management Review - 15 September 1981 - Army authorized to take Abrams Tank into full production. The M1E1 production goal for 1985 was approved.

5. <u>Congressional Reviews/Redirections</u>

a. MBT-70 Program terminated in 1970 due to cost and complexity.

b. XM-803 Program terminated in 1971 due to cost.

c. Army provided with $20M to initiate R&D for a NMBT - competitive prototype program specified.

d. House Armed Services Committee (HASC) appoints M1 Tank Panel in August 1976.

e. "Hillis Resolution" approved by full armed Services Committee, September 1976.

f. Congress directs Army to initiate 1500hp diesel engine development program for turbine engine back-up.

g. GAO requested by Senator T.F. Eagleton to monitor the LEOPARD II (American Version) test and analyze the results.

APPENDIX E

BUSINESS MANAGEMENT

1. PROCUREMENT HISTORY

a. The M1 ABRAMS Tank Program was initiated in December 1971 when Congress directed the termination of the development of the XM-803 Tank System as unnecessarily complex, excessively sophisticated, and too expensive. Congress supported the concept of a new tank for the Army and provided funds for the Army to initiate a prototype development program utilizing competition to produce a new tank.

b. Contracts were awarded in June 1973 for the prototype Validation Phase of the development of the M1 Tank System. The prime contractors were Chrysler Defense Incorporated of Chrysler Corporation and the Detroit Diesel Allison Division of General Motors Corporation. The Army requirement was to develop a tank system that met the MN requirements while remaining within the DCP Design-to-Unit-Hardware-Cost threshold of $507,790 in 1972 dollars as the average cost of 3,312 production tanks, at a production rate of 30 per month.[1] Subtracting $57,790 for GFE equipment from this total established the contractor's DTUHC goal at $450,000 for the manufacturing cost plus engineering support to production. The contractors accepted total system responsibility. While the contractors were encouraged to make tradeoffs within the specified performance bands, they agreed to the following:

- o Design within the DTUHC ceiling.
- o Applicable values for RAM-D, vehicle width, and vehicle weight could not be degraded.

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[1]The DTUHC thresholds of $507,790, as applied to the M1 Program, was also the DTC goal.

- o Their proposed design would offer improvement, not merely marginal gains in performance over existing systems. (A marginal gain was stated to mean performance equal to that of the M60A3).

Both contractors completed Validation Phase with tank prototype designs that met the established performance requirements and with hardware costs validated by the Government to be below the contractual DTUHC threshold.

c. In early February 1976, the Army accepted prototype vehicles from both General Motors and Chrysler Corporations. Engineering and operational testing of the two US candidates were conducted through April 1976. In November 1976, the Secretary of the Army announced that the Chrysler Corporation prototype concept had been selected to enter FSED.

d. A Manufacturing Engineering, Tooling, Special Test Equipment and Facilities Procurement Program (METSFPP) was established with Chysler. The program was initiated to provide for the production planning and support relative to the facilitization, qualification, and technical and cost data required for production of the M1 Tank System. This program was in addition to the FSED contract for fabrication of hardware and testing. The program was developed to ensure a smooth and timely transition of the M1 Tank System from the Full Scale Engineering Development/Producibility Engineering and Planning (FSED/PEP) Phase to production at the Lima Army Tank Plant (LATP) and Detroit Army Tank Plant (DATP). It also included the facilitization of major component subcontractors.

e. The Low Rate Initial Production (LRIP) contract contained the following ceiling priced options related to production:

OPTION	DESCRIPTION	DATE EXERCISED
1A	Long Lead Items for 110 Tanks	Oct 77
1B	110 Tanks - First year Production	7 May 79
2A	Long Lead Items for 352 Tanks	Apr 78
2B	352 Tanks - Second year Production	12 Sep 80

First and Second Year production was reduced to 90 and 309 tanks, respectively, due to program restructuring. Total quantity for the two production years was 399 in lieu of 462. The 63 remaining Option 2 tanks were procured within the third year production contract but the 2d year cost ceiling was applied. Due to the previously mentioned restructuring, these sixty-three tanks had contractor furnished engines, transmissions, final drives, and track which are otherwise broken out for direct procurement during the third year.

The scheduled M1 vehicle deliveries will total 968 by the end of the third year (March, 1983). Based on the plans as of October 1982, the monthly production rate would then be 60 tanks per month (30 at the LATP and 30 at the DATP). In the fourth year, vehicle deliveries will average 70 per month as the production rate progresses toward the 90 per month goal, subject to funds availability. (see Figure E-1).

f. Full-scale production was authorized as of September 1981.

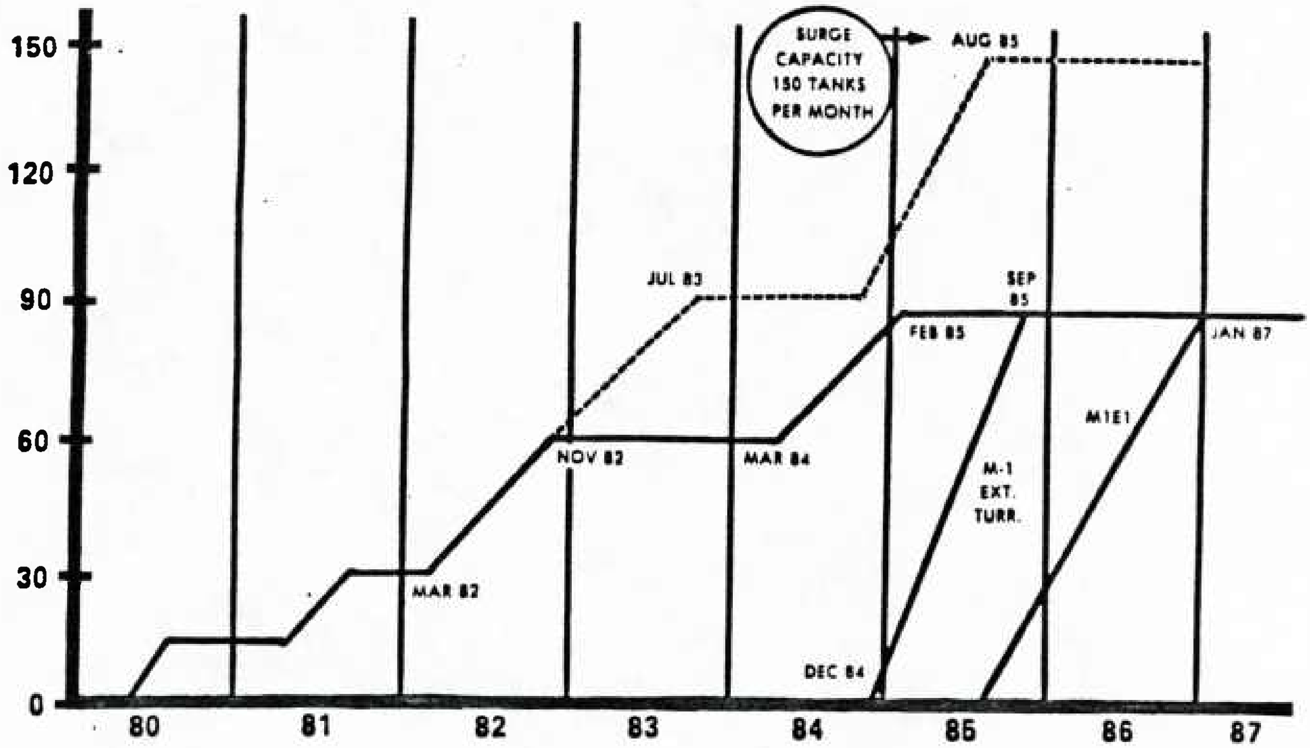

Figure E-1

Source: PMO Aug 82

M1 AND M1E1 PRODUCTION CAPACITIES
(Tanks Per Month)

2. COMPETITION AND SOURCE SELECTION

a. Background

Competition was used on the XM-1 Tank System acquisition during the Validation Phase. Technical and cost competition was conducted between Chrysler and General Motors for award of a contract for FSED with production options.

The source selection plan was modified in July 1976 after the source selection evaluation had been completed. Both contractors had to resubmit their proposals with specific requirements to include a proposal for a tank using a turbine engine and proposals for each engine (diesel and turbine) with and without costs for standardization with the GE Leopard 2 Tank.[2]

Both competitors were essentially equal in the technical aspects of their original proposals, though GM was using a diesel engine and Chrysler a turbine. At the point when new proposals were requested, GM's costs were evaluated as more realistic and lower than its competition. However, during the reproposal period, Chrysler submitted a proposal with lower costs.

Although the final GM and Chrysler proposals were close, Chrysler was awarded the FSED contract with production options.

(b) Observations

(1) Consideration should be given to continuing competition through FSED. However, the tremendous outlay for dual facilitization required to maintain GM in FSED was considered not be be cost effective. Factors other than the availability of funds, e.g. concurrency, also limit the possibilities for competing a major system past the validation phase.

(2) The high investment cost in facilities and tooling required to produce a system or its major components may preclude any competition. Price improvements may be sought through other techniques such as component breakout, multiyear contracts, or use of production options with a competitively awarded FSED.

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[2]Addendum to 1974 MOU between US and Germany required the identification and specification of areas of standardization of their respective tanks, and maximization of compatibility and commonality of components.

(3) The possibility of fostering competition should be evaluated to ensure that the costs of establishing a second source for a system or major component will not exceed the expected long term savings, i.e. production, life cycle costs, and program costs.

(4) Competition increases the difficulty of obtaining data from the competitors beyond that required by the RFP or contract. The contractor's concern for protecting his competitive edge deters him from releasing information the PM staff requires for planning.

(5) Proper validation for the contractor's cost data necessitates the use of qualified Government personnel with sufficient experience to question the rationale as well as the validity of the contractor's submission. An in-depth validation is also an opportunity for the Government to gain detailed knowledge of the contractor's management, operational practices, and credibility.

(6) Although every effort should be made to prevent leveling at source selection, the restrictions should not be so rigid that the SSEB is prevented from seeking necessary clarifications of the contractors' proposal. Similarly, each evaluator must maintain a constant awareness of the potential for leveling and its derogatory effects in a competitive environment.

(7) Evaluation of a matrix of eight alternative proposals as directed by the user was very cumbersome. The Government should limit the number of alternatives it requests to the minimum practical. Since a SSEB is generally resource limited, analysis of additional alternatives can only be accomplished at the expense of other evaluation tasks.

(8) A representative of the PMO staff among the SSEB members serves to improve the communication and coordination between the two entities. It also provides the PMO with a corporate memory of the Source Selection Evaluation Board (SSEB) actions long after the SSEB has disbanded.

3. COST MANAGEMENT

a. Background

Following DSARC III, DOD directed that the PM revise his acquisition strategy, which had not envisioned component breakout prior to the fourth production year, to one that considered and included those approaches resulting in the greatest cost savings to the Government. Specific guidance was given to consider breakout, competitive second sourcing, and leader-follower techniques, the first in regard to engine and transmission procurement. Detailed analyses were conducted by a DARCOM-headed task force on the proprietary of Form Fit and Function (F^3), and Leader-Follower (L-F). Conclusions were that F^3 had no application and L-F adoption would result in cost excesses rather than savings even if the planned production run of 7,058 tanks were doubled. These findings were briefed to DA and DOD. The concepts were not pursued further.

Selected components are being procured directly by the Government and provided to the prime contractor as Government Furnished Material (GFM) in the third and fourth production year.

A plan for second sourcing of selected fire control components was also developed. The plan called for an FY83 educational buy of the Ballistic Computer, Gunner's Auxiliary Sight, Commander's Weapon Station, Line-of-Sight

Data Link, and Thermal Imaging System with deliveries in the sixth program year delivery period. An option was available for a split buy in the seventh year and competitive procurement in the eighth year. Funding of the second sourcing plan was delayed for one year and this provided the opportunity to reconsider the program in lieu of new guidelines for expanded use of multiyear procurement authorized by Congress in fiscal year 1982. The program was restructured to provide for multiyear contracts with current producers for the fifth, sixth, and seventh program years. Based upon a cost benefit analysis, it was concluded that in the absence of present second source capability, use of the revised multiyear contracting approach for acquisition of the fire control components offers the greatest savings to the Government. However, plans for the development of second sources in sufficient time to permit the cost effective competitive acquisition of future requirements remains an active consideration.

The 105mm cannon gun mount has been dual sourced in the fourth and fifth production year programs. The buy will be split between the prime contractor and the Army's Rock Island Arsenal. During the sixth and seventh years, all 105mm cannon gun mount requirements will be produced by the Rock Island Arsenal and the prime contractor will furnish the 120mm gun mounts only.

The cost effectiveness of developing a second source for the AGT 1500 gas turbine engine is being explored for the acquisition of production requirements beginning in the FY86 funded delivery period. Comparative cost benefits, expanded production bases, and improved delivery capability are prime considerations in the evaluation of turbine engine acquisition alternatives.

During the first two years of production, Chrysler Defense purchased and manufactured all components and materials necessary to fabricate and assemble the complete M1 tank with the exception of guns, ammunition, smoke grenades and launchers, driver's viewers, STE/ICE (adapted for turbine engine use), selected hand tools and other basic issue items. These items were purchased separately by the Government and provided directly to Chrysler and/or the user for installation on the tank. Chrysler produced and maintained all applicable publications and manuals that were shipped with the tank at delivery. The third year requirement established the first break-out of the engine, transmission, and final drive. The fourth year requirement establishes additional break-out of gun mounts and selected fire control items. These major components will be procured directly from the manufacturer and provided to the prime contractor as GFM.

Figure E-2 presents the components of the M1 ABRAMS Tank Program cost in terms of the average unit escalated dollars in millions.

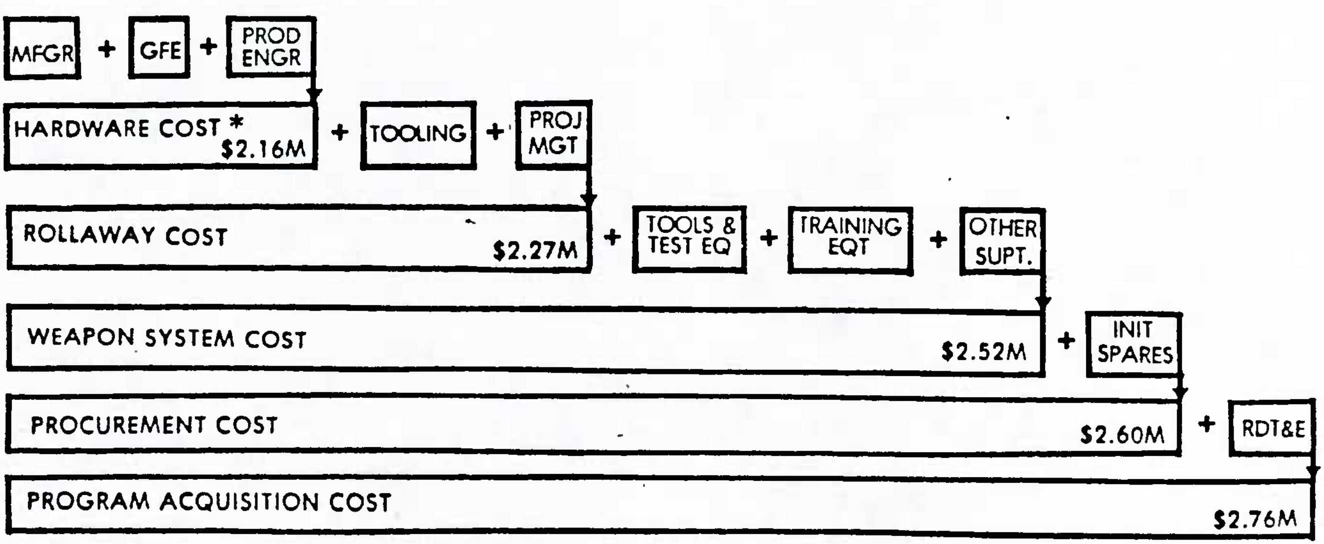

Figure E-2
COMPONENTS OF ABRAMS TANK PROGRAM COST
(Average Unit Escalated Dollars in Millions)

b. Observations

(1) All budgets regarding the M1 program were converted from constant dollars to future year inflated dollars by using the directed OSD/OMB inflation indices. These indices have been consistently low over the years in predicting future year inflation. Budgets become established at a certain inflation value and with the inflexible funding cycle within DOD, budgets tend to get locked in as far as three to four years in advance through the POM process and are solidified two years in advance. If inflation skyrockets within the two-year timeframe, little or no provision is made for adjustment to account for additional inflation. This was evident in the FY79 and FY80 budgets of the M1 and other major acquisition programs when inflation was running well ahead of the predicted Office of Management and Budget (OMB) values, causing budget shortages and quantity reductions. Therefore:

- DOD should establish an "inflation adjustment" process at the beginning of each fiscal year in which all major programs are automatically adjusted for actual inflation in accordance with predetermined indices.

- Major procurement programs should be allowed to project their unique inflation indices. This is necessary since the major defense contractors who produce the items experience inflation at a higher rate than the general economy and labor rates are higher at most of these organizations. M1 tried to get this approval based on the rationale that elements of cost differ among products/programs due to differences in labor content, energy content, types of raw materials, and geography among others. No single general purpose economic index addresses this problem adequately.

(2) The Baseline Parametric Analysis that predicted a $507K tank for the M1 was converted into a budget directly through application of a learning curve to the average value and spreading of costs over the production years with addition of all known supporting budget lines.

- o Contractor's early estimates of tooling and facilitization costs were very close to that determined by the Government. The problem was that the original plan was to facilitize to a 30 per month rate on a no shift basis; later the facilitization plan was changed to a 150 per month on a 3-8-5 basis. This shift naturally caused problems. The other differences arise from the fact that all contractors did not facilitize as originally directed.

- o The Production Budgets of major Army programs should be allowed to have a contingency line or a "TRACE" element to allow for unknowns. RDT&E budgets have TRACE dollars, and procurement budgets should contain a reserve also - until the program gets past the first few years of production and the costs are stabilized.

(3) The M1 Procurement Cost Baseline was established prior to program initiation in 1971, in a parametric study conducted by the MBTTF at Ft. Knox, with input from all available cost estimating sources for cost information. Concurrently, the Army contracted for contractor cost studies to provide industry impact from the Chrysler Corp. and General Motors Allison Division, who were the two prime contenders for the validation phase contracts. The Baseline Study also relied significantly on previous cost estimates provided to the Army during the MBT/XM803 development (1966-1971), wherein a detailed cost estimating process had been conducted in conjunction with a producibility/cost study directed by the Battelle Institutes. All of this information was compiled by the Task Force, best estimates prepared from the data, and a range of most likely costs were presented in the final report of the Task Force in 1971. Based on that report, the threshold of $507K was established for the tank.

- o Outside, independent estimates from industry sources other than the two most likely competing contractors could have been extremely useful. GM and Chrysler knew they would be competing to get into the validation phase, and were compelled to keep their cost studies as optimistic as possible, so as not to jeopardize their potential as future competing contractors.

- o The $507,790 threshold should have had a range around it. If not a range, then the threshold should have been established as the "worst case" or highest value after the analysis was completed. At that time, the thresholds had no allowance for engineering changes, and now ECOs are included, which is an improvement, but some provision should also be added for unknowns of at least 10 to 20%.[3]

- o On all programs, we continually deflate our current estimates to compare to the original threshold in constant dollars which continually decrease in value. For example, on the M1 we are now 10 years away from the original 507K threshold, wherein inflation has decreased by 3 the value of the dollar, and yet we still track to the old dollars. We would be much better off in terms of realism and credibility, if the threshold was adjusted upward each year for inflation.

- o Baseline estimates tend to be too optimistic, partly because they are generated by the Armed Service which is interested in promoting the program. Totally independent "worst case" analyses should be conducted from outside of DOD preferably by contracting with private industry or consultants in the manufacturing or industrial engineering areas and these contracts should be let by OSD, rather than the interested service.

(4) On the M1 program, extensive tracking of Design-to-Cost was conducted during Validation and FSED Phases of Development, with quarterly reports generated by the prime contractor and the major subcontractors. Labor estimates, material costs, detailed vendor quotes, and overhead estimates, were all compiled in great detail. The government conducted detailed reviews of the contractor reports to establish realism of the estimates. Participation by all interested levels of DOD were ensured, including DARCOM, DA, and OSD. Each level confirmed the accuracy of the reports and declared their validity.

A Design-to-Cost Award Fee was established during FSED to incentivize the contractor to do well in his DTC process. The award fee was tied

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[3]The PMO argued for a range of threshold values.

to the production price for the first two years. Of the $7 million total award fee available, $5 million was presented to the contractor.

- o In spite of all the good work done during the DTC process, one must realize there is no commitment on the part of the contractor to finally sell the product at the predicted price. Once the production decision is made, the "sales job" conducted during FSED is over, and the contractor will disown his own predictions made in DTC and charge the government whatever the market will bear. There is no easy solution as to how to enforce the DTC estimates, and make them come true.

- o The design must be producible at the DTUHC. No advantage is served by driving contractors into bankruptcy. No fee should be paid for DTC until the contractor has demonstrated on hard tooling that the item can be produced on the basis agreed upon. Independent assessment should be made <u>before</u> any production.

APPENDIX F

TECHNICAL MANAGEMENT

1. BACKGROUND

a. Main Battle Tank Task Force

The efforts to develop the MBT-70 and the XM-803 resulted in the accumulation of a great deal of knowledge concerning concepts, technology (both state-of-the-art and potential capabilities), and the Army's MBT requirements. The MBTTF drew upon this experience when it prepared its recommendations and the NMBT MN and Development Plan.

In March 1972 the Army Chief of Staff instructed the MBTFF to plan on a six year program with the first unit equipped in 1978. Consequently, the MBTTF had to restrict the development plan to using state-of-the-art technology and components which were on-the-shelf improvements or which were capable of being developed and integrated into a total vehicle with moderate risk or less in a 6 year program. Designed into the system would be the capability to receive product improvements. The hull and turret design was also to consider components that could be available at a later date. In addition, the NMBT would have the growth potential to accept the integration of technical advantages as they become available over the long range time frame. Finally, special purpose kits, such as dozer blades, mineplows or rollers, and environmental kits were also to be considered for the NMBT.

The task force projected the components that they expected to be available in eight and ten years should more than six years be available for development. Some of these components are on the current M1 tank. They include the day/night thermal sight, the turbine engine, and the improved armor. In fact, the MBTTF report was adament about the significant advantages of new armor techniques and stated that they must be incorporated in a NMBT even if one to three years additional development time was required.

The development plan provided for four phases: concept formulation, validation, full scale engineering, and production. The production phase was to consist of two segments; low rate initial production and full scale production.

The component development activities and test programs initiated during concept formulation would continue thru 1973 to provide data to assist in the selection of a best technical approach. Provisions were made for essential testing when uncertainties were present for a particular component. The total program would range from laboratory tests to test rig operation.

System development was to be initiated in the Validation Phase which was to involve two competing contractors. Prototype systems would be tested by the Government.

The winning contractor would be awarded a full-scale engineering development/producibility engineering program contract with requirements for system engineering, configuration management, and a logistic support program. Eleven vehicles were to be produced during the phase.

The production phase was based on the procurement of a total of 3,312 vehicles at an average production rate of 30/month. Initial production was to be non-competitive.

The priorities established for the NMBT characteristics are shown in Figure F-1.

- o Firepower
- o Mobility
- o Crew Survivability
- o Reliability, Availability and Maintainability
- o Cost
- o Weight
- o Equipment Survivability
- o Improvement Potential
- o Human Engineering
- o Transportability
- o Compatibility with associated equipment (bridging, transporters, etc.)

Source: MBTTF Report, August 1972

Figure F-1
PRIORITIES OF NMBT CHARACTERISTICS

b. M1 Tank

In the Validation Phase, the DTUHC goal became a program and design driver. Tradeoffs had to be made in order to keep within the cost goal, e.g., some Built In Test Equipment (BITE) was sacrificed and the auxilliary power unit was removed. R&D costs in the Validation Phase were reduced by such decisions as not funding an ILS development effort, reducing component reliability testing, and postponing development of some components entirely.

In FSED, the prime contractor (Chrysler) had total system responsibility to meet the MN requirements while remaining within the DTUHC goal.

Government furnished equipment included the M68 105mm gun, gun mount, and driver's night vision device. The major subcontractors were AVCO Lycoming for the AGT-1500 turbine engine and Detroit Diesel Allison for the transmission and final drive. With the 3d production year the Government was to assume control of the tank configuration and the breakout of selected major components.

During FSED, eight test sets were developed to support maintenance at the organizational, DS, and GS levels. As a result of the DT/OT II experience, the test sets were found to be unreliable and received little use during the tests. The test set program was reoriented in October 1978. The Simplified Test Equipment/M1 (STE/M1) was to be developed to support organizational maintenance and the Thermal System Test Set (TSTS) and Direct Support Electrical System Test Set (DSESTS) were to be developed for DS/GS maintenance. The test set responsibility was transferred from the Logistic Management Division to the Systems Engineering Division. Further emphasis in test set development was taken in early 1981. The PMO committed a tank from June 1981 to May 1982 to complete the validation of test set diagnostic routines and the corresponding troubleshooting manuals. The PMO also established the ATE Office and a Test Set Incident Reporting (TSIR) system with contractor test set representatives at Fort Hood, Fort Knox, Aberdeen Proving Ground (APG), and Europe to coordinate all test set problems with the user in the field.

Human Factors Engineering (HFE) efforts commenced with the start of FSED with the support of the USA Human Engineering Laboratory and the contractor who had several capable human factors engineers according to PMO personnel. The HFE effort in the program office was described as "an additional duty" for one of the System Engineering Division personnel to coordinate the HFE and design effort. When Chrysler Defense Engineering became the prime contractor, it did not always take the total system approach and involve the human factors engineers. In addition HFE had a low priority (see Figure F-1). The commander's weapon station has been a HFE problem since early in the program.

The finalization of the TDP by the prime and its turnover to the Government was a bigger problem than expected. Many changes were required to: resolve production problems, correct test deficiencies, and solve field problems. As late as November 1982, design changes were still being made. It became apparent that the prime did not systems manage the configuration and that the Army did not supervise closely enough. Part of the problem relates to the PMO engineers not being able to do the true engineering work necessary -- the supervision, planning, advising, reviewing--because of their "paper work" requirements. Another part of the problem relates to the acceleration of the M1 program and finally, to the contract itself which gave the contractor, as the systems integrator, the authority to make changes.

c. TANK MAIN ARMAMENT SYSTEM (TMAS)

When the decision was made in 1978 to use the German 120mm smooth bore gun, the task of technology transfer, fabrication, and testing of the 120mm gun and ammunition was assigned to the PM-TMAS at Picatinney Arsenal, Dover, NJ. PM-TMAS also has the responsibility to develop improved 105mm ammunition for the M1, M60, M48 tanks. The evacuator, thermal shroud, and breech remained the responsibility of the M1 PMO, which is also responsible for total system integration.

d. M1E1

Concurrent with preparing the M1 for production, the Systems Engineering Division also assumed responsibility for development of the M1E1 tank with the 120mm gun, a block of other improvements, and the total system integration. The M1E1 is currently in full scale engineering development. Turret redesign is a major problem associated with the M1E1. Although the dual capable turret decision was made in 1976, the effects of the Hillis Resolution and the subsequent Congressional prohibition against specific expenditures to accommodate a 120mm weapon system until one was selected, licensed, and a special ASARC held to approve the resulting program, left much more to be done following the decision to equip the M1 with the GE 120mm gun. The 120mm rounds with their combustible cases required redesign of the racks and bustles; design of a stub case deflector and the stub case catcher; and human factors considerations, instrumentation changes, problems with debris on the floor, and protection for the more fragile combustible cases.

2. STUDY TEAM OBSERVATIONS

a. Component development should not be deferred. Failure to develop the driver's thermal viewer during the Validation Phase, for example, caused interface problems and program delays during FSED.

b. Component reliability testing should be conducted to allow sufficient time to permit corrective action prior to system testing. Reliability testing of components should not be planned to be accomplished simultaneously with field testing (DT/OT).

c. Plans must provide for adequate laboratory testing so that expensive field tests do not become a substitute for the less expensive laboratory tests.

d. Ensure that the MN requirements and the contract requirements agree precisely. Disagreement will jeopardize user acceptance and an inordinate amount of effort will be expended explaining any differences to investigative and higher echelon agencies. In addition, these differences are confusing to the public and tax program credibility.

e. Imprecise specifications can hamper development efforts. Contract specifications must be specific and verifiable with all requirements clearly defined in the System Specification.

f. A procedure for design approval during FSED is needed to assure that the final product (prime items) is what the Government really wants. Under the system concept, the Government lacks the controls needed to be kept informed of contractor changes until completion of FSED.

g. Human Factors Engineering (HFE) should have up-front involvement with design. The turret (commander's station) problems are partly due to inadequate early attention to HFE.

h. Qualified human factors engineers should be required on both the contractor and PMO staff and the contractor's HFE and test plans carefully reviewed. In addition, the US Army Human Engineering Laboratory (HEL) should be funded to support the PMO through the Validation, FSED, and the LRIP Phases with at least a dedicated one man year effort each year.

i. The general over-all assessment of the FSED test sets was that they were unreliable and they received little use during DT/OT II. Test set development is a function better dealt with by a joint team of engineers and logisticians, particularly in the early stages of a major development program.

j. System hardware must be made available to the test set designers and to the major contractors.

k. A facility vehicle should be furnished to the contractor for testing of redesigned components. Test Hardware Funding, DOD Acquisition Improvement Program, Initiative #12, recognizes the importance of this issue and recommends that PMO provide front end funding for test hardware. In the case of the M1 Program, a vehicle was first provided to the contractor during LRIP for his use as a facility vehicle.

l. The capabilities of in-house consultants such as the U.S. Army's Night Vision Laboratory, Human Engineering Laboratory, and Harry Diamond Laboratories should be utilized by the PMO. However, in an effort to show only one face to the contractors, the consultants should be controlled by the PMO and not allowed to direct contractors.

m. Monthly program reviews were held between the PM and the contractor and between the PMO staff and the contractor. These reviews contributed to prompt communication of problem areas and thereby facilitated corrective actions acceptable to both contractor and Government viewpoints.

n. Production start up was a bigger problem for some contractors than anticipated during the first year. Tasks that required more attention included: quality assurance, production processing, work scheduling, and training.

APPENDIX G

PRODUCTION MANAGEMENT

1. BACKGROUND

a. The initial planning for production of the M1 Abrams Tank had a procurement objective of 3312 tanks. The tanks were to be produced only at the DATP at a rate of 30 tanks per month. However, early in FSED an Army Special Tank Task Force published a report "Production Site Configuration Study" which recommended the establishment of a modern hull and turret production facility and the use of a two phased interdependent plant concept, a production rate of 60 tanks per month, and a total procurement of 7058 tanks. During Phase 1 the Government-Owned, Contractor-Operated (GOCO) facility at Lima, Ohio would produce all the hull and turret structures and conduct all the final assembly operations. In Phase II the DATP would conduct final assembly of tanks in conjunction with LATP.

The Phase I production plan is shown in Figure G-1. Components and supplies would be provided to LATP by the DATP, the Government, other Chrysler facilities, and subcontractors. Phase II of the M1 production plan, shown in Figure G-2, would be implemented with the phase down of the M60 production line at DATP. The DATP would continue to provide selected components to the LATP, and would also do final assembly of M1 tanks.

In July 1977, the ASARC approved the plan. Both the Phase I and Phase II production plans have been implemented, the latter in March 1982. Figure G-3 lists the major subcontractors for the M1 Abrams Tank System.

b. The facilitization and LRIP schedule for the M1 is shown in Figure G-4. It can readily be seen from the schedule that the planning and initial execution of the facilitization paralleled the FSED Phase and continued into

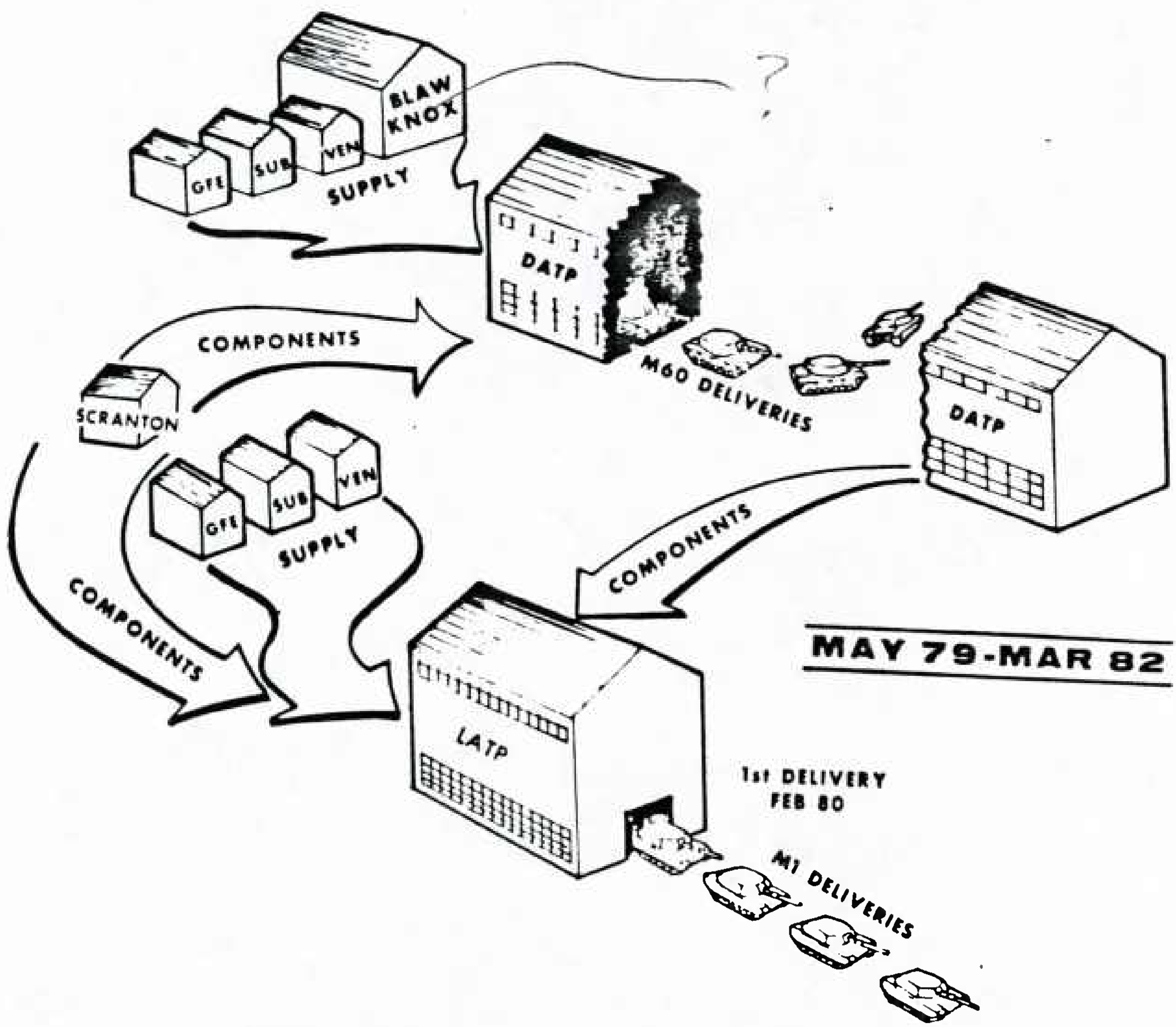

Figure G-1
PHASE I PRODUCTION PLAN

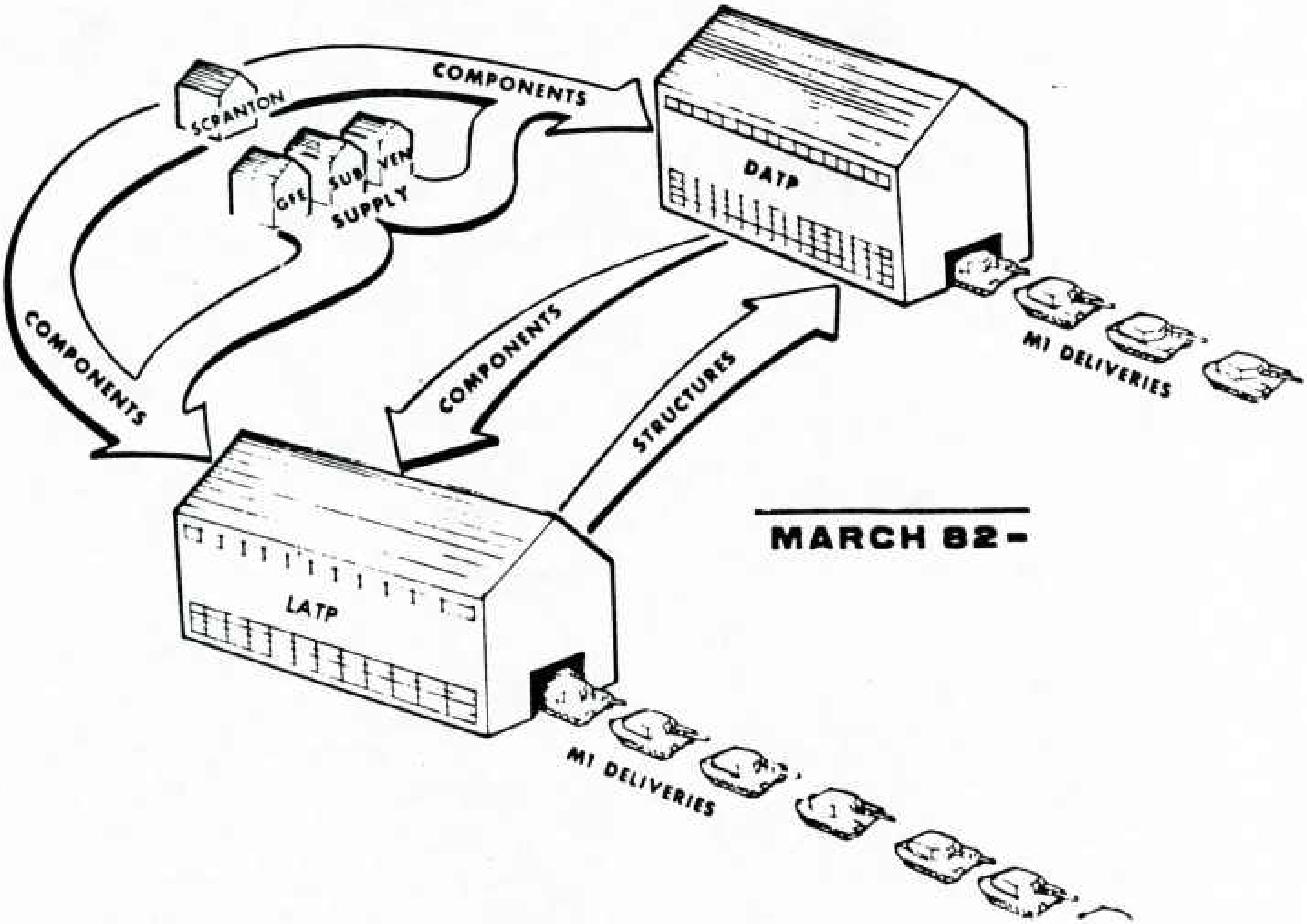

Figure G-2
PHASE II PRODUCTION PLAN

AVCO Lycoming Division, Stratford, Connecticut - turbine engine

Cadillac Gage Company, Warren, Michigan - turret drive and stabilization system

Computing Devices of Canada, Ottawa, Canada - ballistic computer

Detroit Diesel Allison Division, Indianapolis, Indiana - transmission and final drive

Hughes Aircraft Company, Culver City, California - laser range finder and thermal imaging system

Kollmorgan Corporation, Northampton, Massachusetts - gunner's auxiliary sight

Singer Kearfott Division, Clifton, New Jersey - line of sight data link

Radio Corporation of America (RCA), Burlington, Massachusetts -automatic test equipment.

Figure G-3

MAJOR SUBCONTRACTORS ON M1 TANK PROGRAM

the production phase. The original target cost for facilitization, over the 5 year period (FY77-FY81) was estimated at $811 million. This cost was divided into two elements, Initial Production Facilitization (IPF) and Production Base Support (PBS). The IPF consisted of tooling design and fabrication and production engineering to include flow processes, machine load studies, selection of equipment and plant layout. The PBS, on the other hand, pertained to Industrial Plant Equipment (IPE), plant modification/modernization, and government support of the production base, i.e., transportation, storage, and installation of the IPE. Contracts were awarded for both these elements to establish a production base with a capacity to support a production rate of 60 tanks per month on a one shift, eight hour day, five day week (1-8-5) basis

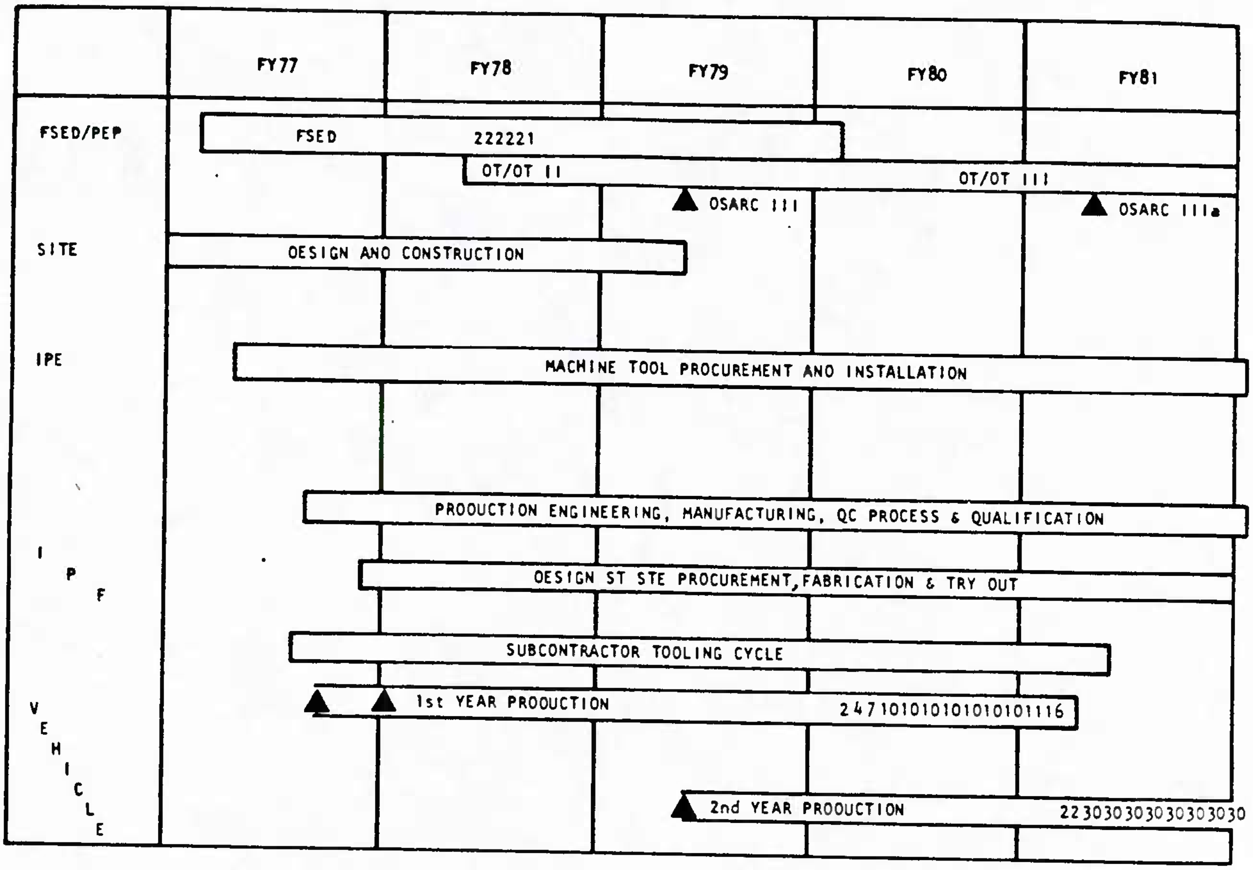

Figure G-4
FACILITIZATION/PRODUCTION SCHEDULE

with a peacetime surge capacity to support a production rate of 150 tanks per month on as 3-8-5 basis.

c. The manufacturing technology employed in production of the M1 Abrams Tank ranges from conventional machines considered to be state-of-the-art equipment to computer aided design and manufacturing. A Manufacturing Methods and Technology (MM&T) program is on-going in production of the M1 Abrams Tank to advance the state-of-the-art. Program elements include ultrasonic testing of welded joints, establishment of a welding laboratory to study the application of new welding techniques; a diagnostic program for determining tool wear and need for equipment maintenance; and laser cutting/welding equipment.

d. The M1 PMO established a Manufacturing Engineering, Tooling, Special Test Equipment, and Facilities Procurement Program (METSFPP) to provide production planning and support relative to the facilitization effort. This program is discussed in more detail in paragraph 1 d, Appendix E.

e. The transition from FSED into production was, in a financial sense, to be smoothed by using production option prices signed during competition for FSED by the contractors. These options established a ceiling price for the first two years of production. However, three years later, when the government exercised the option for LRIP, the prices proved to be too low. The contractors tried every means to force an increase in the price, including generating claims against the original ceiling for an equitable adjustment upward. A lengthy argument regarding escalation procedures to bring the ceiling prices from FY 76 to FY 79 dollars resulted in a substantial increase in the ceiling price.

f. The production cost increases in the transitioning from FSED to production on the M1 Abrams Tank Program were influenced by three factors.

(1) Lack of sufficient devoted manufacturing staff during Producibility Engineering and Planning (PEP) and, in turn, the DTC program.

(2) Concurrency between development and initial production due to the compressed schedule.

(3) Failure of the government to be willing to make the hard decisions to accept performance tradeoffs as permitted by the DCP guidance, in order to stay within production cost goals.

g. The lack of sufficient PEP effort and consequently the lack of early preliminary manufacturing input resulted in a failure of manufacturing to really impact design and hence DTC. PEP is a systems engineering approach to assure that an item can be produced in the required quantities and in the specified time frame, efficiently and economically, and will meet necessary performance objectives within its design and specifications constraints.[1]

h. Concurrency, to the extent required in the M1 Abrams Tank Program, to meet fielding schedules, resulted in numerous manufacturing changes because of DT results. These changes can and did result in obsolescence, reprocessing, and changes to manufacturing equipment on the production line. When this occurs during the actual period of manufacture, such as LRIP, it is difficult for a contractor to achieve projected efficiencies in production, off standard rework requirements, and scrap rates.

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[1]DARCOM Materiel Acquisition Management Guide, 11 February 1980.

i. During the first two years of LRIP, the contractor was required to correct deficiencies within the existing contract price. However, these corrections frequently resulted in higher manufacturing costs which carried into full scale production.

j. The DTC process tends to create a widened gap between early estimates and final price because DTC has as its primary goal - to keep prices down during design. In the case of the M1, numerous design decisions made by the contractor during FSED to keep the unit hardware price within the mandated ceiling had to be reversed when the production process began. Some components were found to be deficient on durability and reliability, i.e., power train and tracks. A result was requirements for repeated and costly testing as the emphasis shifted to improving RAM-D because of the attention by all concerned, including Congress, GAO, and the media, on what a "poor product" the Defense Department was buying. Significant and costly design changes were then made to increase the RAM-D performance. These decisions were a clear reversal of the earlier emphasis on designing a cheaper product.

k. Configuration management is a technical and management discipline for applying systematic techniques to configuration identification, control, accounting and audit. The PMO established a Configuration Management Office within the Systems Engineering Division in July 1979. This office was responsible for controlling changes to the M1 Abrams tank specifications, monitoring contractor activities (including preparation and maintenance of the technical data package) and conducting required configuration audits. On the M1 Program the system concept was used and the contractor (Chrysler) maintained control of changes to the technical data package during the first two years of production. The Government assumed control of the TDP per MIL-STD-480 in the 3rd production year.

l. Since the development schedule for the M1 Abrams tank was success-oriented there was literally no time allotted for experiencing failures during testing, determining the corrective actions, and retesting prior to the DT/OT tests. Consequently, the performance failures experienced were over amplified. Avoidance of many of the failures was not possible and they reflected unfairly upon the overall M1 programs.

m. The M1 program's use of the system concept for configuration/quality control denied the government the control needed to assure a quality product. The contractor made changes without informing the government and did, on occasion, change the design several times. These design changes impact not only cost and schedule, but also invalidate test results.

n. The Unit Hardware Cost averaged over the 7058 tank buy for the M1 Abrams Tank Program shows an increase over the FY 72 DTUHC baseline of approximately 19%. Directed program changes of an extreme nature accounted for the bulk of this increase. These changes include integration of the 120mm gun; armor modifications; addition of a Nuclear, Biological, and Chemical (NBC) Protective System; and an overall increased production rate which necessitated the prime contractor shifting from a single to a multiple plant production operation. The true cost growth accounts for only about a 5% increase from the original DTUHC threshold. Figure G-5 is an assessment, as of August 1982, at the subsystem level, of the percentage of cost for each major component of the tank. Most major components have come in very close to or below the original cost projection. The only gross deviation is in the power train subsystem.

	ORIGINAL FY72 $507.8K AVERAGED OVER 3312 TANK BUY	CURRENT* $595.6K AVERAGED OVER 7058 TANK BUY
Hull	13.6%	12.4%
Suspension	10.8%	5.4%
Powertrain	19.5%	38.1%
Auto/Electric	1.9%	2.7%
Turret Assy	17.5%	15.3%
Fire Control	24.6%	17.0%
Armament	9.9%	6.7%
Ancillary Eqmt.	2.2%	2.4%

*As of Aug. 82

Source: PMO Briefing, Abrams Tank Cost Management; 13 Aug 82

Figure G-5
UNIT COST ASSESSMENT ($FY72)

o. The Production Readiness Review (PRR) for the M1 Abrams Tank System was conducted from 13 November to 14 December 1978. The PRR team chairman was the Chief of the Procurement and Production Division of the M60 Tank System Program. The PRR team was organized into six functional areas/subteams: materials, engineering/configuration management, manufacturing, program management, logistics; and contracts. Each area was evaluated at the level of detail necessary to determine readiness to proceed into production and confirm the resolution of identified problems. The review team concluded that the M1 Tank program was ready to proceed into production.

p. The quality program for the M1 was structured around MIL-Q-9858A and the quality assurance provisions of the Technical Data Package. Initially, MIL-Q-9858A requirements were not passed onto the subcontractors. This made it difficult for Defense Contract Administration Service (DCAS) offices to perform PMO delegated quality functions.

q. The prime contractor's tank plants are under the direct cognizance of the PMO, M1 Abrams Tank System's LATP Quality Assurance Branch (at Lima, Ohio) and PMO M60's Quality Assurance Division (at Detroit). The quality elements at both tank plants have as their primary missions the conduct of daily, periodic, and special reviews of the Contractor's quality program; the conduct of independent assessments; and the maintenance of a product deficiency and data feedback system. The subcontractor and vendor facilities are now under DCAS or Army Plant Representative Office (AFPRO) jurisdiction.

r. Quality Systems Reviews (QSRs) have been conducted and will continue. An independent assessment of the contractor's quality program was performed by a DARCOM Review Team in February, 1981 at the LATP. A similar assessment was made at the DATP in 1982 after M1 production was initiated.

2. OBSERVATIONS

a. Initial production cost estimates must be realistic and should provide for unknown contingencies. (TRACE)

b. Substantial Management Reserves (MR) should be used to ensure that the contractor management can react when it becomes aware of program areas headed for difficulties. During FSED, Chrysler was persuaded by the PMO to increase the MR amount to $25M, which was roughly 10 percent of the final contract value.

c. Although Chrysler had an engineering program manager, it was not until late in the program that a system program manager was established. During the transition to production and during production the contractor must have a central management team devoted to the program with tasking authority over all disciplines.

d. The Government must be involved in the process of design change during FSED and LRIP. Government approval of design changes is required to assure that the final production product meets the government's requirements.

e. If test schedules are compressed as they were on the M1 program, adequate shake-down time and assets must be provided to the contractor.

f. The lack of, or minimal expertise in, the production/manufacturing disciplines with the Army, both civilian and military, create problems in transitioning from development to production. PMOs should consider the use of consultants to gain the required expertise.

g. The prime contractor should be provided a facility vehicle during the FSED for development site experimentation and testing of redesigned components.

h. Compression of a program schedule (concurrency) increases costs, e.g., engineering modifications encountered in testing require replanning on the production line.

i. The timing of completion of the Technical Data Package (TDP) is critical, especially under a compressed schedule. Provisioning requirements must be firm and must be considered in establishment of the completion date for the TDP.

j. Consideration should be given to including production planning as a portion of the FSED award fee to ensure that the contractor's planning is sound and sufficient during early stages of development. This also is a motivational factor to enhance the contractor's production planning.

k. Design-to-Cost could be a more viable tool if the award fee was delayed until actual hardware has come off the production line and real production costs are determined. This is the thrust of DAIP Action 22, Design-to-Cost Contract Incentives.

APPENDIX H

TEST AND EVALUATION MANAGEMENT

1. BACKGROUND

a. Test and Evaluation Requirements

The M1 Abrams Tank System has been described as "the most tested major weapon system in Army history." The test experience shown in Figure H-1 below is indicative of the extent to which the tank has been tested.

Phase	Miles	Main Gun Rounds
Validation (DT/OT I)	24,600	6,350
FSED (DT/OT II)	98,500	15,250
Production (DT/OT III)	82,300	18,400
TOTALS	205,400	40,000

Figure H-1
M1 ABRAMS TANK SYSTEM TEST EXPERIENCE

Developmental Tests and Operational Tests (DT/OT) are designed to determine if the system meets the specified Reliability, Availability, Maintainability, and Durability (RAM-D) requirements; operational characteristics; and technical capabilities.

RAM-D requirements were included in DCP No.117, dated 26 December 1972, and in the subsequent MN. When the decision was made to develop the NMBT, these RAM-D requirements became important design criteria. Figure H-2 shows the 1972 RAM-D Requirements.

With only minor exceptions, the RAM-D requirements have remained unchanged to this date. One change was the addition of the system reliability criterion which was necessary in order that comparisons with M60 data could be made. A second change dropped the Inherent Availability criterion because it was not meaningful. The current set of RAM-D requirements as well as their status as determined by tests to date is shown in Figure H-3. There are two reliability requirements to control both the several combat and nondeferrable combat rates; six logistics/Life Cycle Cost (LCC) drivers are identified to control the field maintenance burden; and five maintenance parameters that control both the time and maintenance level required to repair the tank.

In addition, the M1 Abrams Tank System must also meet the MN specified operational requirements listed below.

- o Be capable of sustained operations in climatic design types/daily cycles (formerly climatic categories 1-8) defined in AR 70-38. Operation in cold and severe cold climatic design types can be performed with a kit.
- o Provide all terrain mobility, protected firepower, and communications permitting rapid massing and dispersion of forces, sustained operations for up to 22 hours, and a range of 275 to 325 miles without refueling.
- o Have sufficient speed, agility, firepower, protection, and fire control to acquire, engage, and defeat all projected enemy force arrays in the time frame specified, at extended ranges.
- o Possess ease of employment on the battlefield without excessive training/maintenance requirements.

Finally, the M1 Abrams Tank System must meet the key characteristics/ requirements shown in Figure H-4.

	DT III[1] GOAL	REQUIREMENTS	M60A2
RELIABILITY - Mean Miles Before Failure (MMBF)	440	320	232
AVAILABILITY-INHERENT (A_I)[2]	92%	89%	73%
MAINTAINABILITY-Maint Ratio (MR)	0.66	1.25	1.43
DURABILITY-Miles[3]	6000	4000	2-3000

1/ 85% Achievement By End of DT II

2/ MTBF/MTBF + MTTR = A_I

3/ Probability of 50% for power train life of (x) miles without replacement or overhaul of any major component.

Figure H-2
RAM-D REQUIREMENTS

PARAMETER	REQUIREMENT	STATUS
COMBAT RELIABILITY	320 Mean Miles Between Failure (MMBF)	351
SYSTEM RELIABILITY	101 Mean Miles Between Failure (MMBF)	126
SCHEDULED MAINTENANCE		
DAILY	0.75 CLOCK HOURS/3 MANHOURS	0.6/2.55
AT 1500 MILES	36 CLOCK HOURS/64 MANHOURS	28.3/42.9
UNSCHEDULED MAINTENANCE		
ORGANIZATIONAL 90 PERCENT	4 CLOCK HRS/8 MANHOURS	3.4/6.14
DIRECT SUPPORT 90 PERCENT	12 CLOCK HRS/22 MANHOURS	11.4/18.94
MAINTENANCE RATIO	1.25 MANHOUR/OPERATING HOURS	1.18
VEHICLE LIFE	6000 MILES	6000+ MILES
POWERTRAIN DURABILITY	.5/4000 MILES	.48/4000
PRIMARY WEAPON LIFE	1000 ROUNDS	1000
TRACK LIFE	2000 MILES	1056
ROAD/IDLER WHEEL DURABILITY	20 PERCENT IN 3000 MILES	MET
SPROCKET LIFE	1500 MILES	1805

Figure H-3
RAM-D STATUS

PHYSICAL

Weight, Combat Loaded (Tons)	60
Ground Clearance (Inches)	17-23
Height to Turret Roof (Inches)	90-95
Width (Inches)	120-144
Ground Pressure (PSI)	13.1

PERFORMANCE

Acceleration, 0-20 MPH (Seconds)	6-9
Speed (MPH)	
10% slope	20-25
60% slope	3-5
Level Cross-Country	25-30
Maximum (Governed)	45
Cruising Range (Miles)	275-325
Fording Depth	
Without Kit (Inches)	48
With Kit	Turret Roof
Obstacles	
Vertical Step (Inches)	49
Trench Crossing (Feet)	9

AMMUNITION STOWAGE (ROUNDS)

Main Gun (105mm)	55
Coaxial (7.62 Machine Gun)	10,000
Commander's Weapon (Calibre .50 Machine Gun)	1,000
Loader's Weapon (7.62 Machine Gun)	1,400

Figure H-4
KEY M1 CHARACTERISTICS/REQUIREMENTS

The functional area tree, shown in Figure H-5, identifies the parameters associated with each of the four tank mission functions; mobility/agility, firepower, survivability, and communications that the tank must demonstrate through testing.

b. Test Management

(1) The M1 Tank Program Office is managing or monitoring four sets of tests. The M1 and M1E1 tank tests are managed by the Product Assurance and Test Division, Abrams Tank System Program Office, Warren, MI. The main armament system 105mm and 120mm gun and ammunition tests are managed by the Product Assurance and Test Division of the Tank Main Armament System Office at Picatinney Arsenal, Dover, NJ. Training Device tests are managed by PM-TRADE, Orlando, FL.

(a) M1 Tank. The M1 Test Integration Working Group (TIWG) was formed in June 1974 during the competitive Validation Phase. At that time, test management was a function of the Systems Engineering Division, M1 Program Office. The TIWG is still in existence with meetings held approximately every six weeks. It is currently being chaired by a representative from the Test Management Branch of the M1 Product Assurance and Test Division.

The Test and Evaluation Master Plan (TEMP) and the Coordinated Test Program (CTP) were not prepared for DT/OT-I but have been prepared for both DT/OT-II and DT/OT-III. The final update of the TEMP for the M1 tank was prepared in December 1981. Figure H-6 depicts the M1 test program accomplishments to date.

There are nine principal members of the M1 TIWG. Two from the Office of the Program Manager; one from the system prime contractor; and one

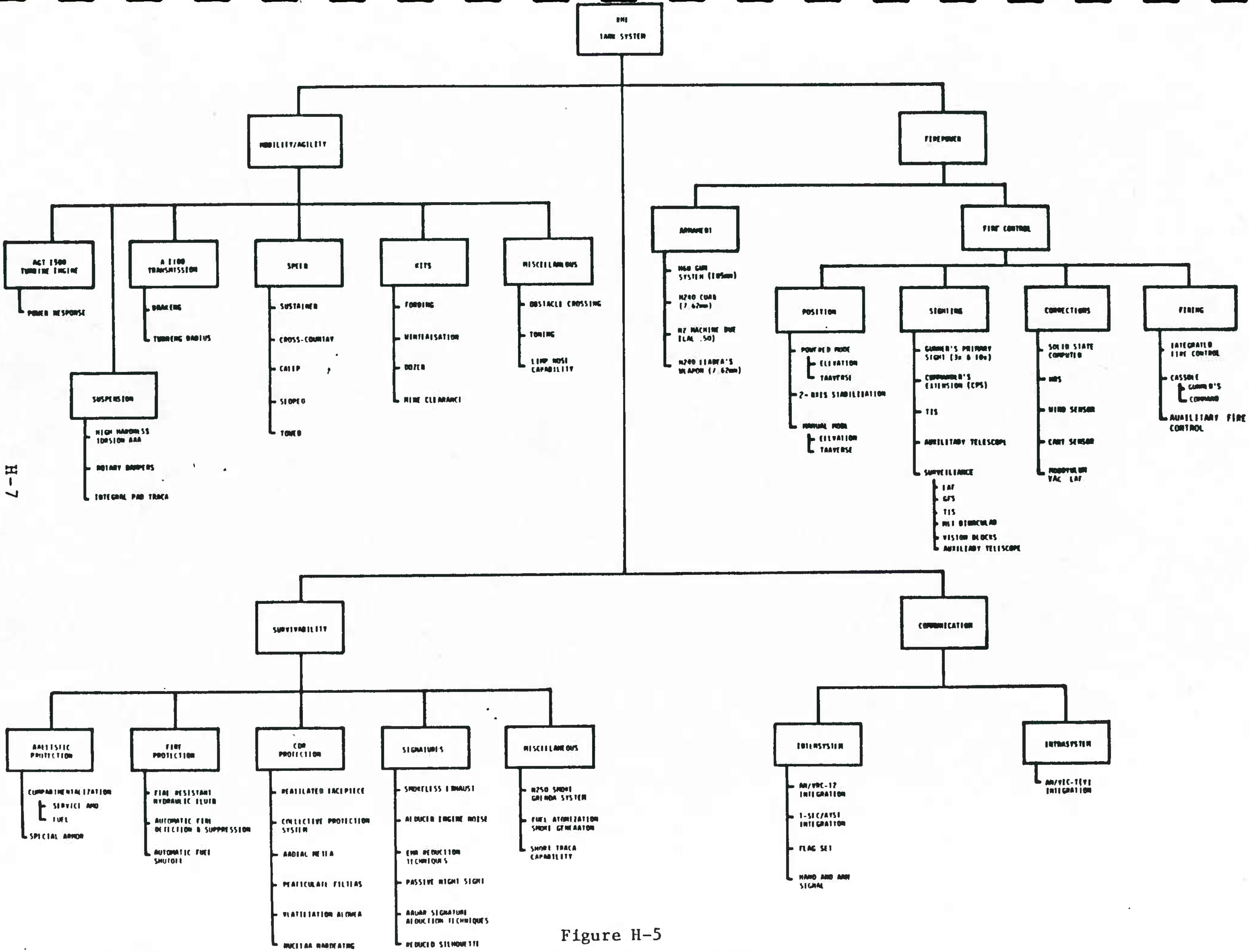

Figure H-5

XM1 FUNCTIONAL AREA TREE

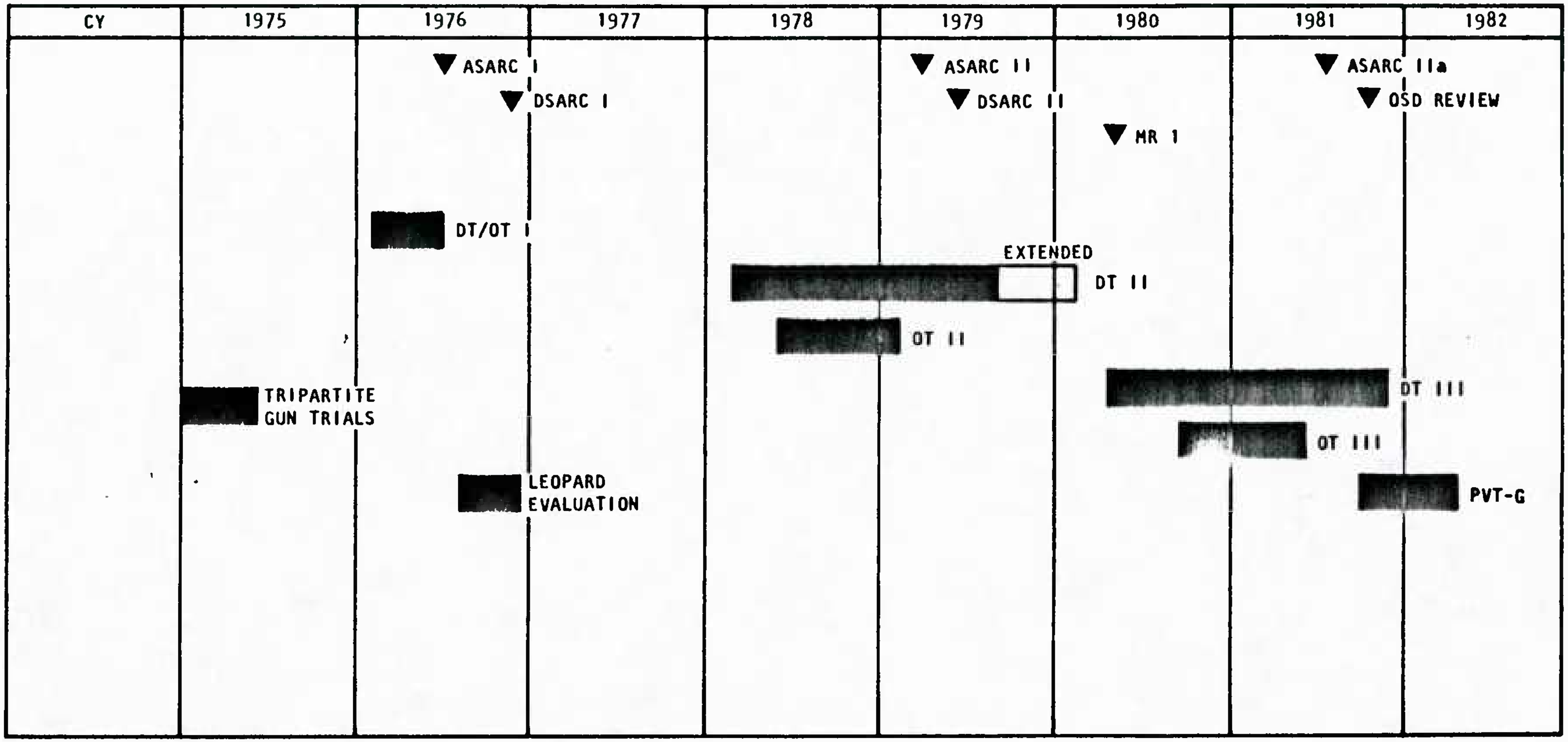

Figure H-6
M1 TEST AND EVALUATION PROGRAM

each from TECOM, TRADOC (TSM), OTEA, AMSAA, LEA, and TACOM. In addition, associate membership included representatives from fourteen agencies to include the Armor Center, Logistics Center, HEL, MRSA, FORSCOM, OSD, and the several test centers, proving grounds, and ranges.

Representatives of other headquarters and organizations are invited to attend--as appropriate to the agenda. These other headquarters and organizations include: OSD; HQDA; HQDARCOM; and the DARCOM Materiel Commands, Laboratories, and Arsenals.

The M1 TIWG had several subgroups. One was the Logistics Subgroup, chaired by the AMSAA representative. Its purpose was to prepare the Logistic Section of the CTP and to serve in an advisory capacity to the Logistic Management Division. Another subcommittee, chaired by the TRADOC System Manager (TSM), prepared the set of test issues and identified the critical issues and their technical and operational scopes and criteria. Other subcommittees were established as required by the TIWG chairman.

The general objective of the M1-TIWG is to reduce costs by integrating testing to the maximum extent possible, eliminating unnecessary redundancy, and eliminating potential problem areas in testing. The TIWG is a vital element in T&E management. It not only ties together the PMO Divisions in test planning, but also the user, tester, trainer, evaluator, logistician, developer, and contractor. It is part of the effort required to maintain both formal and informal coordination within the total test and evaluation community.

During the competitive Validation Phase, the PMO initiated steps to ensure fair and equal treatment to each competitor and prevent technology transfer during testing. Although they were primary members of the TIWG, the contractors were permitted to attend only designated TIWG meetings. "Competition Sensitive" markings were used to control the unauthorized transfer of information between the competing contractors. PMO personnel were careful not to give one contractor an advantage; they were given equal time, technical information, and instructions. Information provided to one contractor was also provided to the other and test documentation for the two systems were kept separate.

(b) M1E1 Tank. The M1E1 TIWG was formed in November 1979. Separate M1E1 TEMPs and CTPs have been drafted. An ambitious test plan has been established for the M1E1 System leading to its production in 1985.

(c) Tank Main Armament System (TMAS). TMAS has its own TIWG, TEMP, and CTP for the 120mm gun and ammunition and 105mm ammunition development tests. In addition to the XM256 120mm cannon, TMAS is also responsible for the development of four 105mm projectiles and four 120mm projectiles. (This requirement is discussed further in Appendix F - Technical Management.) The TMAS test plan is shown in Figure H-7.

(d) PM-TRADE. PM-TRADE has his own TIWG, TEMP, and CTP for testing the M1 Training Devices. The TIWG membership includes a member of the M1 PMO staff.

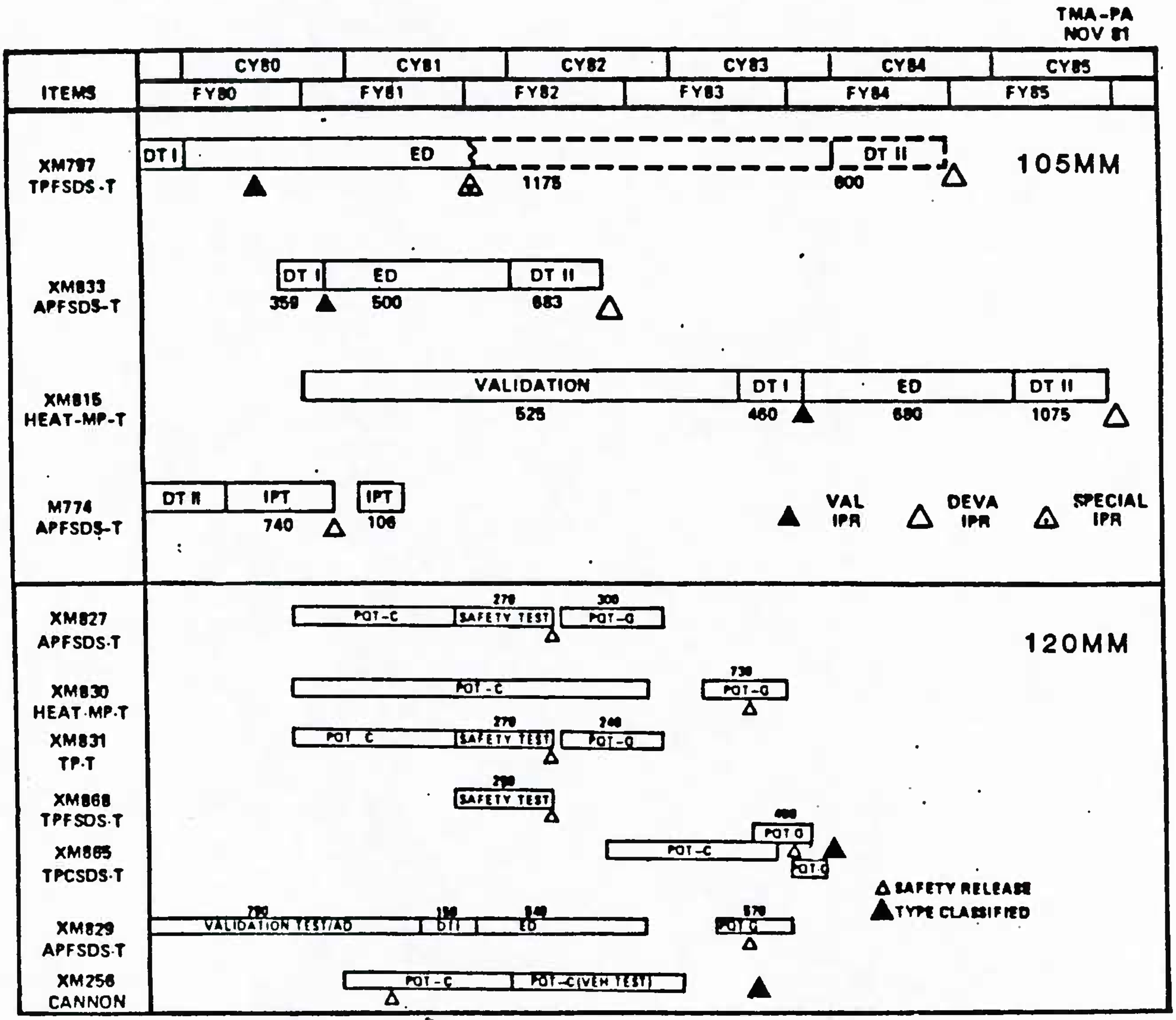

Figure H-7

TMAS DEVELOPMENT TESTING PROGRAM

c. M1 and TMAS Tests

(1) M1 Abrams Tank System

(a) Initial test and evaluation planning provided for a complete range of tests:

- DT/OT-I late in the Validation Phase to provide information on the technical and operational suitability of the GM and Chrysler candidate systems to aid in the selection process and to provide information to the ASARC II for its consideration in determining if the selected system was ready to enter full-scale development.

- DT/OT-II, prior to ASARC III, in order to provide data and associated analysis on the performance, operational effectiveness, and utility of the tank system as part of the information on which to base a decision concerning low rate initial production.

- DT/OT-III during LRIP to provide information that would, in part, provide the basis for a Full Scale Production decision by the ASARC IIIa.

In addition to the planned tests and evaluations, several special tests were conducted to meet various Congressional and OSD requirements. Included were:

- German, British, and American gun trials in 1975.

- Comparative evaluation of the German Leopard tank in 1976.

- Post-DSARC III requirements to demonstrate mission reliability and power train durability.

(b) DT/OT-I (February - May 1976)

During the concept validation phase, developmental testing addressed critical issues related to automotive performance, firepower performance, vulnerability, and human factors engineering. RAM-D results from validation phase tests were used to determine the RAM-D potential. Competing contractors provided one each of the following items for test:

- A ballistic hull and turret for ballistic vulnerability testing.
- An automotive test rig (with dummy turret) for automotive tests.
- A prototype vehicle with operable fire control for firepower performance tests and operational testing.

Results of this testing indicated that both systems had the potential of meeting all of the Army's requirements and identified those areas where further engineering development was required.

During the M1 concept validation phase, operational testing was conducted to address issues of: potential operational effectiveness and survivablity; adequacy of proposed personnel qualifications, training and selection; maintenance; and reliability. Operational Test of the M1 was conducted during the period 7-30 April 1976 at Aberdeen Proving Ground in conjunction with the Development Test I. Two candidate M1 tanks, one from each competitor, and two M60A1 tanks were used. Six crews participated in the OT I; two were trained on one of the candidate vehicles and the M60A1; two were trained on the other candidate vehicle and the M60A1; and two were trained on both candidate vehicles and the M60A1. Operational activities centered around two basic areas; non-firing exercises and live firing exercises. Crew maintenance activities were examined and the failure data recorded. An independent evaluation of this testing was presented by OTEA for ASARC and DSARC II.

In its Independent Evaluation Report,[1] OTEA concluded that both candidate vehicles met the operational effectiveness requirement for that stage of development. Nothing was noted during OT I which would prelude either XM1 candidate from entering the FSED phase.

(c) DT/OT-II (February 1978 - February 1979)

FSED developmental testing began in January 1977 with contractor engineering design testing utilizing two facility vehicles to verify achievement of technical characteristics, to demonstrate test-identified design modifications, and to provide additional engine maturity testing. Government testing began in February 1978 with the initiation of a physical teardown/maintenance evaluation followed by firepower, automotive, vulnerability, environmental, and RAM-D performance. One Pilot Vehicle (PV) underwent desert testing at Yuma Proving Ground (YPG), followed by electromagnetic radiation and nuclear vulnerability testing at White Sands Missile Range (WSMR). A second PV was consumed in a series of destructive survivability/vulnerability tests at APG. A third PV was dedicated to firepower testing at APG. Eight PVs, including the five OT II vehicles shifted from Fort Bliss to DT testing at APG in February 1979, were dedicated to RAM-D. The time spent on modifications and engineering investigations in DT prevented completion of desert testing. Test delays, performance problems, and funding considerations delayed planned cold environmental testing from FSED to LRIP.

OT II at Fort Bliss employed side-by-side comparison testing of the M1 and M60A1 to enable evaluation of performance and human factors

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[1]OTEA, IER-OT-031, November 1976

(fightability) in realistic crew and platoon (five tanks) live firing and nonfiring force-onforce combat operations. Capabilities of the M1 were compared against the M60A1 in target detection, acquisition, identification, and hit performance. Speed and agility of the M1 were evaluated in light of mission accomplishment and contribution to survivability. The OT II employed the M1 in a typical operational environment. The tanks maneuvered over rugged terrain at relatively high speeds (up to 25 mph) while firing at surprise targets camouflaged and tactically sited in the terrain using radio controlled pop-up mechanisms.

The rigorous nature of OT II exposed RAM-D design weaknesses early in testing. However, there was little room in the test program to permit system redesign, modification, and retesting. Deficiencies, primarily in the hydraulic system, fuel filtration, air induction system, powertrain, and tank commander's weapons station identified during the training phase between May and July 1978, forced a one-month modification stand-down in OT during August and, consequently, extension of the OT end date from mid-December 1978 to 2 February 1979.

In its Independent Evaluation Report [2], OTEA concluded that:

- Firepower - exceeded baseline
- Reliability - below FSED thresholds
- Operational Availability - marginal
- Maintainability - valid assessment difficuilt to make
- Survivability - exceeds baseline but adversely impacted by track problem
- Fightability - marginal due to problems with commander's station

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2 OTEA, IER-OT-049, April 1979

Reliability was identified as the most critical issue with the commander's station the next most critical issue. OTEA stated that the XM-1 was unsuitable for issue and that the difficiencies must be corrected and the corrections confirmed by test.

(d) Tests in Support of Post-DSARC III, Management Review I. (June 1979 - January 1980)

The DSARC III established a series of OSD management reviews to follow the M1 tanks progress in meeting mission reliability and powertrain durability requirements. The first of these Management Reviews (MR1), occurred in February 1980. Test results were sufficient to obtain OSD cancellation of further formal interim reviews prior to DSARC IIIa.

The testing that supported MR1 included the completion of scheduled DT II, additional engine laboratory tests, and the Fort Knox Extended FSED M1 Durability/Reliability Test.

Two refurbished FSED engines incorporating all available production modifications were run 1000 hours each from October 1979 to January 1980. These 1000 hour laboratory tests of two AGT 1500 engines were successfully completed. Areas for further examination in subsequent production engine laboratory tests were also identified.

The test objectives of the Fort Knox Extended FSED Durability/Reliability test were to obtain data to assess the powertrain durability and the reliability growth of the M1. Three refurbished FSED tanks, rebuilt insofar as possible (chassis only) to the production configuration, were run at Fort Knox from June to December 1979. Testing was conducted by the US Army Armor and Engineer Board, using a modified Operational Mode Summary (e.g., one round for each 50 miles). The three vehicles accumulated 4,000 miles each by October. Later, from October to December 1979, two of the tanks were run an additional 2,000 miles each. A third tank also completed an additional 2,000 miles, thus validating production components under a joint PM-Contractor test.

The results of the first phase of tests demonstrated a substantial increase in mission reliability and power train durability from the previous DT/OT II tests. The thresholds which OSD had established for these two parameters were exceeded. The trend of improved RAM-D was also carried over to the second phase. During Extended FSED testing, the M1 MN and specification values for reliability and durability were exceeded. However, several issues remained to be addressed by OT-III.

On 12 March 1980, OSD revised the 8 May 1979 DEPSECDEF direction. Based on achieved levels of reliability and durability, it was decided to release the balance of FY80 funding and authorize obligation of FY81 funds as required to assure production continuity. In addition, the requirement for further OSD reviews prior to DSARC IIIa was rescinded.

(e) DT/OT-III (March 1980 - May 1982)

DT III performed the various engineering/MN tests on nine tanks at several TECOM sites. The contractor test involved six tanks at Fort Knox prior to the start of OT III. This test was intended to provide the first identification of problems incurred by the production process and allow prompt initiation of corrective actions. In addition, the contractor tested one tank in the environmental chamber at Eglin AFB. Test sets and manuals were validated concurrently with LRIP and beyond. OT III was conducted at both Fort Knox and Fort Hood. At Fort Knox, four tanks underwent RAM testing. At Fort Hood, 41 tanks underwent battalion testing in an operational environment. The three APG RAM tanks and all four Fort Knox tanks were run in a test-fix-test scenario, principally to assess reliability, durability, annual maintenance manhours, and maintenance burden. The Fort Hood tests were principally to assess logistical supportability and training at the battalion level. Data collected on the three APG RAM tanks and four Fort Knox tanks was scored through formal scoring conferences. Data collected at Fort Hood was not scored for reliability evaluation but yielded subjective and qualitative information. A discrete test of the test sets was not conducted within M1 DT III or OT III. Test sets were used as required during the M1 DT/OT III and data on test set usage was collected and reported as a part of the overall M1 system evaluation.

AMSAA evaluation of DT III as presented to the ASARC in August 1981 focused on the five issues:[3]

- o requirement compliance
- o production/engineering completeness
- o RAM-D
- o logistic support
- o climatic conditions

The evaluator stated that the M1 had not yet grown to required levels in maintenance ratio and powertrain durability, but meets the majority

[3]HQDA, ODCSRDA, Minutes, M1 Program Review, 10 Sep 1981

of its MN performance requirements. The final conclusion was that deployment should proceed at a rate consistent with the maturation rate of the support structure.

The OTEA Independent Evaluation[4] concluded that the combined effect of firepower, agility and survivability as demonstrated by the M1 Abrams Tank makes it clearly superior to the M60 series of tanks. OTEA also pointed out that the tank system availability after fielding will be low unless aggressive action is taken to improve test and diagnostic equipment, manuals, and troubleshooting capabilities. In addition, aggressive action should be continued to identify and solve production quality control and power train durability problems.

(f) Future Testing

A RAM-D growth program designed to provide increases in vehicle RAM-D beyond the MN/Specification values and to demonstrate logistics maturity is planned for FY83 and FY84. The Production Acceptance Test and Evaluation Phase (PAT&E) began with the first Production Comparison Tests (PCTs) from the LATP early in CY82 and will continue until production is terminated. In addition, the Initial Production Tests (IPTs) of the DATP commenced in the Fall of CY82. A powertrain durability test to demonstrate improvement (and to perform an extensive evaluation of test sets) was also initiated but was suspended on 1 October 1982 due to engine failures. This test is now planned to resume on 1 August 1983 with the use of 7 new tanks that will run 4025 miles each.

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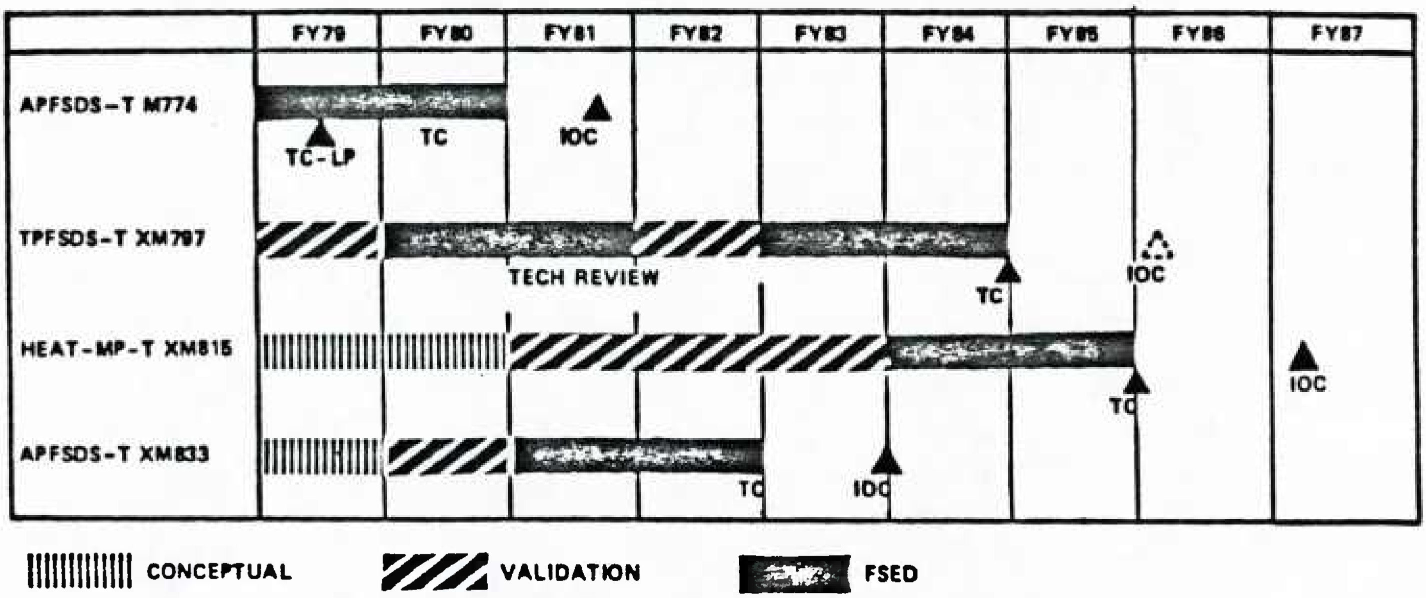
[4]OTEA, IER-OT-058, November 1981

(2) Tank Main Armament System

The PM-TMAS is responsible for the developmental testing of the improved 105mm ammunition, the 120mm gun, and the 120mm ammunition. The 120mm gun and ammunition tests support the M1E1 Tank System program and are included in the M1E1 TEMP. They will not be further discussed here. The 105mm Ammunition Improvement program will increase the capability of the M1 (105mm), as well as the existing M60A1, M60A3, and M48A5 tanks. PM-TMAS has responsibility to develop, produce, and field advanced technology, Kinetic Energy (KE) cartridges, 105mm; develop KE training cartridges, 105mm, with reduced down range hazard zones; and develop a modern technology 105mm Heat-Multi-Purpose cartridge to improve the capability of the 105mm tank fleet. TMAS also has a requirement to develop a rocket assisted KE round. This latter project is still in the requirement determination stage. Figure H-8 shows the status of the 105mm, ammunition development projects. The M735 Armor Piercing, Fin Stabilized, Disposable Sabot-Tracer (APFSDS-T) is a KE cartridge that was placed in production pending the development and production of the M774 APFSDS-T KE projectile that uses a Depleted Uranium (DU) Monobloc penetrator. An improved KE round, the XM833, is an accelerated program, by VCSA direction, which has just completed development and has been typed classified. The XM833 utilizes a longer, thinner DU penetrator. The XM815 HEAT Multi-Purpose Tracer (MP-T) is an increased performance projectile with improved hit probability at extended ranges, improved warhead design, and incorporates full frontal fuze sensitivity for improved performance against T72 type targets. Finally, the XM797, TPFSDS-T (a KE training round) is scheduled for fielding in FY86. In order to limit the range of the training round, breakup is induced by aeroballistic heating. Because the firing of DU rounds on some ranges is prohibited, and because of the many controls, the training round will not use DU as a penetrator material.



Source: TMA-TM Oct 81

Figure H-8

105mm TANK AMMUNITION SCHEDULE SUMMARY

Testing the tank system and the KE rounds with the DU penetrators was a greater problem than first anticipated. Use of DU penetrators is subject to Nuclear Regulatory Commission (NRC) controls. The extent of the precautions and actions required for testing delays firings and has limited the number of firings to as few as four per day. Firings cannot be conducted at hard stationary targets unless the penetrator is aeorolized. A "catcher box" had to be constructed at APG wherein a negative pressure chamber contains and filters the aeorolized DU particles. Moving targets must be "soft" or "cloth" targets, and provisions have to be made to recover the penetrator so that DU range debris does not become a problem.

2. OBSERVATIONS

a. Planning and Management

(1) Realistic times must be alloted to experience failures, determine corrective actions, and retest prior to official DT/OT tests. Failure to do so, even in a compressed schedule, can result in failures during DT/OT that might have been detected earlier under less visible conditions.

(2) Although the influence of the PM on the independent operational test design is limited, a constant and continuing effort must be made to maintain both informal and formal coordination with OTEA. The TIWG provides one channel for coordination but additional and more frequent contact is necessary to see that all test plans and activities are well coordinated.

(3) In order to ensure that test planning is properly coordinated and controlled and to avoid dupliction of effort or omission of critical areas, the PMO made full use of the TIWG. In addition, a logistic subgroup of the TIWG was established to coordinate among divisions within the PMO and with the contractor (who was also a primary member of the TIWG) to alleviate contradictory directions from various government groups on T&E matters.

(4) In keeping with the concept of integration of all contractor and government development tests in order to maximize the use of test data and save time and money, contractor testing had to be carefully planned to meet government test requirements. An example was the duplication of the severity of the government test site at APG at the contractor's test site.

(5) TIWG chairman have a great challenge for which they may or may not be prepared depending on their experience and training. AR 70-10, Test

and Evaluation During Development and Acquisition of Materiel, provides insufficient guidance for the inexperienced TIWG chairman.

b. DT/OT Scheduling

(1) Compression of test schedules that result in concurrent DT and OT creates potential problems that must be anticipated and planned for. These problems may include: lack of sufficient parts, components, test sets, etc; no time for contractor end item shake-down; overwhelming administrative requirements; and inability to resolve developmental test problems prior to the conduct of the operational tests.

(2) Milestone decision points should be set at a time that permits sequential developmental and operational tests and time for preparation of inputs to the ASARC/DSARC process.

c. Data Gathering/Scoring

(1) Particular attention should be given to failure scoring early in the program. Reliability failure criteria should be developed and coordinated with all scoring conference members prior to testing.

(2) Scoring conferences should be scheduled after accumulation of about 300 incidents. Their duration should be no longer than two days.

(3) Data collection systems used for DT and OT should be similar. Direct computer access of both DT and OT data banks should be available throughout testing.

(4) The participation in the Scoring Panel by a representative of the independent testing agency raises the question of his ability to remain "independent."

(5) Scoring conferences should not be closed until the status of the parameters have been determined and agreed to by the panel members. In several cases the MI panel members were left to determine the status at their home stations. Differences in their results caused time consuming settlement efforts.

(6) The prime contractor must be instructed to brief its subcontractors on the rules of RAM-D scoring.

d. On-Site Management

(1) In order to gain the confidence of test personnel, it is essential that the on-site teams consist of top quality, highly knowledgeable contractor and government personnel. The team members must know the equipment thoroughly and must be responsive to test requirements. The team should present one face to the test activity. It should thus be made clear to the contractor, and his technical representatives, that they work for the senior PM representatives on-site. They should take direction from him, and take no action without his approval. This, then, requires that the PM's representative either be permanent or be rotated from a limited group of personnel with on-site stays in excess of two weeks.

(2) A fully functional field office should be established by the PMO at the DT and OT sites at least 45 days in advance of the test start dates. Manned by a military staff and a full time secretary, the field office should be responsible for:

- o Coordinating, welcoming, and briefing visits by outsiders.
- o Receiving and passing test information to the contractor and PMO.

- o Coordinating, expediting, and monitoring test support requirements.
- o Following progress of OT II and DT II testing.
- o Providing day-to-day guidance to the contractor on-site test manager.
- o Collecting, recording, and passing raw logistics data to the contractor and PMO.
- o Monitoring performance of the Maintenance Test Support Package (MTSP) in conjunction with the testing unit, OTEA, and the contractor. Recommending changes to the MTSP as deem necessary.
- o Act as the focal point for all PMO/contractor support operations.

(3) Prior to the release of equipment to government test agencies, the contractor and PMO should conduct an inspection and shake-down at the plant. Time should be provided in the schedule for a technical inspection by both contractor and PMO engineers prior to shipment to the test site. At the test site, three (3) to four (4) days should be allowed for deprocessing and a final check prior to official turnover of equipment to the test organization.

(4) Contractor personnel should be controlled to prevent their "helping" the military maintenance personnel. Such help distorts the data collected to support evaluations of RAM-D, training effectiveness, validity of the MAC, etc.

e. Component Reliability Testing

Component reliability testing is needed prior to DT and OT in order to identify deficiencies and problems that could disrupt the test activities. Sufficient time must be allowed to test and redesign components prior to system testing. (See Appendix F, Technical Management)

f. Test Site Selection

High density major weapon systems should be tested where the full range of organizational, DS, and GS capabilities are available.

g. Laboratory Testing

Even with a compressed schedule, a vigorous laboratory test program must be planned and executed prior to system tests. The alternative is too discover problems, which often become highly visible during development or operational tests, that could have been resolved in the less conspicuous and less expensive laboratory environment (see Appendix F, Technical Management).

h. Technology Transfer

(1) Little guidance is available regarding the unique requirements associated with the testing of foreign systems. Army Regulations 70-10, Test and Evaluation During Development and Acquisition of Materiel and 71-3, User Testing do not address the subject. The problem is complicated due to the following factors: U.S. planners and engineers may have little historical experience with the foreign system; may not understand the foreign acquisition process, support concepts, or state of system maturity.

(2) Early tests of foreign systems being acquired by the U.S. will usually be accomplished with purchased equipment. Test designers must understand the state of development of the purchased equipment and make early plans for its procurement.

(3) Maximum advantage should be taken of foreign test results--provided that the test conditions are thoroughly understood.

i. RAM-D Data

OT-II was conducted with five (5) M1 tanks and five (5) new M60 tanks. Comparisons of mobility, firepower, survivability, and communications were made between the two tanks. In addition, RAM-D and logistic support concepts were critical test objectives for the M1 but were not officially compared to similiar data for the M60. RAM-D data was collected on the M1 during the rigorous operations that were conducted in the severe test environment. However, RAM-D data was not collected on the M60 tanks which were also adversely effected by the harsh environment. Rather, historical baseline data was used for the M60s, data that was not indicative of the actual test experience. The M1 RAM-D data was unfairly compared to the unrealistic historical M60 data in spite of the fact that such comparison was not the intent of the test and evaluation plan. Because the M1, which replaces the M60, was constantly being compared to M60 parameters, RAM-D data should have been collected on the M60 during OT-II under the identical procedures as used for the M1.

j. Test Player Selection

Operational test guidance includes a requirement that the player personnel be typical of the ultimate user in the field. Over qualified or under qualified player personnel prejudice test results with potential costly future impacts. The procedure used by OTEA for OT-II was a good solution to the problem of at least ensuring that the competing platoons were equally manned and, if the 3d ACR personnel can be considered typical of all armor crewmen, representative of the potential users of the M1.

APPENDIX I

INTEGRATED LOGISTIC SUPPORT MANAGEMENT

1. BACKGROUND

a. Conceptual Phase. The MBTTF prepared the MN(ED) in 1972. One of the minimum acceptable characteristics as stated in the MN was, "the MBT must have a degree of simplicity and reliability which will ensure its presence on the battlefield without excessive training or maintenance requirements."[1] The MN also provided for the following logistical concepts:

(1) Support and test equipment. The tank was to be designed to require the least amount of specialized suport and test equipment possible. As the need for specialized support or test equipment became evident, a review of on-hand support and test equipment was to be made prior to the development of any new equipment. This requirement was not intended to compromise the ease of maintenance requirements.

(2) Supply Support. The tank design shall be compatible with standard Army lubricants, fuels, and other consumables to provide the least possible added burden on the supply support system.

(3) Maintenance Plan. The proposed maintenance philosophy was based on the probability that 90 percent of all malfunctions would be detected and corrected at the operator/organizational level. Maintenance functions were to be assigned to the level best qualfied, most responsive, and cost effective. "Mission Failure" items were to be limited to that frequency that would

[1]MBTTF Report, MN(ED), 1 August 1972.

assure an acceptable mission reliability, vehicle design would incorporate built-in test equipment where ever practicable.

Daily operational checks and services were to be conducted by the crew. Scheduled maintenance would be conducted by the crew and organizational mechanics. Inclusion of built-in indicators for fuel, air, and oil filters as well as fuel, lubricant and hydraulic reservoir levels should be considered. Unscheduled maintenance at the organizational level would be limited to component replacement.

Maintenance at the Direct Support (DS) level was generally to be limited to end item repair (unscheduled maintenance) by component replacement. Repair would be authorized in those instances where diagnostic equipment, special tools, and skills are readily available.

General Support (GS) level repairs were, for the most part, to be limited to common components and piece parts. Further GS level repairs were to be authorized based on the extent of facilities, special diagnostic and calibration equipment, and special tools, as well as the density of components, cost of repair parts, and availability of skills.

Rebuild of the end item and major assemblies was to be accomplished at depot level only. Additionally, piece part repair of any component requiring extensive calibration or alignment equipment would be accomplished at depot level.

(4) Personnel and Training. The tank was to be designed to provide for efficient operation and field support maintenance by personnel properly trained in its use and care. Requirements for special aptitudes and training

were to be kept to the lowest level commensurate with fielding an acceptable tank. The MOS structure would be similar to that for other fielded tank systems of the time frame.

(5) Transportation and Handling. The MBT was to be designed to be transported by land, sea, and air transport vehicles of the time with the least possible preparation.

(6) Performance and physical characteristics/requirements were explicity described for mobility, firepower, and survivability. Primary consideration was to be given to subsystem packaging and integration that would allow for improvement potential. The hull and turret design were to be effective into the 1990 decade, with consideration given at the outset for their capability to receive an improved gun, fire control, engine, powertrain, suspension system, and night vision equipment without having significant impact on the turret and hull design. Performance and physical characteristic requirements are shown in Appendix H--Test and Evaluation Management. Reliability, Availability, and Maintainability (RAM) requirements were set forth in the MN. These requirements are also discussed in Appendix H.

(7) The facilities plan, logistic support resource funds, technical data, and logistic support management information areas were omitted from the MN.

b. Validation Phase. In order to minimize the costs associated with funding two competing contractors for the 34-month Validation Phase, no funds were programmed in ILS development.[2] The Logistic Support Analysis (LSA), a

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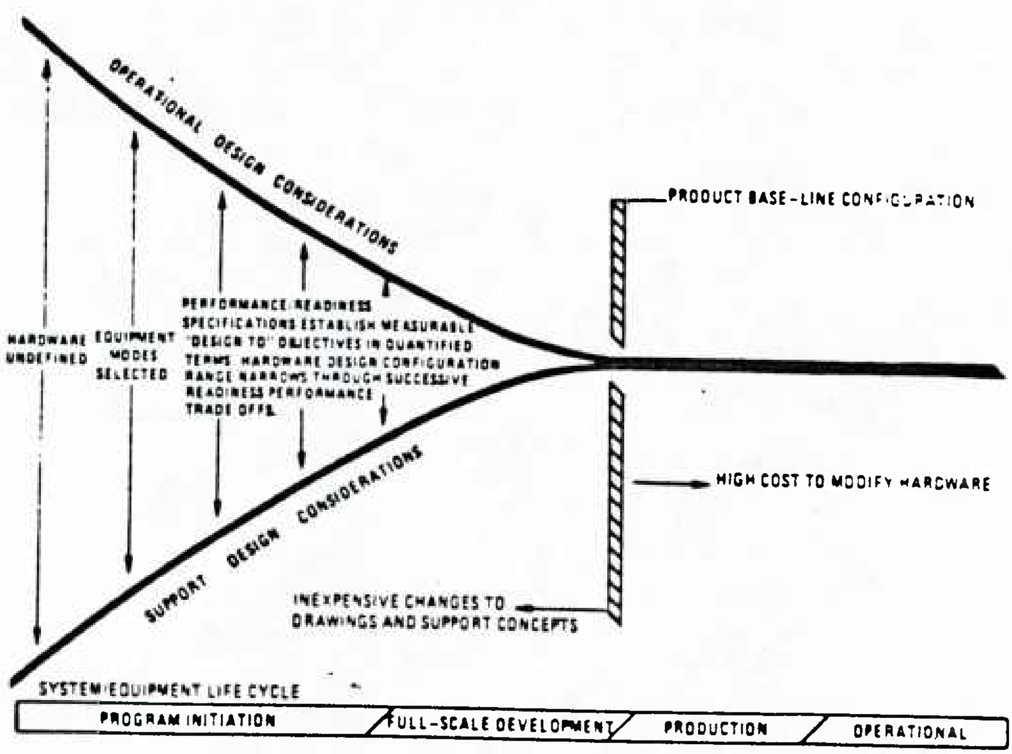
[2]MG D.M. Babers, Lessons Learned, 1980.

newly developed procedure,[3] was not required to be initiated by the two competing contractors. This meant that the data required to initiate the development of task analysis, maintenance manhour requirements, provisioning, technical manuals, level of maintenance analysis, and the Maintenance Allocation Chart (MAC) was not available at the start of the next phase. PMO estimates are that as much as $30M was saved during the Validation Phase by postponing the ILS effort. Figure I-1, from Mil Std 1388, illustrates the importance of early consideration of ILS and early initiation of the LSA effort in terms of the cost of future design changes.



Source: DSMC 1982

Figure I-1

COST OF DESIGN CHANGES VS. SYSTEM LIFE CYCLE

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[3]Military Standard 1388-1, LSA 15 October 1973.

Operational and Support (O&S) costs are estimated to be 60 percent of a systems total Life Cycle Costs (LCC). In addition, 70 percent of the LCC are chargeable to decisions made prior to the start of FSD. See Figure I-2.

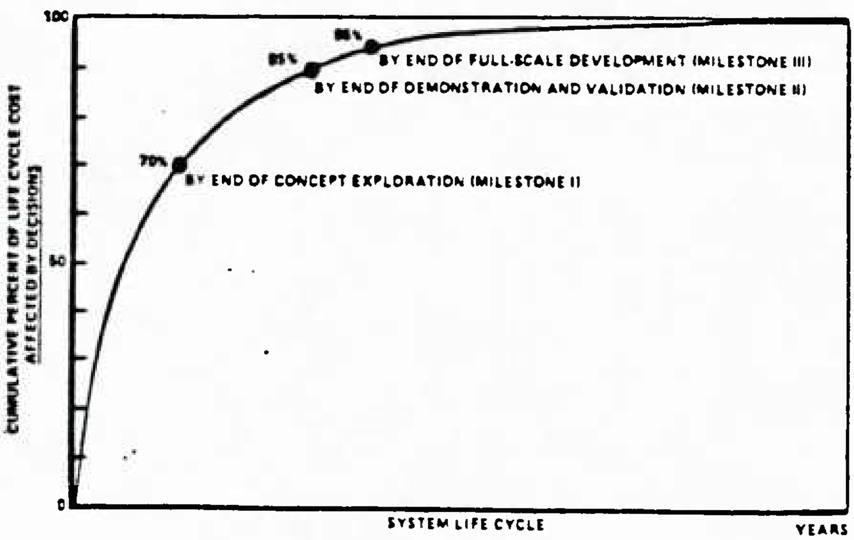

Figure I-2

SCHEDULE OF DECISIONS AFFECTING LIFE CYCLE COST

The LSA process was developed to promote early and continuing involvement between the design engineer and the logistician. The recently implemented DOD Acquisition Improvement Program [4] includes requirements for considering logistics early in a weapon systems program and explicitly designating resources early (up-front) to logistic support (Initiative No. 9, System Support and Readiness).

At the completion of the Validation Phase, each contractor was required to submit a proposal for the Full Scale Engineering Development Phase. Several ILS elements were considered in these proposals but they did

[4] DOD Acquisition Improvement Program, DepSecDef, 30 April 1981.

not have the benefit of ILS efforts during the validation phase. Included in the proposals were the contractor's description of their plans for:

- o Logistic concept
- o Maintenance concept
- o Maintenance Allocation Chart, and
- o Technical Manuals

c. Full Scale Engineering Development (FSED) Phase. The FSED contract awarded to Chrysler in November 1976 included requirements to perform LSA to support the logistics concepts which had been defined in the Validation Phase and to support other M1 Abrams Tank program ILS requirements. But, because the ILS effort was begun during FSED, the support package for the M1 Abrams Tank system was essentially one development phase behind the weapon system. ILS management was placed in a costly "catch-up" mode throughout the remainder of the program--although ILS is always playing catch-up, the problem was intensified because of the M1 PMO decisions to start late in an accelerated program.

The LSA effort was initiated with working meetings with the contractor at the start of the FSED contract. These meetings definitized the contractual requirements. An M1 ILS Team was formed by the PMO and contractor (the Logistic Management Division was not established until 1977). Among the ILS efforts planned and contracted for were requirements to:

- o Conduct LSA
- o Prepare training requirements
- o Identify repair requirements
- o Prepare the new look publications

- o Develop support equipment
- o Review training device requirements for Loader Trainer, Conduct of Fire Trainer, Tank Driver Trainer, and a Turret Maintenance Trainer
- o Consider packaging and transportation requirements
- o Developing a PERT Network for ILS activities
- o Develop Test Sets for Organization, DS, and GS use
- o Provisioning documentation
- o Develop BITE to test Line Replaceable Units (LRU)

However, initial FSED funding constraints prevented a full LSA effort. This reduction in effort was partially due to the lack of understanding of what LSA could do for the PMO. Later, in the FSED phase, LSA went to a full scale effort. In another effort to save funds during FSED and in order too get DT/OT II started early because of the compressed schedule, reliability testing at the unit level was not conducted as intensively as it might have been.

d. Production Phase. During this phase, commencing with Low Rate Initial Production (LRIP) in November 1979, the ILS effort matured. Significant progress was made with provisioning, RAM-D requirements, MAC development technical manual preparation, LSA, test sets, personnel and training, and materiel fielding.

ILS efforts culminate with successful fielding and the subsequent support of the new system. The M1 program required three Materiel Fielding Plans (MFP): one for active CONUS units, one for the National Guard (Round-out-units), and one for the U.S. Army Europe (USAREUR). Both the CONUS and USAREUR MFPs are currently in use. A draft MFP for the National Guard is being staffed. The Materiel Fielding Agreements establish the responsibilities of each party and are an integral part of each MFP.

The PM M1 Tank System is responsible for management of all logistic functions relative to fielding and follow-up support of the M1. A Fielding/Training Branch has been established within the Logistic Management Division to furnish assistance and resolved problems that arise during deployment. The PM will be assisted by DARCOM Commodity Commands, Depot System Command, and contractor support. The TRADOC System Manager (TSM) is the counterpart of the program manager on the user side. Working for the CG TRADOC through the appropriate school/center commander, the TSM is responsible for personnel, training, employment concept, and user-oriented logistic requirements.

The CONUS materiel fielding teams will travel to each location to deprocess and hand-off the equipment and train the organizational personnel. The fielding teams also ensures that the gaining units' support capabilities are in place, to include manuals, spares, repair parts, tools, and test sets. The new equipment training will normally be conducted on-site for the crew and the organizational level maintenance personnel. CONUS DS/GS personnel receive their training at the appropriate proponent school.

The M1 Abrams NET team went to USAREUR to train in 7th Army Training Center (7ATC) cadre at Vilseck, maintenance personnel, field maintenance technicians, and some depot personnel. The 7ATC cadre will then train the receiving units and supporting maintenance units.

The original draft MFPs were prepared in March 1979 under the guidance provided in Army Regulations 700-127, Integrated Logistic Support, and DARCOM Circular 700-9-4, Instructions for Material Fielding supplemented with the experience of several PMO personnel who had been involved with the earlier fielding of M60 tanks in Europe. The early fielding regulations were inadequate and the M1 PMO suffered from lack of guidance and experienced fielders, as have most other new system.[5] A revision of DARCOM Circular 700-9-4, August 1982, has recognized the problems and improved the situation.

e. Current Status

Paragraph a. of this appendix identified the M1 ILS requirements as stated in the MBTTF and MN. The status of those early requirements and other ILS objectives as of October 1982 are shown in Figure I-3.

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5 J.B. Lincoln, Fielding Army Systems: Experiences and Lessons Learned, Concepts, DSMC, Autumn 1980.

Requirement/Objective	Status
Semi-Annual Scheduled Maintenance	Achieved
Reduce Quantity of Special Tools Required Compared to Other MBTs	133 Special Tools Required of which 84 are New and Unique. Compares to 214 for M60A1
Use Metric Tools Fastners for all Crew Maintained Tank Components	Achieved - Also an RSI Objective
Substantially Reduce Requirement to Remove Power Pack from Tank to Perform Maintenance	Achieved. 90% of all engine compartment components can be removed with power pack in tank
Develop Improved TMs using SPAs Concept	Achieved. TMs in process of validation/verification
Develop Skill Performance Aids ETM.	Soldier validated/verified manuscripts delivered to TRADOC
Develope Training Devices	Continuing
90% of all Malfunctions Detected and Corrected at Operator/Organization Level	Achieved
Provide Least Possible Burden on Standard Army Supply Support System	Achieved as planned
Extensive Use of BITE	Planned use of BITE constrained by DTUHC
DS Maintenance	Achieved as planned
GS Maintenance	Achieved as planned
Depot Maintenance	Contractor support initially
Personnel and Training - Special aptitudes and training requirements to be kept low	Achieved as planned
Transportable in vehicles available	Achieved
Develop ATE for Organizational and Field Maintenance	Test Sets proven in DT/OT-III. Currently supporting fielded tank
Use MOS Structure similar to that used for the fielded tank systems	Achieved W/M1 MOSs and ASIs

Figure I-3
STATUS OF ILS REQUIREMENTS

2. OBSERVATIONS

a. Planning

(1) Requirements for logistics development must be recognized early and detailed planning begun before release of the Validation Phase RFP. In addition to the definition of readiness objectives, the logistics strategy should be developed, required operational and support systems identified, and resources designated for the Validation Phase ILS effort. The level of ILS effort has to be balanced against available resources and other program requirements. Not all ILS efforts have to be initiated immediately, some can be postponed without penalty.

(2) Savings realized by not funding for ILS development during a competitive Validation Phase, may later be lost, either directly or indirectly, due to increased development and production phase costs and PMO and user requirements for management catch-up corrective actions. This is a trade-off that must be made by the PMO. In addition, the high visibility of the M1 program intensified the negative impacts of the late starting ILS program. The Acquisition Improvement Program Initiatives #9, System Support and Readiness and #31, Improved Reliability and Support established in 1981 address the importance of early ILS efforts.

(3) The impact of delaying the M1 program ILS effort was particularly costly because of the compressed scheduled required to meet the "seven years to production" mandate. The two actions -- compression of the schedule and delay of the entire ILS program -- were incompatible.

(4) People have to be attuned to the fact that the logistics community is continually outpaced by hardware development. The system can not

keep up unless it accepts some risk of "wasted effort" e.g. something will have to be repeated - there will be mistakes - and changes must be accepted. Otherwise, logistics becomes the delaying element as IOC approaches.

b. Logistic Support Analysis (LSA)

(1) Ideally, the LSA effort should be initiated early and performed in its entirety. The impact of delaying the LSA effort is deceiving because it is not immediately apparent. Also, the LSA effort should not be scaled down, without consideration of the impact on other ILS requirements.

(2) The LSA process is not well understood by the Army and its contractors. This fact makes it difficult to prepare well defined statements of work, prepare proposals on the LSA effort, or evaluate the proposed LSA efforts. The use of computer aided design techniques, either with an in-house capability or through a consultant service, could help the PMO with the LSA portion of the RFP and the contractor with his LSA tasks and could lead to better schedules and deliverables.

c. PMO Organization for ILS

In addition to the late initiation of the ILS effort, the Logistic Management Division was not established until 1977. This was too late to influence the FSED Phase preparations or to participate in the initial work meetings with the contractor. Also, the division experienced a slow personnel build-up until 1980 when it reached it current strength.

d. Provisioning

(1) During early fielding, it is important to make provisions for the return of failed parts to the contractor for failure analysis. In addition, data collection in the field by visiting technical experts provides an on-site capability that can better relate failures to the environment in which they occurred.

(2) For a number of reasons, the LSA developed failure factors are less than perfect. Major, high management items are less of a problem than that presented by the countless minor parts. Other data sources are needed for these minor equipments. These sources can be test data, like and similar data, or engineering judgement.

(3) The PMO has designated the two Army Depots to prepare the Depot Maintenance Workload Record (DMWR) for the engine and tank. Emerging conclusions from the early DMWR efforts indicate that it must be a team effort. The PMO must buy contrctor support and provide up-to-date technical data. Also, there must be close management of the contractor/depot information exchange.

(4) With the concurrence of the Readiness Commands, the PMO discontinued use of the Support List Allowance Card (SLAC) system for developing Prescribed Load List (PLL) and Authorized Stockage List (ASL). Instead, they used actual demand data gathered from the extensive DT/OT II experience.

e. Maintenance

(1) In order to obtain timely, complete, and objective records of all maintenance actions in fielded units the PMO contracted with a civilian firm to collect data from three tank battalions, two in Europe and one in CONUS.

(2) Eight FSED test sets were developed as part of the ILS program. The overall assessment was that they were unreliable and they received little use in DT/OT II. The development of such equipment requires a joint effort by design engineers and logisticians.

f. Fielding

(1) The people needed for NETT, fielding teams, and PMO logistic management are also in demand in the logistic and armor community. The Army has a critical need for experienced materiel fielders.

(2) Fielding procedures need to be more standardized, at least by type of system, to include responsibilities and requirements. Guidance documents, DA Pamphlet 11-25, LCSMM; AR 700-18, Fielding of US Army Equipment; and DARCOM Circular 700-9-4, Instructions for Materiel Fielding do not talk sufficiently to the details, although the August 1982 version of DARCOM-C-700-9-4 is a vast improvement.

(3) The M1 NETP was built upon the proven M60 procedures for fielding in USAREUR. The experience of M1 PMO personnel who had formerally been involved with M60 fielding was invaluable.

(4) Material Fielding Plans (MFP) coordinate the complex fielding process. The first draft should be prepared approximately 30 months prior

to the fielding date. The plans should be revised at 6-9 month intervals and a continuous dialouge must be maintained with the receivers. The final plan should be published 90 days before fielding - earlier publication would not be up-to-date, later would be too late to be useful. The requirements for MFP are outlined in DARCOM Circular 700-9-4.

APPENDIX J

INTERNATIONAL COLLABORATION

1. BACKGROUND

a. The first attempt at a cooperative effort to develop an Army tank occurred in 1957 when the United States, Germany, and France signed an agreement to develop a common tank. This agreement was dissolved almost immediately due to differing concepts and national pride. In 1963, the United States and Germany entered into an agreement to jointly develop a Main Battle Tank (MBT-70). After six years, this second attempt was terminated due to extremely high costs. Today, nearly 25 years after the first attempt to develop a standard tank, there is still no standard tank in NATO.

b. In 1974, Congress expressed it's interest in standardization with the passage of the Nunn-Culver Amendment to the DOD Appropriation Authorization Act for FY 75. Two years later, the policy of the United States toward NATO Rationalization, Standardization, and Interoperability (RSI) was set forth in Public Law 94-361.[1] This policy statement, commonly referred to as the Culver-Nunn Amendment, stated:

> "It is the policy of the United States that equipment procured for use of personnel of the Armed Forces of the United States stationed in Europe under terms of the North Atlantic treaty should be standardized or at least interoperable with equipment of other members of the North Atlantic Treaty Organization."

c. The first serious recognition of the importance of rationalizing the NATO defense posture occurred in 1977 when members agreed to the Long Term Defense Program. Since 1977, members of the Alliance have pursued a variety

[1]Public Law 94-361, Section 802 (a)(1), July 14, 1976

of efforts to standardize weapons systems, components, fuel, and ammunition. This collaboration among members has become an important thrust in the ongoing NATO improvement program. Collaboration is defined as: "any attempt to coordinate the development of new systems in an effort to rationalize defense production or to achieve standardization or interoperability of military equipment."[2]

d. Concurrent with the increased Congressional interest and awareness of NATO RSI, was the third attempt to develop a standardized tank within NATO. A chronology of this collaborative effort among the United States, the United Kingdom, and Germany follows:

	Date	Event
1974	March	U.S., U.K., GE agreed to test tank guns (Tripartite Gun Trials)
	December	Two-part Memorandum of Understanding (MOU) signed by U.S. and GE.
		U.S. agreed to test the German Leopard 2 for possible purchase.
		Both nations agreed to make reasonable efforts to achieve maximum standardization between the Ml Abrams and the Leopard 2 tank. [If U.S. did not purchase latter.]
1975		
	March	Trilateral Gun Trials held in U.K.
	July	U.S. and U.K. agreed to test British 120 mm rifled tank gun.
1976	July	U.S. and GE signed Addendum to 1974 MOU agreeing to an exchange of tank components.
	September	U.S. Army began testing of Leopard 2 tank.

[2]RAND Note, N-1680-RC, August 1981

	December	U.S. completed Leopard 2 competitive tests.
1977	January	U.S. and GE signed addition to Addendum to MOU which: Extended gun competition to DEC 77 Ended tank competition
	May	Joint Agreement between U.S. and GE reemphasized commonality between tanks and provided an apology to GE for criticism of Leopard 2 Tank [3]
1978	January	U.S. Army selected GE 120mm gun for later production models of the Ml Abrams Tank (MlEl)
	September	U.S. Congress approves 120mm gun development program
1979	February	U.S. and GE signed licensing agreement for the 120mm gun and ammunition U.S. and GE signed addendum 2 to MOU
	March	U.S. 120mm gun program initiated

The collaboration of the previously mentioned efforts have produced some degree of success. The U.S. plans to equip the MlEl with the 120mm gun commencing in 1985. In addition, both tanks use DF2 fuel, have common metric fastners at the crew maintenance level, and have common night vision modules. Interoperability of other components system) is being investigated.

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[3]Richad C. Fast, The Politics of Weapon Standardization in NATO, July 1971

2. STUDY TEAM OBSERVATIONS

a. Although the U.S./GE MOU was signed in 1974, with subsequent additions and addendums being signed in 1975, 1976, 1977, and 1979, the National requirements of each country were too strong and the design/development of the respective tanks had advanced too far to enable the development of a standardized tank. These requirements differed because the doctrine and concepts differed between the two countries. Differing national requirements (design, performance, mission) for weapon systems present the greatest obstacle to future attempts at system collaboration with our allies.

b. When standardization and interoperability are primary objectives for major weapon systems, they must be considered prior to program initiation and identified in the Justification of Major System New Start (JMSNS). The process should begin with harmonization of user requirements. National procurement requirements should also be reviewed. National restrictions impinging on standardization and interoperability objectives should be waived where the advantages of international standardization and interoperability outweigh national standardization objectives.

c. A Memorandum of Understanding and/or Letter of Agreement must be carefully negotiated, staffed, and scrutinized by industry, user, and legal staffs. An agreement must be specific; generalities and vagueness only serve to breed future confusion and invite debate over the intentions of its drafters, who may or may not be available to clarify the situation. Figure J-1 shows the U.S. policies for delegation of approval authority to negotiate and conclude international agreements.

	SECRETARIES OF THE ARMY, NAVY AND AIR FORCE	CHAIRMAN, JOINT CHIEFS OF STAFF	UNDER SECRETARY OF DEFENSE RESEARCH AND ENGINEERING	ASSISTANT SECRETARY OF DEFENSE COMMUNICATIONS, COMMAND CONTROL AND INTELLIGENCE (C3I)	ASSISTANT SECRETARY OF DEFENSE MANPOWER, RESERVE AFFAIRS AND LOGISTICS (MRA&L)	ASSISTANT SECRETARY OF DEFENSE COMPTROLLER	DIRECTOR NATIONAL SECURITY AGENCY	DIRECTOR DEFENSE SECURITY ASSISTANCE AGENCY	DIRECTOR DEFENSE MAPPING AGENCY
1 TECHNICAL, OPERATIONAL, WORKING OR SIMILAR AGREEMENTS OR ARRANGEMENTS CONCLUDED PURSUANT TO A TREATY OR EXECUTIVE AGREEMENT THAT ENTAILS IMPLEMENTING ARRANGEMENTS	✓	✓					✓	✓	
2 AGREEMENTS WITH ALLIED AND FRIENDLY COUNTRIES AND ORGANIZATIONS FOR COOPERATIVE OR RECIPROCAL OPERATIONAL LOGISTICAL, OR OTHER MILITARY SUPPORT, INCLUDING ARRANGEMENTS FOR SHARED USE OF LICENSING OF MILITARY EQUIPMENT, FACILITIES SERVICES AND NONPHYSICAL RESOURCES	✓	A			B		✓		
3 AGREEMENTS RELATING TO COMBINED MILITARY PLANNING, COMMAND RELATIONSHIPS, MILITARY EXERCISES AND OPERATIONS, MINOR AND EMERGENCY FORCE DEPLOYMENT, AND EXCHANGE PROGRAMS	C	B							
4 AGREEMENTS FOR THE COLLECTION OR EXCHANGE OF MILITARY INFORMATION AND DATA	✓								D
5 COOPERATIVE RESEARCH, DEVELOPMENT, DATA EXCHANGE, AND RELATED LICENSED PRODUCTION AND STANDARDIZATION AGREEMENTS	✓		✓						
6 MILITARY AND INDUSTRIAL SECURITY AGREEMENTS UNDER THE PROVISIONS OF V.A.4.b. DoD DIRECTIVE 5230.11 AND AGREEMENTS RELATING TO MILITARY BANKING FACILITIES AND CREDIT UNIONS						✓			

NOTES
A OPERATIONAL COMMAND OF JOINT FORCES
B UNLESS UNISERVICE MATTER
C UNISERVICE
D RELATING TO MAPPING, CHARTING, GEODESY & AERIAL PHOTOGRAPHY

Figure J-1

DELEGATED APPROVAL AUTHORITY TO NEGOTIATE[4]
AND CONCLUDE INTERNATIONAL AGREEMENTS

d. A MOU should be written so as not to jeopardize the national sovereignty of the United States, e.g., preclude, U.S. export rights.

e. The most efficient approach to licensing negotiations provides that they be conducted at industry level, with the governments involved using their good offices to assist as required.

f. The Program manager and his team are the instruments for DOD to initiate Intellectual Property (IP) transfers. If IP rights are not considered early, their subsequent transfer becomes much more difficult and expensive.

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[4]Guide for the Management of Multinational Programs, DSMC, July 1981

g. Once a collaborative effort has been entered into between the United States and one or more of our NATO Allies, a clearly defined organizational structure must be established. Figure J-2 shows the Tank Main Armament System Standardization Organization between the U.S. and the GE and its relationship with the Leopard 2 and M1 Tank harmonization programs.

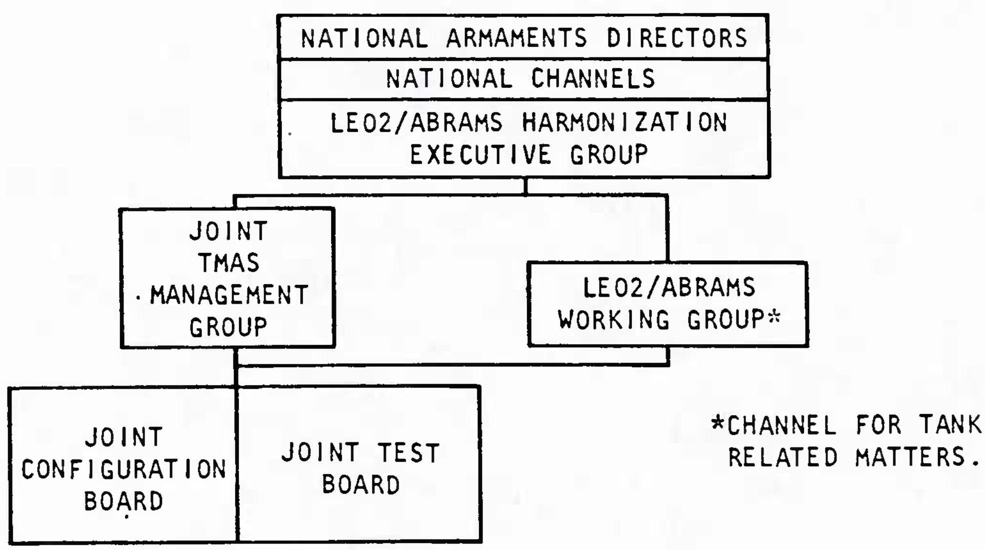

Figure J-2
U.S.-GE 120MM TMAS STANDARDIZATION ORGANIZATION

h. As a result of the Congressional debate over the collaboration efforts to standardize the MBT, three important guidelines evolved which should be considered in future collaborative efforts. Collaboration should:

(1) Not disrupt the development program of a weapon system by either increasing costs, reducing performance, or stretching-out the schedule.

(2) Lead to demonstrable increases in military effectiveness for the system being developed.

(3) Not impede subsequent U.S. export of that system.

APPENDIX K

GENERAL OBSERVATIONS

The following study team observations cover issues that do not clearly fall into any single functional area included in the preceeding appendices.

a. Major programs, particularly those heavily involved in RSI activities, and operating under severe DTUHC and schedule restraints, should not be treated as guinea pigs for experiments with new management techniques, data management systems, and acquisition concepts.

b. Major high visibility programs with antagonists at all levels of the Government and in the media should be provided with public relations assets or support and organized to present one face (the same answers) to critics.

c. There appears to be an over kill of inspections, audits, investigations, and studies concerning major programs. Some, GAO for instance, are not under Army control although their schedule may be negotiated. Others can be controlled by the Army, and if not consolidated or eliminated, at least scheduled so as not to conflict with such program activities as DSARC preparations, major reviews and major tests.

d. Program/Project offices are required by several DARCOM publications (DARCOM R-11-16 and DARCOM C-700-9-4 for example) to submit lessons learned reports to HQDARCOM. However, the program is not enforced and the benefits that could be realized from the dissemination of timely observations by program management personnel are lost.

e. Newly formed program/project offices could use more support than they presently receive in such areas as providing functional expertise/resources to meet the initial requirements; identifying reporting requirements; providing guidance on PMO organizational requirements and management information systems; and career management of PMO civilian personnel. The PM or his deputy should expect to become involved in the personnel process.

f. The Army should vigorously react against any attempts by program/project management offices, staffs of major commands, or the HQDA staff to tie their programs/budgets to major new systems in an attempt to "sell" their own programs.

g. Concurrency is a deliberate and generally worthwhile solution to shortening the acquisition process, however, managers planning concurrent programs should be aware of the implications--the impacts on the ILS program, test and evaluation, and production facilitization planning.

h. The Army has produced a tank that has demonstrated its superiority over existing tanks, that has had only a small real cost growth, that has met the production schedule, and has received favorable support from the users in Europe and in the CONUS.

i. The TSM developed an information briefing which is presented to unit personnel prior to receipt of the M1 Abrams Tank. The purpose of this briefing is to provide the user with an understanding of the system and to overcome widespread misconceptions about the system that have been promulgated by the media. The use of this indoctrination has proven very useful and should be considered by fielding teams for other systems.

APPENDIX L

REFERENCES

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APPENDIX M

GLOSSARY OF ACRONYMS

ACR	-	Armored Cavalry Regiment
AFB	-	Air Force Base
AI	-	Availability - Inherent
ARPRO	-	Army Plant Representative Office
AMSAA	-	US Army Materiel Systems Analysis Activity
APFSDS-T	-	Armor Piercing, Fin Stabilized, Disposable Sabot-Tracer
APG	-	Aberdeen Proving Ground
APU	-	Auxiliary Power Unit
ARRADCOM	-	US Army Armament Research and Development Command
ASARC	-	Army Systems Acquisition Review Council
ASI	-	Additional Skill Identifier
ASL	-	Authorized Stockage List
ATC	-	Army Training Center
ATE	-	Automatic Test Equipment
BG(P)	-	Brigadier General (Promotable)
BITE	-	Built in Test Equipment
CAIG	-	Cost Analysis Improvement Group
CBR	-	Chemical Biological Radiological
CG	-	Commanding General
CONUS	-	Continental US
CSA	-	Chief of Staff, Army
CTP	-	Coordinated Test Program
CY	-	Calendar Year
DA	-	Department of the Army
DAIP	-	Defense Acquisition Improvement Program
DARCOM	-	US Army Materiel Development and Readiness Command
DATP	-	Detroit Army Tank Plant
DCAS	-	Defense Contract Audit Service
DCP	-	Development Concept Paper
DEPSECDEF	-	Deputy Secretary of Defense
DEVA	-	Development Acceptance
DMWR	-	Depot Maintenance Workload Record
DOD	-	Department of Defense
DODD	-	Department of Defense Directive
DODI	-	Department of Defense Instruction
DS	-	Direct Support
DSARC	-	Defense Systems Acquisition Review Council
DSESTS	-	Direct Support Electrical System Test Set
DSMC	-	Defense Systems Management College
DT	-	Development Test
DTC	-	Design to Cost
DTUHC	-	Design to Unit Hardware Cost
DU	-	Depleted Uranium
ED	-	Engineering Development

ERADCOM	-	US Army Electronics Research and Development Command
ETM	-	Extension Training Materials
ET/ST	-	Engineering Test/Service Test
F3	-	Form, Fit and Function
FORSCOM	-	US Army Forces Command
FOT	-	Follow-On Test
FSED	-	Full-Scale Engineering Development
FY	-	Fiscal Year
GAO	-	General Accounting Office
GDLS	-	General Dynamics Land Systems
GE	-	Federal Republic of Germany
GFE	-	Government Furnished Equipment
GFM	-	Government Furnished Material
GOCO	-	Government-Owned, Contractor-Operated
GS	-	General Support
HASC	-	House Armed Services Committee
HEL	-	US Army Human Engineering Laboratory
HFE	-	Human Factors Engineering
HQDA	-	Headquarters, Department of the Army
HQDARCOM	-	Headquarters, DARCOM
ICTT	-	Intensified Confirmatory Troop Test
ILS	-	Integrated Logistics Support
IOC	-	Initial Operational Capability
IOT	-	Initial Operational Test
IP	-	Intellectual Property
IPE	-	Industrial Plant Equipment
IPF	-	Initial Production Facilitization
IPT	-	Initial Production Test
JMSNS	-	Justification for Major System New Start
KE	-	Kinetic Energy
L-F	-	Leader-Follower
LATP	-	Lima Army Tank Plant
LCC	-	Life Cycle Cost
LEA	-	US Army Logistics Evaluation Agency
LLTI	-	Long Lead Time Item
LOA	-	Letter of Agreement
LRIP	-	Low Rate Initial Production
LRU	-	Line Replaceable Unit
LSA	-	Logistic Support Analysis
MAC	-	Maintenance Allocation Chart
MBT	-	Main Battle Tank
MBTTF	-	Main Battle Tank Task Force
MERADCOM	-	US Army Mobility Equipment Research and Development Command
METSFPP	-	Manufacturing Engineering, Tooling, Special Test Equipment and Facilities Procurement Program
MFP	-	Material Fielding Plan
MG	-	Major General
MLRS	-	Multiple Launch Rocket System
MMBF	-	Mean Miles Between Failures
MM&T	-	Manufacturing Methods and Technology
MN	-	Material Need
MOS	-	Military Occupation Specialty

MOU	-	Memorandum of Understanding
MPH	-	Miles per Hour
MP-T	-	Multipurpose Traces
MR	-	Management Review
MRSA	-	US Army Material Readiness Support Activity
MTBF	-	Mean Time Between Failures
MTSP	-	Maintenance Test Support Package
MTTR	-	Mean Time to Repair
NATO	-	North Atlantic Treaty Organization
NBC	-	Nuclear, Biological and Chemical
NET	-	New Equipment Training
NETP	-	New Equipment Training Plan
NETT	-	New Equipment Training Team
NMBT	-	New Main Battle Tank
NRC	-	Nuclear Regulatory Commission
ODCSRDA	-	Office, Deputy Chief of Staff (Research, Development and Acquisition)
OBM	-	Office of Management and Budget
O&S	-	Operating and Support
OSD	-	Office of the Secretary of Defense
OT	-	Operational Test
OTEA	-	US Army Operational Test and Evaluation Agency
QSR	-	Quality Systems Review
PAT&E	-	Production Acceptance Test and Evaluation
PBS	-	Production Base Support
PCT	-	Production Comparison Test
PEP	-	Producibility Engineering and Planning
PERT	-	Program Evaluation and Review Technique
PIP	-	Product Improvement Program
PLL	-	Prescribed Load List
PM	-	Project/Program Manager
PMO	-	Project/Program Management Office
POM	-	Program Objectives Memorandum
PQT	-	Production Qualification Test
PQT-C	-	Production Qualification Test - Contractor
PQT-G	-	Production Qualification Test - Government
PRR	-	Production Readiness Review
PSI	-	Pounds per Square Inch
PV	-	Pilot Vehicle
PVT	-	Production Verification Test
PVT-C	-	Production Verification Test - Contractor
PVT-G	-	Production Verification Test - Government
RAM	-	Reliability, Availability and Maintainability
RAM-D	-	Reliability, Availability and Maintainability and Durability
RFP	-	Request for Proposal
RSI	-	Rationalization, Standardization and Interoperability
SLAC	-	Support List Allowance Card
SPA	-	Skill Performance Aid
SSEB	-	Source Selection Evaluation Board
STE-M1	-	Simplified Test Equipment/M1
STTF	-	Special Tank Task Force
TACOM	-	US Army Tank and Automotive Command

TC	-	Type Classification
TDP	-	Technical Data Package
TECOM	-	US Army Test and Evaluation Command
TEMP	-	Test and Evaluation Master Plan
TIS	-	Thermal Imaging Sight
TIWG	-	Test Integration Working Group
TM	-	Technical Manual
TMAS	-	Tank Main Armament System
TPFSDS-T	-	Training Round, Fin Stabilized, Disposable Sabot - Tracer
TRACE	-	Total Risk Assessing Cost Estimate
TRADOC	-	US Army Training and Doctrine Command
TSIR	-	Test Set Incident Reporting
TSM	-	TRADOC System Manager
TSTS	-	Thermal System Test Set
USADC	-	US Army Combat Developments Command
USAREUR	-	US Army Europe
VCSA	-	Vice Chief of Staff, Army
WSMR	-	White Sands Missile Range
YPG	-	Yuma Proving Ground

APPENDIX N

STUDY TEAM COMPOSITION

1. TEAM LEADER

Lieutenant Colonel Garcia E. Morrow is assigned to the Research and Information Department, Defense Systems Management College, Fort Belvoir, Va. He graduated From St. Lawrence University in 1963 with a Bachelor of Science degree. Following graduation, LTC Morrow entered the US Army Guided Missile Staff Officer Course and has had R&D assignments with the Pershing, Sergeant, Lance and SAFEGUARD Systems. LTC Morrow was also the Team Leader for the Lessons Learned Report prepared for the Multiple Launch Rocket System (MLRS) in 1980.

2. TEAM MEMBERS

a. Mr. Charles M. Lowe, Jr., is a Procurement Analyst with the U.S. Army Procurement Research Office, U.S. Army Materiel Systems Analysis Activity, Fort Lee, Virginia. He earned a BBA from East Texas State University in 1974, an MBA from Southern Illinois University in 1977, and an MS in Procurement and Contract Management from Florida Institute of Technology in 1978. Mr. Lowe has worked on APRO studies in the areas of Government furnished equipment, administrative leadtime costs and improvements, and acquisition of advertising services. He was a Logistics Specialist and Procurement Analyst with the Troop Support and Aviation Readiness Command (formerly the Troop Support Command) prior to joining the APRO.

b. Mr. Elmer H. Birdseye is a retired U.S. Army Officer who is currently employed as a management analyst with Information Spectrum, Incorporated, Arlington, Va. He is a 1951 graduate of the United States Military Academy. He received a Master of Engineering Administration degree from the George Washington University in 1968. Mr. Birdseye's military experience includes service with field artillery howitzer and rocket units; R&D staff officer in the Office of the Deputy Chief of Staff for Research and Development, Department of the Army; and as the US Army Field Artillery Standardization Representative to the United Kingdom. Mr. Birdseye was also a Team Member for the Lessons Learned Report on MLRS.