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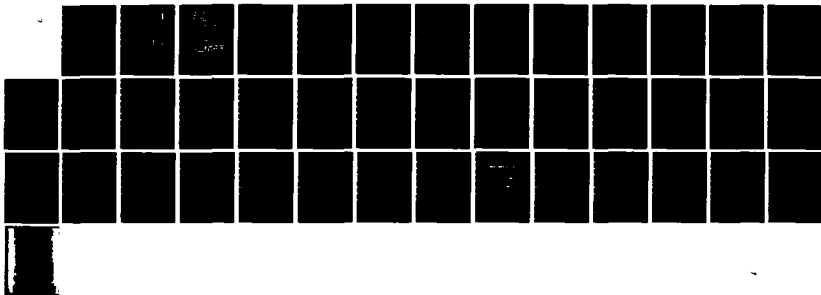
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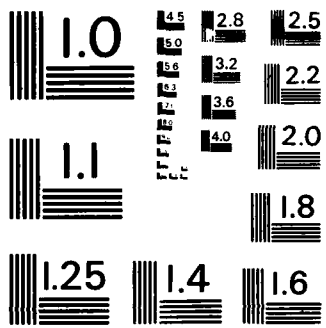
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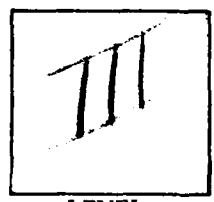
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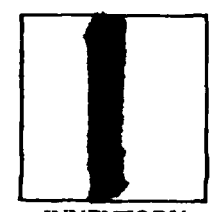
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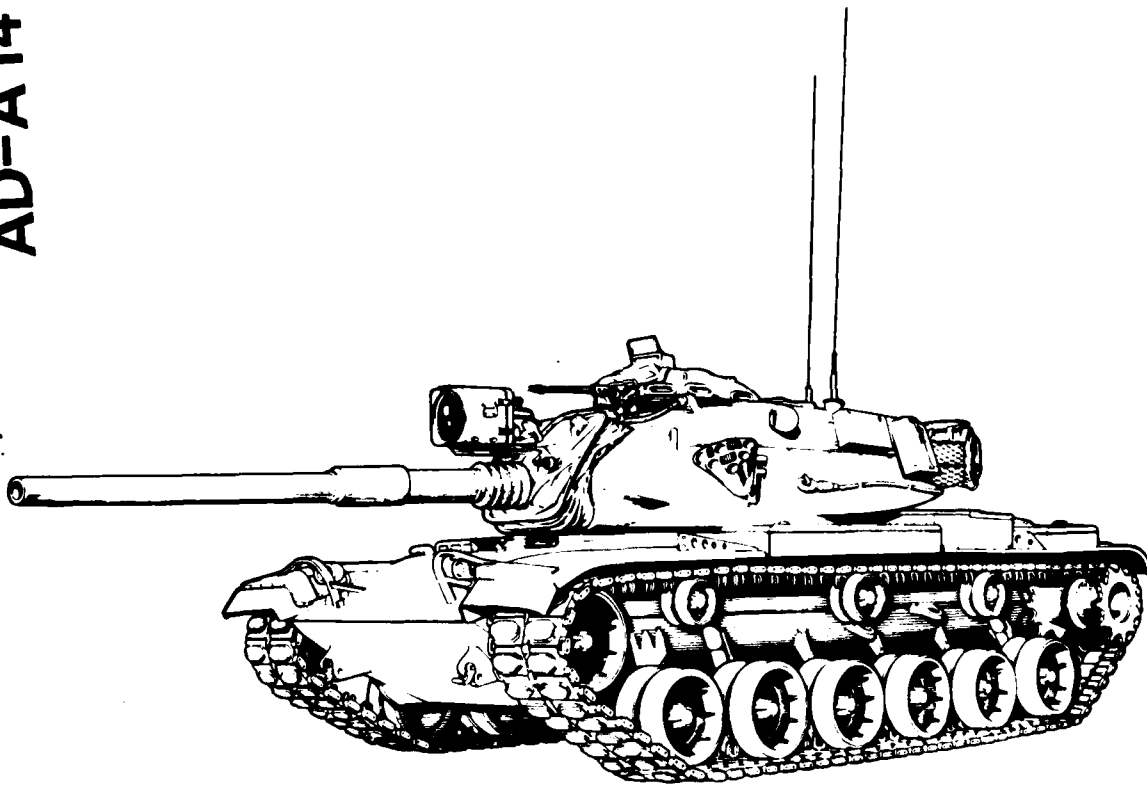
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**M60A1, M60A1 RISE,
AND M60A1 RISE (PASSIVE) SERIES
TANKS, COMBAT, FULL-TRACKED
105-MM GUN**

UPDATE SYSTEM ASSESSMENT

AD-A141 935



PREPARED BY

LOGISTIC MANAGEMENT DIVISION

PMO M60 TANKS

MAY 1980

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FOREWORD

A Disciplined Review I for the M60 Series Tanks was conducted in October 1977. The review was accomplished through a series of working group sessions that addressed the hull and assessories, engine compartment, electrical systems, track and suspension and turret including cupola, main, and secondary armaments.

This Update System Assessment provides a follow-up to the Disciplined Review I. It addresses the system changes which have occurred since that review, current problems, and planned actions.

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SECTION I

DEVELOPMENT HISTORY

1.1 System Description

The M60A1, M60A1 (AOS), M60A1 RISE, and M60A1 RISE Passive Tanks are full track-laying, heavily armored combat vehicles operated by four-man crews consisting of a commander, gunner, loader, and driver. The vehicle is powered by an air-cooled 750-hp diesel engine with power transmitted to the final drives through a cross-drive transmission. The cross-drive transmission includes controlled differential steering and braking functions. The main weapon is a 105mm high velocity cannon mounted to a 360 degree rotatable turret. The gun is used as an armor penetrating anti-materiel weapon, but can be used against personnel and soft targets. A 7.62mm machine gun coaxially mounted with the main gun is used as the primary anti-personnel weapon. A .50 caliber machine gun mounted in the cupola serves as an antipersonnel, soft target weapon, and for use in defense against low performance aircraft. When vehicles are equipped with add-on stabilization, the 105mm gun and the coaxial 7.62mm machine gun may be used in any one of three modes of control: (1) power-with-stabilization-on, (2) power-with-stabilization-off, and (3) manual. In the power-with-stabilization-on mode, the gunner's aim on target is automatically retained while the vehicle is in motion. This mode provides a fire-on-the-move capability. The power-with-stabilization-off option eliminates needless exercise of the stabilization system and provides a back up power mode. The manual back up system permits the crew to aim and fire the weapons should the electrical/hydraulic subsystems malfunction. The rangefinder is a full-field coincidence image instrument used as the ranging device of the primary direct sighting and fire control system. Range information from the rangefinder is fed into the ballistic computer through a shaft. The ballistic computer is a mechanically driven unit that permits ammunition selection, range correction, and superelevation correction. The ballistic computer receives range input and, through the use of cams and gears, provides superelevation information to the superelevation actuator. The superelevation actuator adds sufficient hydraulic fluid to the elevating mechanism to correctly position the gun. The M60A1 series tanks can be operated at night through the use of infrared or passive night vision devices that extend the crew's ability to see at low light levels. A searchlight is provided to illuminate targets at night with visible white light or with high security infrared light. These tanks can ford water up to four feet deep without special equipment and up to eight feet deep with a water fording kit installed. When equipped with two smoke grenade launchers and/or an engine smoke generator, these tanks can create their own limited smoke screen.

1.2 Original Design Objectives

In accordance with DARCOM Reg. 702-9 and for brevity purposes, this update system assessment will not address the original design objectives.

1.3 Test Results

The most recent testing performed with M60A1 (overhauled) and M60A1 RISE (new production) tanks was the Baseline Armor Reliability Test (BART). The BART test included five overhauled M60A1 tanks and five new production M60A1 RISE tanks. The test was conducted at Fort Hood, Texas and ran from April to November 1976. The purpose of the test was to obtain data which could be used to estimate the reliability of new M60A1 RISE and overhauled M60A1 tanks and to provide information on maintenance and supply requirements. The reliability assessments were based on each test tank having accumulated approximately 2,250 miles and fired 450 main

gun rounds. The overhauled M60A1 tank had a Mean Miles Between Failure of 59 miles without Mission Reliability Factors applied and 91 miles with Mission Reliability Factors applied. The new production M60A1 RISE tank had a Mean Miles Between Failure of 114 miles without Mission Reliability Factors applied and 170 miles when Mission Reliability Factors are applied. It should be noted that the demonstrated Mean Miles Between Failure for the overhauled M60A1 tank was less than expected and that the Mean Miles Between Failure for the new production M60A1 RISE tank was about the expected value for a 4000 mile tank life. For more detailed information on BART results, see Appendix I.

On a continuing basis, Initial Contractor Tests (ICT)/Controlled Production Tests (CPT) are conducted on new production vehicles. A summary of the test status and problem areas is shown in Appendix I.

1.4 Correction of Deficiencies

1.4.1 Battery Slave Cable Assembly. In mid-1979 a potential electrical fire hazard was identified on some new production M60A1 RISE Passive tanks due to inadequate insulation covering the bus-bar of the battery slave cable assembly. Field units were provided instructions for a temporary fix to eliminate the hazard. A permanent fix was developed and installed by the contractor.

1.4.2 Coaxial machine gun trigger (palm) switch. It was discovered on a few M60A1 Rise Passive tanks that inadequate insulation between the trigger switch contacts was permitting the main gun or coaxial machinegun to fire without the trigger being depressed. Field units were provided with instructions for testing the firing circuits to identify and replace defective trigger switches. An engineering change was incorporated into production to assure that adequate insulation was provided.

1.4.3 Brake master cylinder. It was reported in the safety assessment for the October 1977 Disciplined Review that the master cylinder is physically interchangeable with the 5-ton truck master cylinder. However, the functional characteristics of the two cylinders are different. Users were notified of the interchangeability and action was taken to label the cylinders to assure proper identification. However, a recent Equipment Improvement Report (EIR) indicates that users are receiving master cylinders that are not marked. Several PS Magazine articles have been published showing maintenance personnel how to properly identify the unmarked master cylinders.

1.5 Safety Hazards

Operation and maintenance of M60A1 (RISE) tanks since the Disciplined Review I have not disclosed any unusual safety hazards to personnel and equipment as a result of vehicle design. The Army accident reporting system does not report M60A1 accidents separate from the total M60 series world wide accident experience. However, a review of the M60 series tank accident experience indicates that vehicle design is not a contributing factor in M60 series tank accidents. During the two year period ending May 1979, there were 17 fires reported against the M60 series tanks. This is a 55% reduction in fires when compared to the two year period (FY75 and 76) covered in the Disciplined Review I.

During design several safety features were incorporated into the M60A1 series tank to reduce the safety hazards inherent in the operation of a tank. The main gun has a loader's safety switch to prevent firing of the main gun until the loader is ready. The stabilization system has a loader's shut off switch which enables the loader to shut off the stabilization system so he can safely service the main gun and the coaxial machinegun. The pushbutton control unit for the smoke grenade launcher system was designed with shields around the pushbuttons to prevent

accidental discharge of the smoke grenades. All things considered, the M60A1 series tank is a relatively safe vehicle when properly operated and maintained.

SECTION II

FIELD PERFORMANCE

2.1 Initial Field Performance

Distribution of the M60A1 tank began in the early 1960's and is continuing as required. The M60A1 RISE tank distribution started in FY 75. The M60A1 RISE tank is a product improved tank which incorporated a Reliability Improved Selected Equipment (RISE) engine, top loading air cleaner, add-on-stabilization, T-142 track, and a 650 ampere generating system. The M60A1 RISE Passive tank distribution began in FY 78. This tank is an M60A1 RISE tank with passive night vision gunner's and commander's periscopes and a passive night vision driver's viewer. The M60A1 and M60A1 RISE and RISE Passive tanks generally have been performing satisfactorily in the field and are popular with the troops.

2.2 System Changes

The main engineering changes incorporated in the M60A1 series tank prior to 1980 include:

- Add-On-Stabilization
- Aluminum Top Loading Air Cleaner (earlier tanks)
- Armored Steel Top Loading Air Cleaner with Air Restriction Indicator (later tanks)
- T-142 Track with Replacable Pads
- RISE Engine
- Water Fording Kit
- 650 Ampere Generator
- Solid State Regulator
- Passive Gunner and Commander Periscopes
- Passive Driver's Viewer
- Engine Smoke Generator (early 1980)
- Smoke Grenade Launcher
- M240 Machine Gun Mount
- Improved Final Drive
- Hydraulic Shock Absorbers
- Sprockets With Built-in Wear Gage
- Improved Personnel Heater
- Steel Road Wheels

As the major changes were incorporated into the production line, the vehicle model designations were changed. See Appendix II for the M60A1 tank evolution chart.

2.3 Performance Today

The M60A1 and M60A1 RISE and RISE Passive tanks are currently performing satisfactorily in the field and are popular with the troops. The tactical contributions offered by the increased reliability in the power train of the RISE tank have been many. Vehicle availability obviously contributes to the other functions of target acquisition, hit performance, movement, and command and control. In the Reliability, Availability, Maintainability (RAM) areas the M60A1 RISE tank has demonstrated itself to be far superior to previously fielded M60 and M60A1 series tanks. The major problem area which has been with the M60 series tank fleet since initial fielding is excessive engine loss due to dust ingestion. Other items which appear to be failing/wearing out most often are suspension components and roadwheel wear plates (used on aluminum roadwheels). Under sandy terrain and soil conditions, excessive sprocket and end

connector wear is a big problem. The primary problem within the main gun system is leaking replenisher cylinders. All of these items when not available in the supply system have an adverse impact on equipment readiness.

2.4 Logistic Support

Based on user reports, logistic support has been adequate to good depending upon location, density of tanks, and extent of operation of the tanks. Such items as special tools, test equipment, and technical manuals are in adequate supply; however there are some repair parts shortages which have been on back order for some time. Some of the back ordered items include vision blocks, fenders, universal joints, no-bak parts kits, track pad kits, end connector kits, roadwheels, ammunition rack handle parts kits, and sprockets. Cyclic shortages of certain components such as torsion bars, roadwheel arms, hubs, blower motors, accessory relays, engine overhaul gasket sets, piston assemblies, engine oil coolers, oil pressure transmitters (60 p.s.i.), air filter elements, air cleaners, engines and transmissions are causing maintenance problems as these shortages occur from area to area within the armor force. Items that are RISE peculiar, such as the 650 amp alternator and solid state regulator, are not always readily available and repair below-depot level is not authorized. Shortages of these types of items cause maintenance problems and can result in excessive downtime on some vehicles.

SECTION III

REBUILT/STORAGE RELIABILITY

3.1 Shelf Life

No unusual shelf life problems are associated with the M60A1, M60A1 (AOS), M60A1 RISE, and RISE Passive tanks or components.

3.2 Storage Reliability

All current M60A1, M60A1 (AOS), M60A1 RISE, and RISE Passive depot assets (POMCUS) are stored in either controlled humidity warehouses or indoor storage. No unusual storage problems are known.

3.3 Rebuilt/Overhauled

Approximately ²⁸¹ ~~100~~ M60A1 RISE tanks were processed through the ^{and Mainz (MAD)} ~~cur~~ at Anniston (ANAD) and Mainz (MAD) during FY 79. ~~Some were overhauled and others were inspected and repaired as required.~~ Quantities of each by depot facility are shown below.

<u>Process</u>	<u>ANAD</u>	<u>MAD</u>
Overhauled	77 281	11 0
Inspect/Repair	77 0	25 0

The table below shows M60A1 RISE and RISE Passive new production and depot overhaul and/or conversion by quarter from 1Q78 through 1Q80. Distribution by major commands during this period is also shown. The ~~101~~ tanks at Anniston Army Depot are being utilized as float tanks to accommodate an exchange of tanks from CONUS organizations.

M60A1 RISE and M60A1 RISE Passive Procurement and Overhaul/Conversion

	1Q78	2Q78	3Q78	4Q78	1Q79	2Q79	3Q79	4Q79	1Q80
Total Army Production of M60A1 RISE/RISE Passive Tanks	194 ✓	273	268 ✓	284	301 300	74	34 ✓	46	52 52
Distribution to:									
FORSCOM		26		23	16	89	96	28	27
TRADOC AND OTHER	1	1	1	1	1				
EUROPE	193	246	248	257	228				
Remain at Anniston (ANAD)			19	3	56			18	25

The overhauled/converted tanks perform as well as the new production vehicles. The problems existing with the overhauled/converted tanks are no different than with new production tanks; however, the reliability of overhauled/converted tanks is less than that of new tanks. During the Baseline Armor Reliability Test (BART) the overhauled tanks achieved only half the Mean Miles Between Failure when compared to new production tanks. For more detailed information see Appendix I.

SECTION IV

USER OPINION

4.1 User Opinion

In response to TARCOM inquiries, seven divisional size units, U.S. Army Training and Doctrine Command (TRADOC) and DARCOM Materiel Readiness Support Activity (MRSA) submitted data for this assessment from January through March 1980.

The field user's opinions of the M60A1 RISE tank ranged from adequate to excellent. Although there are problems with certain aspects of the system, they do not significantly detract from the performance of the system.

Users recommended the following improvements:

- More reliable air cleaner system
- More durable track
- Improved torsion bars
- Better blower motors
- An electrical shut-off switch to ensure radios are shut-off prior to starting and stopping the engine

The most frequently reported user maintenance problems include:

- Fallen prisms in the rangefinders
- A high rate of engine failure due to dust ingestion
- 650 amp generators with bus bars incorrectly installed
- Air cleaner blower motors fail excessively
- Air cleaner doors are improperly fitted
- Electrical troubleshooting in TM's leads to unnecessary replacement of parts
- Sprockets wear out prematurely
- Shock absorber pins falling out
- Personnel heater is unreliable
- T-142 track is unreliable

Overall, the M60A1, M60A1 (AOS), and M60A1 RISE and RISE Passive tanks are considered to be satisfactory.

SECTION V

CURRENT PROBLEMS

5.1 System Performance

The most common problems identified as adversely impacting on system performance are as follows:

- a. Torsion bars are suspected of having a fatigue point because failures occur frequently after 3-5 years of operation.
- b. Tank engines are failing prematurely as a result of dust ingestion through the air induction system.
- c. The overall poor performance of the T-142 track remains a serious concern.
- d. Roadwheel arms, dust deflectors, seals and roller needle bearings of the suspension system are a problem due to their high failure rate caused by inadequate maintenance.
- e. Oil levels on the RISE engine are difficult to check.
- f. Engine oil coolers continue to develop leaks.

5.2 Operational Readiness

During the past year, the operational readiness (OR) rates for the M60A1, M60A1 (AOS), M60A1 RISE, and M60A1 RISE Passive tanks have exceeded the eight-quarter historical average. The OR rate trend for the active army has increased by more than a 5 percentile from 1Q78 to 1Q80. The majority of users state they are able to consistently maintain an OR rate above the DA standard. The OR trend is shown on a chart in Appendix III.

The present OR rate of the M60A1, RISE, and RISE Passive tanks exceeds the Department of Army established standard of 85% and most units have consistently been able to maintain a 90% or higher OR rate at all times.

5.3 Manuals

The current TM 9-2350-378 and TM 9-2350-215 series of technical manuals (TMs) are adequate to support the M60A1 tank in its present configuration. Problems do occur periodically as to availability in specific units but research has indicated these shortages are attributable to both internal problems in units and deficiencies in the publications system itself. The current TM 9-2350-257 series of technical manuals are adequate to support the M60A1 RISE and RISE Passive tanks as they exist today. Recently, publication availability of M60A1 RISE TM's has improved at most installations.

As mentioned in the October 1977 Disciplined Reivew, an extensive program was undertaken to upgrade the utility and the accuracy of the tank TM's. The new TM's are part of the Skill Performance Aids (SPA) program and will be fully compatible with the performance oriented training materials developed under the same program. The hull technical manuals are being developed by Chrysler Corporation and the turret technical manuals are being developed by Hughes Aircraft Corporation. The program is progressing on schedule and the following TM's

are scheduled for review in final draft form prior to submission to the publication system (TAG) for printing:

<u>TM NUMBER</u>	<u>DATE</u>
TM 9-2350-257-10-1/-2/-3 (M60A1 RISE)	June 1980
TM 9-2350-215-10-1/-2/-3 (M60A1 AOS)	August 1980
TM 9-2350-257-20-1-1/-2/-3/-4 (M60A1 RISE)	October 1980
TM 9-2350-257-20-2-1/-2/-3/-4/-5 (M60A1 RISE)	May 1980
TM 9-2350-215-20-1-1/-2/-3/-4 (M60A1 AOS)	November 1980
TM 9-2350-215-20-2-1/-2/-3/-4/-5 (M60A1 AOS)	May 1980
TM 9-2350-257-34-1 (M60A1 RISE)	June 1980
TM 9-2350-257-34-2-1/-2/-3 (M60A1 RISE)	May 1980
TM 9-2350-215-34-1 (M60A1 AOS)	July 1980
TM 9-2350-215-34-2-1/-2/-3 (M60A1 AOS)	May 1980
TM 9-2350-257-20P-1 (M60A1 RISE)	August 1980
TM 9-2350-257-20P-2 (M60A1 RISE)	August 1980
TM 9-2350-257-34P-1 (M60A1 RISE)	August 1980
TM 9-2350-257-34P-2 (M60A1 RISE)	August 1980
TM 9-2350-215-20P-1 (M60A1 AOS)	September 1980
TM 9-2350-215-20P-2 (M60A1 AOS)	September 1980
TM 9-2350-215-34P-1 (M60A1 AOS)	September 1980
TM 9-2350-215-34P-2 (M60A1 AOS)	September 1980

5.4 Training

Training appears to be adequate for crew level personnel. Most units agree that the crews need to fire more often and agree that having more Mini-Tank ranges would enhance their gunnery skills. The major exception to the adequacy of crew training is the limited amount of time being dedicated to air cleaner maintenance. Currently, the training is limited to a very small part of one four-hour block of instruction on Preventive Maintenance Checks and Services (PMCS). MRSA has forwarded a letter concerning this shortcoming to the Deputy Chief of Staff for Training, TRADOC. It is MRSA's opinion that an insufficient amount of time is dedicated to air cleaner system maintenance training. This contributes to the poor maintenance services being performed on air cleaner systems and hence premature engine failure due to dust ingestion.

Units in the field report that training of organizational and support maintenance personnel is not adequate. An extensive On-the-Job-Training (OJT) program in the unit is required for incoming maintenance personnel that have recently completed their school training. It is the unit's opinion that many maintenance MOS's are overburdened, training courses are too short, and the self-paced method of instruction all combine to adversely impact training. The units report that major deficiencies exist in the training of track vehicle mechanics. Specifically, field units say additional training is required in troubleshooting, the use of the Test, Measurement, and Diagnostic Equipment (TMDE) and the use of technical manuals. TRADOC is currently reviewing the Programs of Instructions (POIs) in this area in an effort to upgrade the training program.

Contributing to the problem is a shortage of qualified personnel to supervise and to provide adequate OJT to these mechanics after they are assigned to the units.

5.5 Personnel

Personnel shortages exist in almost every MOS required to support the M60A1 and M60A1 RISE and RISE Passive tanks. Most units are critically short MOS's 63C40 Track Vehicle Mechanic (Motor Sergeant) and 45K40 Tank Turret Repairman (Section Sergeant/Shop Foreman). The latest figures reflect manning at 76% for 63C40 and 78% for 45K40 personnel. Because of these shortages, the middle management supervisors that are expected to train and supervise the "apprentice" turret and track vehicle mechanic graduates are not available in the units. This shortage creates an extensive gap in the quality of personnel and their ability to accomplish the mission.

The opinion exists in field units that the quality of training a tanker receives in Advanced Individual Training (AIT) results in an inadequately trained soldier. Units are forced to incorporate basic skills training into their training programs, not as refresher training, but to bring soldiers up to a level of proficiency that all believe should be obtained in AIT. This requirement, when coupled with the shortages of supervisory personnel, creates a difficult situation within the affected units.

5.6 Maintenance

Users indicate the system is adequately maintained, although the following maintenance difficulties are being encountered and require resolution:

- Engines. Approximately one half of engine failures are attributable to dust/dirt ingestion caused by inadequate maintenance and design inadequacies in the air induction system.
- Fuel cells. The shifting fuel load as the vehicle moves on rough terrain causes the baffle welds to crack, resulting in fuel leaks.
- Rangefinder. One unit reported that several rangefinder prisms have become loose on some rangefinders during shipment.
- Passive Sights. One unit reported that several passive sights were inoperative upon receipt.
- 650 Amp Generator. Some early production 650 amp generators had the bus bar incorrectly installed causing arcing between the bus bar and the fire extinguisher discharge tube.
- T-142 Track. The track pads are not achieving the anticipated life expectancy.
- Shock Absorber Pins. When the shock absorber bearing fails, the pin vibrates and wears through the cotter pin allowing the shock absorber pin to fall out. This allows the shock absorber to swing freely and become damaged.
- Personnel Heater. The reliability of the personnel heater is questionable at best. Most tanks have inoperative personnel heaters. During cold weather the low temperature has serious effects on the tanks weapons and fire control systems.

Adequate maintenance however, is dependent on personnel and training. The majority of complaints concern the inability of maintenance personnel to properly diagnose the malfunctions and then perform the proper repair actions. Vehicle down time is often the result of the organizational maintenance repairman exchanging parts in an effort to find the failed item.

Troubleshooting using the proper test equipment is not being accomplished because of inadequate training and publications.

5.7 Supply

Supply availability for the M60A1 and M60A1 RISE tanks at the end of December 1979 was at 74.4 percent based on a monthly demand rate of 5,776 requisitions totaling \$13.43 million. The demands and value for the past two years by quarter are as follows:

	<u>DEMAND BY QTR</u>								
	1Q78	2Q78	3Q78	4Q78	1Q79	2Q79	3Q79	4Q79	1Q80
Demands	5,163	5,114	6,309	6,122	6,101	6,592	7,030	6,663	10,139
\$ Value (MIL)	11.4	10.3	11.5	15.0	21.5	12.8	21.1	15.3	15.0

Most user responses stated that Prescribed Load List/Authorized Stockage Lists (PLL/ASL) stockages were adequate to support the system. Most users, however, felt that the National Inventory Control Point did not provide the timeliness of response that they felt it should. This is evident by the cyclical shortages of critical parts such as fuel injectors, sprockets, track block assemblies, air cleaner blower motors, rate sensors for stabilization systems, and a variety of sending units.

Some users stated that common and special tool sets and kits are often received from the depot short of required tools and that requisitions for these tools take an excessive amount of time to be filled. It is also the users opinion that additional torque wrenches and multimeters need to be authorized because of the increased requirement for these types of tools.

The majority of supply problems, however, seem to exist on the users own installation. Organizational level personnel will requisition a part and not receive any feedback on the status of the requisition. Often the submitted requisition will be cancelled or returned for editing and the organization will not receive the returned requisition or cancellation card and will maintain a due out for the part. This adds considerably to vehicle down time. Improved requisition reconciliation is urgently needed between the using organizations and their direct support units.

5.8 System Safety

5.8.1 Safety Experience

Operation and maintenance of M60A1, M60A RISE, and M60A1 RISE Passive tanks since the October 1977 Disciplined Review have not disclosed any unusual safety hazards to personnel and equipment as a result of vehicle design. The Army accident reporting system does not report M60A1, M60A RISE Passive tank accidents separate from the total M60 Series worldwide accident experience. However a review of the M60 Series tank accident experience indicates that vehicle design is not a contributing factor in M60A1 series tank accidents.

5.8.2 Battery Slave Cable Assembly

Since the Disciplined Review I a potential electrical fire hazard was identified on some new production M60A1 RISE Passive tanks due to inadequate insulation covering the bus-bar of the battery slave cable assembly. Field units were provided instructions for a temporary fix to

eliminate the hazard. A permanent fix was developed and installed by the contractor. Correction of this possible hazard increases the system safety.

5.8.3 Coaxial Machine Gun Trigger Switch

It was discovered that on a few M60A1 RISE Passive tanks that inadequate insulation between the trigger switch contacts was permitting the main gun or coaxial machinegun to fire without the trigger being depressed. Field units were provided with instructions for testing the firing circuits to identify and replace defective trigger switches. Repair was accomplished so that the system could be safely operated. An engineering change was incorporated into production to assure that adequate insulation was provided.

5.8.4 Brake Master Cylinder

Users were notified of the interchangeability between tank and 5 ton truck master cylinders and action was taken to label the master cylinders to assure proper identification. A recent EIR indicates that users are still occasionally receiving some master cylinders that are not marked. Because the functional characteristics of the two master cylinders are different, it is important that the correct master cylinder be installed on the tank. To prevent a safety problem several PS Magazine articles have been published showing maintenance personnel how to properly identify unmarked master cylinders.

5.8.5 Stabilization System

Fatalities have occurred in USAREUR as a result of the operation of the stabilization system on the M60A1 and RISE tank. The tank was subsequently equipped with a loader's stabilization system shut-off switch similar to switches used by the commander and gunner to turn the vehicle stabilization system on and off. With the stabilization system on and operating during tank movement, the main gun adjusts its position to stay approximately on-target regardless of vehicle motion. This automatic position adjustment creates gun motion which hinders the loader's capability to safely service the main gun or machine gun. Depressing the loader's stabilization system shut-off switch allows the loader to turn off the main gun stabilization system whenever such gun servicing is required.

5.8.6 Fuel Lines

It was reported in the disciplined review of October 1977 that several fuel injector lines were breaking due to excessive vibration. The fuel line retaining brackets were redesigned to provide better support for the fuel injector lines. This action has eliminated further problems of fuel injector line failures.

5.8.7 Summary

From an overall safety point of view, the M60A1, RISE, and RISE Passive tanks can be safely operated and maintained by adequately trained personnel.

5.9 Technical Support

Technical assistance is available to the field from various sources. The most direct contact with the user is by the TARCOM and ARRCOM Field Maintenance Technicians (FMT's). Technical assistance is also available from the National Maintenance Point (NMP), the National Inventory Control Point (NICP), and through the DARCOM Logistics Assistance Offices (LAO).

The adequacy of technical support varies from installation to installation. The number of times the units request technical support is dependent on the (LAO's) record for resolving problems. Most user responses indicated that technical support is satisfactory.

5.10 Stockpile Reliability and Special Facilities

There are no known problems in these areas at the present time.

5.11 Depot Experience

Depot experience to date has included overhaul of components and overhaul/conversion of the tank itself. Currently, the AVDS 1790-2A engine is being converted during overhaul to the RISE configuration (AVDS 1790-2C or AVDS 1970-2D). This is being accomplished through the use of a conversion kit at Anniston Army Depot and at Mainz Army Depot. Some of the older transmissions (CD-850-5) are being converted to the CD 850-6A configuration because the CD-850-5 is obsolete to the tank fleet. Overhaul of fire control instruments is being accomplished at several Army depots. Overhaul/conversion of tanks is being accomplished at Anniston and Mainz Army Depots through the use of conversion kits. Currently, the M60A1 and M60A1 AOS tanks are being converted during overhaul to the M60A1 RISE Passive configuration. (Also, M60A1 RISE tanks are being converted to be M60A3 Passive tanks. The M60A3 Passive tank is a product improved M60A1 tank and will be discussed in greater detail in Section VI. No major problems are being encountered during overhaul/conversion of the M60A1, RISE, and RISE Passive tanks or their components.

Will not start until 4Q81.

5.12 Equipment Improvement Reports

Maintenance deficiencies encountered by the user are reported by Equipment Improvement Reports/Quality Deficiency Reports (EIR/QDR). A total of 34 EIRs were submitted on the M60A1 RISE tank during FY79. A breakdown of these EIR's is shown below:

<u>ITEM</u>	<u>QUANTITY</u>
Engine & Components	12
Electrical System	4
Brake System	1
Transmission	8
Suspension System	9

For a summary of the latest EIR/QDR's on major and secondary items, refer to Appendix IV.

5.13 Modification Work Orders

5.13.1 General

Over the past few years, several Modification Work Orders (MWO) have been published for application in the field by both field and depot personnel. There are four principle MWO's that were used to apply product improvements. These four MWO's are discussed here.

5.13.2 The M239 Smoke Grenade Launcher - MWO 9-2300-300-50-1

The purpose of this modification is to install the necessary mounting hardware, electrical harnesses, and controls to allow the M60A1 and M60A1 RISE tanks to accept the M239 Smoke Grenade Launcher. This modification was applied by a depot team at the units' location. Use of the M239 Smoke Grenade Launcher allows the tank to create its own limited smoke screen.

should be M60A1 R/P and M60A3 tanks

This capability significantly improves the combat effectiveness of the tanks that are so equipped. Application of this modification began in late 1977 and is on schedule.

5.13.3 The M240 Machine Gun - MWO 9-2300-301-3-1

The purpose of this modification is to install the necessary hardware and electrical harness to allow mounting of the M240 (MAG 58) coaxial machine gun. This modification was applied by Organizational and Direct Support maintenance personnel at the units' location. The M240 machine gun is an air cooled, fixed headspace, quick-change-barrel weapon that replaces the M219. Its rate of fire is faster and its reliability exceeds that of the M219. Bolt design permits the cover to be opened or closed regardless of bolt position and without damage to components. The combat effectiveness of tanks equipped with the M240 machine gun is significantly improved. Application of this modification began in mid-1978 and is progressing on schedule.

5.13.5 Engine Smoke Generating System - MWO 9-2350-378-50-12

The purpose of this modification was to install the necessary hardware, electrical harnesses, and controls onto the tank engine and chassis to allow the vehicle to create its own smoke screen. This modification was applied by a depot field team at the units' location. Use of the engine smoke generator allows the tank to create a limited smoke screen while on the move. This capability significantly improves the combat effectiveness of the tanks that are so equipped. Application of this modification began in early 1980 and is on schedule.

5.13.6 Shimming the Ballistic Drive - MWO 9-2350-232-23/1

The purpose of this modification is to eliminate play in the ballistic linkage by adding two spacers to the M10 Series Ballistic Drives. Scattered shot patterns and loss of elevation boresight alignment in the gunner's periscope and in the rangefinder were determined to be caused by lateral movement of the eleven-inch arm on the eccentrics spindle. Shimming the arm limits the lateral motion of the ballistics drive linkage and will eventually eliminate subsequent boresight alignment losses. Application of this modification will greatly improve the accuracy of fire from the M60A1, RISE and RISE Passive Tanks. Application of this modification is progressing on schedule.

5.14 Foreign Sales and International Marketability

The overall assessment of the M60A1 RISE tank for the Foreign Sales and International Logistics Market is favorable. A total of 427 vehicles were shipped to host countries with no major deficiencies being reported. International Logistics customers received repair parts support, special tool sets, major assemblies, and publications/manuals to support and maintain their vehicles. International Logistics customers have been notified of the U. S. Army plans to discontinue the M60 Series tank production.

SECTION VI
DEVELOPMENT INITIATIVES FOR REPLACEMENT

6.1 Replacement Systems

Currently the M60A3 Passive and M60A3 TTS tanks and the XM1 tank are being produced. These tanks are replacement tanks for the M60A1, RISE and RISE Passive tanks.

6.1.1 Characteristics

The M60A3 tank is being built in two configurations. The earlier version had a passive gunner's sight and the latest version has a Tank Thermal Sight (TTS). The mobility performance of the M60A3 tank is the same as for the M60A1 RISE and RISE Passive tanks. The differences are in the fire control instruments. The M60A1, RISE, and RISE Passive tanks use a coincidence rangefinder and a mechanical ballistic computer. The M60A3 Passive uses a laser rangefinder and a solid state ballistic computer. This system increases the first round hit probability. The M60A3 TTS uses a laser rangefinder, a solid state ballistic computer, and a thermal-imaging gunner's sight. This sight allows the gunner to see through fog, smoke, and at night without the aid of a searchlight.

The XM1 tank is completely different than the M60 series tanks. It is significantly superior in mobility, maintainability and crew survivability.

6.1.2 Requirements for Replacement

The threat situation today demands a highly mobile armor force that can survive on the battlefield. This can only be accomplished with a tank that can see targets that are screened by fog, smoke or are under the cover of darkness. The tank must be highly mobile under all variations of terrain and must be able to shoot accurately while on the move. These requirements must be met if a tank is to survive and be effective on the modern day battlefield. Accurate fire power which provides first round hits is essential if we are to be able to fight out numbered and win.

6.1.3 Operational Capability Date

Fielding of the M60A3 tank began in May 1979 and is continuing. The XM1 tank is scheduled for fielding at Fort Hood, Texas, for the OT-III test during September 1980. The XM1 will be fielded in Europe starting in 1981. Considering the remaining life of the M60A1, RISE, and RISE Passive tanks, the Initial Operational Capability (IOC) date of the replacement vehicles is consistent with the condition/expected life of the M60A1, RISE, and RISE Passive tanks.

6.2 Other Systems Compatibility

The M60A3 tank is compatible with the M60A1, RISE, and RISE Passive tanks that it is replacing in all aspects except for fire control. Repair parts are about 65% common between these tanks. The XM1 is a totally new tank that is not compatible with the M60 Series of tanks. The XM1 currently will use the same ammunition as the M60 Series tanks.

6.3 Product Improvement Programs (PIP)

There have been several approved Product Improvement Programs to upgrade the effectiveness and reliability of the M60A1, RISE and RISE Passive tanks. For brevity purposes these will be only listed here. Detailed discussion of the product improvements is covered in Section VIII.

- M735 Cam for M13A2 Ballistic Computer
- Hull and Turret Update Kits, M60A1
- Engine Smoke Generator
- Smoke Grenade Launcher Adaption Hardware
- M240 Machine Gun Adaption
- Driver's Viewer, AN/VVS-2
- Deep Water Fording Kit
- Add-On-Stabilization
- Solid State Regulator
- Improved RISE Engine Kits
- Armored Steel-Top-Loading Air Cleaner
- Gunner's Sight, M32E1
- Commander's Sight, M36E1
- Oil Cooled Alternator

SECTION VII

IMPROVEMENT ACTIONS REQUIRED

7.1 Alternatives For Problem Areas

Of the problem areas, the most pressing are as follows:

- Excessive engine loss due to faulty air induction systems
- Excessive use of T-142 track components
- Inadequate coverage in Technical Manuals

These deficiencies are causing maintenance problems and are currently under study for resolution. Resolutions to these problems are anticipated in the near future.

7.2 Recommended Corrective Actions

7.2.1 Air Induction Systems

Improperly maintained air induction systems are the greatest cause of premature engine failure. An assessment of the current status of tank air induction was undertaken between October 1978 and April 1979. It was determined that problems fell into three categories: (1) unsatisfactory maintenance in the field, (2) design inadequacies, and (3) quality problems. Poor maintenance is the result of unclear, sometimes conflicting, or inadequate instructions in manuals and other publications, improper or inadequate training, and lack of command emphasis or awareness. Design inadequacies appeared as poor sealing of components, inadequate means to detect loss of system integrity, and insufficient durability. Less than satisfactory quality control of manufactured components resulted in poor system performance and added maintenance burden. A table listing the major problems and their causes is at Appendix V in table 1.

In October 1978, the Project Manager M60 tanks initiated a four-point program to correct problems identified by the assessment. The program is designed to accommodate a current inventory of about 9700 tanks. It considers that, under current programs, only 1749 tanks will be added between now and 1981. The program consists of: (1) improving the maintenance of air cleaner systems now in the field, (2) increasing the interval between maintenance actions, (3) improving the design of current air induction components, and (4) exploring long range technological improvements (systems which will reduce or eliminate the need for maintenance) and organizational considerations (levels of maintenance at which air cleaners can best be handled). Table 2 of Appendix V is a listing of the on going and planned tasks for each principle element of the program.

To alleviate the problem of the user not knowing how to maintain the air induction system a program called "Operation Clean Air - Phase II" was created. The mission of the program was to provide instruction on inspection and servicing of tank air induction systems. Two-man training teams visited CONUS posts and will visit Korea (2ID) (May 80). Instruction was given to all tank crews and organizational maintenance personnel. In USAREUR, one two-man team trained TARCOM field maintenance technicians who in turn provided training to their assigned tank units. To enable the battalions/squadrons to give future instruction a training package was given to them. The package consists of a Program of Instruction, a training film, Operation

Clean Air pamphlets, revised PMCS's, emergency procedures, pocket cards, wall posters, and decals.

The thrust of the M60 air induction program is to make improvements quickly, in all areas which have an impact upon system performance. Because it consists of many separate actions with differing times to complete, it is expected that some gains will be seen very shortly, with the total benefit accumulating as later changes are introduced.

7.2.2 T-142 Track

The greatest problem with the T-142 track is that the life expectancy is less than anticipated. The replaceable pads tear loose from the metal backing plate due to inadequate bonding. The track pins break due to overstressing caused by loose centerguides and end connectors. End connectors wear out prematurely. Several versions of pins and hardened end connectors were tested in the past. Currently testing is under way on T-142 track with austempered pins and specially hardened end connectors. After testing is complete an assessment can be made to determine whether these changes should be implemented.

7.2.3 Technical Manuals

There have been several reports highlighting discrepancies within the fielded technical manuals (TM). For short term correction, PS Magazine articles, EIR/Maintenance Digest articles and Field Service Bulletins are published and distributed to the field. As the number of corrections reaches an appreciable quantity, a TM change is published and released to the field through pin point distribution of the publications system. An extensive program is being undertaken to upgrade the utility and accuracy of the tank TMs. The new TMs are part of the Skill Performance Aids (SPA) program. The program is progressing on schedule and during 1980 the new TMs on the M60A1, RISE and RISE Passive Tanks will be printed and released to the field units through the publications system. Included in this effort is a set of new Repair Parts and Special Tools Lists (RPSTL) which will clearly define the correct repair parts required for repair of these tanks.

7.2.4 Training

see pg 5-4
Training appears to be adequate for the crew level personnel. The major exception to this, is the limited amount of time being dedicated to air cleaner maintenance. Currently, the training is limited to a very small part of one 4-hour block of instruction on Preventive Maintenance Checks and Services (PMCS). The DARCOM Material Readiness Support Activity (MRSA) has forwarded a letter to the Deputy Chief of Staff for Training, TRADOC, concerning this shortfall. The letter asked TRADOC to evaluate the possibility of increasing the allotted training time devoted to air cleaner maintenance.

According to the field units, training for organizational and support maintenance personnel is not adequate. Additional training is required in troubleshooting, use of the TMDE and use of Technical Manuals. Currently, TRADOC is reviewing the POIs in this area in an effort to upgrade the training program within the Army training schools..

7.2.5 Doctrine

The doctrine for armored warfare does not need to be changed for this system.

7.2.6 Use of the System

The M60A1, RISE and RISE Passive tanks were designed to be used in their present environment, therefore, no change in the use of these systems is recommended.

7.3 RISE Candidates

In the early 1970's an assessment for RAM improvement was made for the M60A1 Tank. The result of some redesign and improved materials created the M60A1 RISE Tank. The M60A1 RISE tank is a better tank than the M60A1 Tank from a RAM point of view. Currently there is no list of additional RISE candidate items.

SECTION VIII

SYSTEM IMPROVEMENT PLAN

8.1 Problem Areas

Currently, there are several problem areas with regard to the M60A1, RISE and RISE Passive tanks. Some of these are problems related to reliability and others are related to the tanks inability to function in the environment and mission profile required by todays armor doctrine. Below is a list of the product improvements that will solve these problems.

8.1.1 Armored Steel Top-Loading Air Cleaner (TLAC)

The side loading air cleaner was a very unreliable air cleaner due to its inability to withstand the stress created when hit by a thrown track. The air cleaner base plate was easily bent upward which caused the filter element assembly not to seal. The top-loading air cleaner (TLAC) was developed, tested, and released into the M60 Series tank program as the direct result of the Task Force Study initiated to investigate the premature engine failures of the tanks. The primary purpose of the aluminum TLAC was to reduce the engine failure caused by dust ingestion. The aluminum air cleaner though was all too susceptible to damage from small arms fire. An armored steel version of the TLAC was developed to provide increased ballistic protection. It is planned to convert all tanks to the armored steel TLAC during depot overhaul and in the field as older air cleaners become unserviceable.

8.1.2 Improved RISE Engine Kits

The problem with the original tank engine (AVDS-1790-2A) was its low reliability, maintainability, and availability. An excessive quantity of engines were failing prematurely in spite of having proper maintenance performed. This product improvement is to provide an engine for the M60 series tanks that has increased reliability, availability, maintainability and mean time to overhaul. The kits will be used to convert AVDS-1790-2A engines to the AVDS-1790-2C and -2D engine configurations.

8.1.3 Add-On-Stabilization

The requirement to shoot on the move was created by the need to increase system effectiveness and battlefield survivability. The problem was that the gunner could not easily place consistent first round hits on the target while the tank was moving. The add-on-stabilization system provides stabilization control for both gun elevation and turret traverse. It provides the gunner with the capability of aiming and target tracking while the tank is moving. It also provides improved surveillance of the battlefield terrain by the gunner while the tank is moving.

8.1.4 Hull and Turret Update Kit

The problem is that over a period of 15 years of tank production, several essential engineering changes have occurred. Many of these miscellaneous changes are to improve the system safety, reliability, and maintainability and increase mission performance. The M60A1 tank hull/turret update kit includes those items that cannot be readily identified with basic major product improvements and to incorporate essential engineering changes that have occurred over 15 years of M60 tank production. The update program includes engineering changes and minor product improvements which are not part of specific product improvements, but are required to upgrade early vintage M60A1 tanks up to the current M60A1 production baseline configuration.

These kits are also needed to update the M60A1 tanks before they can be converted to M60A1 RISE Passive tanks.

8.1.5 Oil Cooled Alternator

The M60A1 tank was in need of a greater electrical power supply. The tank was first built with a 300 ampere generator system and after adding more electrically operated systems, it was determined that increased amperage was required. The original air cooled 300 ampere generator also required installation of special attachments before water fording could be undertaken.

The M60A1 RISE and M60A1 RISE Passive tanks were manufactured with the AVDS-1790-2C engine. This engine is equipped with the oil cooled 650 ampere generator.

This product improvement is to provide an oil cooled 650 ampere generator to the M60A1 to M60A1 RISE Passive tank conversion program. In addition to upgrading electrical power supply capabilities from 300 amperes to 650 amperes, the oil cooled generator has a longer life, improved high and low temperature performance capabilities, improved shock and vibration characteristics, eliminated the need for special water fording equipment and has greater reliability with lower maintenance required.

8.1.6 Solid State Regulator

The shortcoming of the original voltage regulator was its inability to automatically regulate voltage and current. Over voltage was common place, short life caused by shock and vibration, and generally low reliability of the carbon pile voltage regulator was a big problem.

The solid state regulator provides for automatic voltage regulation, current limit control, over-voltage control, longer life, improved shock and vibration characteristics, improved reliability, lower maintenance costs, and a fail safe trip circuit.

8.1.7 Deep Water Fording Kit

Without application of this kit, the tank is limited to crossing streams of four feet or less in depth. This severely limits the combat effectiveness of an armor unit.

This product improvement provides the M60A1 tank the capability of fording eight feet of water with one foot of freeboard. The capability to ford rivers and streams of eight feet maximum depth without bridging equipment is the major benefit of this product improvement. This capability enhances the ability of tanks to move cross-country and through streams without the delays that bridging equipment inherently causes.

8.1.8 M240 Machine Gun, Adaption

The M219 coaxial machine gun was a very unreliable weapon and its rate of fire was relatively slow. The Army selected a new Armor Machine Gun, M240 (MAG M58) to replace the M219 machine gun as the coaxial mounted weapon in its combat vehicles.

The purpose of this product improvement was to develop adaption hardware for installation of the MAG M58 machine gun on the M60 series tanks. This program is to provide an interface mount to replace the mount presently used for the M219 machine gun because the mount for the M219 could not be modified to accept the M240 (MAG M58) machine gun.

8.1.9 Drivers Viewer

The M24 drivers I.R. periscope is difficult to use because of the two eyepieces, it requires an I.R. source of light which sacrifices security, and its distance capability is insufficient as well as its inability to provide the driver with adequate depth perception.

The driver's viewer, night vision, AN/VVS-2 was recommended for development by the Senior Officer Review Board and approved by the Chief of Staff, Army, in June 1970. The M60A1 (PI) Materiel Need documents also contained a requirement for passive night driving capability. The viewer, AN/VVS-2, with interfacing hatch module is a direct replacement for the M24 drivers I.R. periscope and will provide the tank driver a completely passive capability for night driving.

8.1.10 Gunner's Sight M32E1 and Commander's Sight M36E1

The present periscopes in the M60A1 and M60A1 RISE tanks require an active source of light provided by the IR filtered searchlight. This compromises the security of the vehicle. Use of Pasive night sights increases surviveability on the battlefield.

The M60A1 RISE Passive tank was manufactured with the M32E1 Passive gunner's sight and the M36E1 Passive commander's sight.

These two product improvements are to provide increased night vision capability over extended ranges for the M60A1 and M60A1 RISE tanks. The new passive gunner's and commander's periscopes will provide recognition capability at longer ranges and at relatively low night light levels (1/2 moonlight). Under starlight conditions, they will provide recognition beyond 500 meters.

8.1.11 M735 Cam for M13A2 Ballistic Computer

Development of the 105mm APFSDS-M735 round created the requirement that a new cam be placed into the M13A2 Ballistic Computer. Installation of the M735 cam into the M13A2 Ballistic Computer enables correct ballistic computations to allow accurate delivery of the M735 round to target. The purpose of this product improvement is to provide M735 cams for all tanks having the 105mm gun, the M13A2 Ballistic computer, and potential access to M735 ammunition.

8.1.12 Engine Smoke Generator and Smoke Grenade Launcher Adaption Hardware

The development of anti-tank missiles that are guided to the target created a great need to be able to screen one's exact location from the anti-tank crew. It was determined that with a smoke screen, a tank could successfully evade the anti-tank guided missile.

The purpose of the Smoke Grenade Launcher product improvement is to provide the M60 series tank with an instantaneous self-screening capability as a defensive measure against anti-tank weapons in consonance with the Department of Army approved Phase II Materiel Need documents. The Phase II system is comprised of dual British 6-tube smoke grenade dischargers, an on-off power switch, a fire control box, two six compartment grenade storage bins, mounting brackets, and electrical interface wiring. The 12 red phosphorous smoke grenades, when fired in salvo, provide an 8-10 meter high smoke curtain over a 100° arc, which extends 30 meters from the vehicle within 2-1/4 seconds.

Utilizing over 75% military standard hardware, the Engine Smoke Generator is composed of fuel lines connected to the exhaust pipes next to the turbosuperchargers and an on-off switch in the dirver's compartment. Two solenoids control the flow of fuel which provides a dense white

smoke column behind the tank when fuel is vaporized by the hot exhaust pipes. This system provides a screening capability which the tanks or unit can use as a defense for an extended period of time to complement the M239 Smoke Grenade Launcher, which is used for instantaneous smoke screening for anti-tank missile evasion.

8.2 Impact

The benefits to be gained by installing the armored TLAC, RISE engine, hull and turret update kit, oil cooled alternator, solid state regulator, and M240 machine gun are primarily in the RAM area. The secondary gains, by improving the RAM in these areas, are improved target acquisition, (kit) performance, movement, and command and control. The benefits to be gained by incorporating the add-on-stabilization, deep water fording, driver's night vision viewer, Commander's and Gunner's Passive sights, M735 cam, engine smoke generator, and Smoke grenade launcher are several. When firing the M735 round, hit performance is improved if the M735 cam is installed in the ballistic computer. Shoot on the move capability is gained by the add-on-stabilization. Forging streams and rivers up to a depth of eight feet without the use of bridging equipment is possible when the water fording kit is used. Creation of an instantaneous smoke screen is possible when the tank is equipped with the engine smoke generator and the smoke grenade launcher thereby allowing the tank to screen itself from anti-tank guided missiles. Better operational capability during hours of darkness is gained by the passive gunner's/commander's sights and the driver's viewer without sacrificing security of the tanks location.

8.3 Improvements

A complete description of the product improvements is cited under each of the product improvements in paragraph 8.1 and for brevity purposes will not be repeated here.

8.4 Payoffs

The payoffs to be gained by incorporating these product improvements are increased reliability, availability, and maintainability. The improvements to the air induction system and to the power plant areas will result in lower engine consumption. The payoff obtained from the improved fire control items are improved target acquisition, hit performance, and hence, being able to fight out numbered and win.

8.5 Implementation

It is planned that conversion hardware for the M60 Series Tanks for installing the Armored TLAC will be applied during normal scheduled overhaul and on an as needed basis in the field by Direct Support personnel. The RISE engine kits and the hull and turret update kits will be installed during depot overhaul of the tanks and engines, as applicable. The Add-On-Stabilization system will be installed by depot personnel both in the field and during depot overhaul. The oil cooled alternator will be installed at time of depot overhaul/conversion of the M60A1 RISE and RISE Passive tanks. The solid state regulator is being applied during depot overhaul/conversion of the tanks. The water fording kit will be applied to M60 Series tanks during normal overhaul at selected depots. The M240 machine gun mount is being installed in the field by depot personnel. The passive driver's viewer, commander's and gunner's sights are being applied during normal scheduled overhaul/conversion in the depots. The M735 cam is being installed in the field by field personnel. The smoke grenade launcher is being applied by depot personnel both in the field and during depot conversion and overhaul. The engine smoke generator is being applied to new spare engines, to engines during overhaul, and to tanks during overhaul/conversion by depot personnel.

8.6 Funds

The source and amount of funds (in Millions \$) are as shown below:

<u>Product Improvement</u>	<u>Engineering and Hardware (PEMA)</u>	<u>Application (OMA-7M)</u>
Armored Top-Loading Air Cleaner	\$ 16.266	\$ 0.863
Improved RISE Engine Kit	140.648	10.823
Add-On-Stabilization	25.821	4.463
Hull & Turret Update Kits	18.108	12.488
Oil Cooled Alternator	21.404	
Solid State Regulator	1.544	
Deep Water Fording Kit	2.595	1.032
M240 MG Adaption	3.986	1.689
Driver's Viewer	27.709	0.514
Gunner's Sight M32E1	7.159	1.831
Commander's Sight M36E1	16.614	6.656
M735 Cam for M13A2 Ballistic Computer	0.180	
Smoke Grenade Launcher	2.737	4.426
Engine Smoke Generator	2.157	1.246

8.7 Milestones

The last kits to be applied are as shown below. Any slip in programming/funding from one fiscal year to another will cause an appropriate slippage of these milestones.

<u>Product Improvement</u>	<u>Last Kit Applied (Planned Est)</u>
Armored Top-Loading Air Cleaner	1Q86 4.80
Improved RISE Engine Kit	4Q87
Add-On-Stabilization	1Q81 4.00
Hull & Turret Update Kits	1Q86 3.00
Oil Cooled Alternator	1Q87 4.00
Solid State Regulator	2Q86 4.00
Deep Water Forging Kit	4Q86
M240 MG Adaption	4Q85 4.00
Driver's Viewer	3Q87
Gunner's Sight M32E1	1Q87 3.00
Commander's Sight M36E1	2Q87 3.00
M735 Cam for M32A Ballistic	4Q80
Computer	
Smoke Grenade Launcher	3Q86
Engine Smoke Generator	4Q87

SECTION IX

COMMANDER'S OVERALL ASSESSMENT

9.1 Commander's Assessment

This Update Systems Assessment was conducted by the Project Manager, M60 Tanks. Participants included TARCOM, DARCOM Materiel Readiness Support Activity, TRADOC and using units from CONUS and from USAREUR. Contributions to the Update System Assessment from the user, TRADOC, and MRSA were in the form of written assessments covering problems encountered with the tank fleet. Covered by this system assessment are the following different models of tanks -M60A1, M60A1 (AOS), M60A1 RISE and M60A1 RISE Passive. These different models enjoy a high degree of parts and support commonality. This report covers all problem areas adequately and provides corrective actions in response to the problems and comments raised during this assessment.

Over the past several years, there have been major improvements made to the M60 series tanks. One of the most significant has been the AVDS 1790-2C/2D RISE engine. The tanks equipped with the RISE engine have been received with considerable enthusiasm by the field and it is proving to be a very reliable engine. The preponderance of positive feedback from the user about the RISE engine, the Commander/Gunner Passive Night Sights and the Drivers' Night Viewer, certainly indicates that the M60A1 RISE Passive tank is a highly satisfactory weapons system.

The Project Manager, recognizing the shortcomings of the present technical publications and manuals, has implemented short and long range programs to bring the M60 series tank publications up to standard.

- The short range program is designed to provide the user with the best technical guidance available. This is being accomplished through a system of low cost publications that are essentially a series of pocket sized "How To" booklets and full size booklets covering the latest information about the subsystem covered. One of the first of these was the "Clean Air" pamphlet, which provided the user with up-to-date instructions on the proper maintenance of the tank air induction and filtering system. This booklet was revised during 1979 and reflected the latest changes in maintenance philosophy and complete instructions for basic maintenance of the air induction system. This booklet also included the latest in part numbers and NSN'S to aid the user in requisitioning the correct repair parts to repair the system. Another in this series is the booklet "Get on the Right Track", which provides tips and procedures on track inspection and maintenance. To provide the latest information on track maintenance this booklet is in the process of being updated. Following these two booklets were pocket books on electrical generating systems, ground hop procedures and other trouble shooting techniques. All of the published pamphlets to date have received high praise from the user. Efforts such as these, coupled with the maintenance of a very close liaison with the user enables the Project Manager to maintain an envelope of integrated logistic support around the tank user that will help keep his equipment operable and the tank crews among the best informed soldiers in the Army.

- The long range program is the application of Skill Performance Aids (SPA). The development of technical documentation and operator manuals in the SPA format will produce publications that will be fully compatible with performance oriented training manuals applicable to the full M60 series tank family. Further details of this very ambitious program for the improvement of technical publications are shown in Section V of this report. Application of the

SPA concept could prove to be the most significant improvement in the integrated logistics support structure of the tank systems to come along in many years. These publications should be available through publication channels during the later part of 1980.

The overall assessment is that the M60A1, RISE and RISE Passive tanks satisfactorily perform the missions within the original design limits of the system. While it is not problem free, reported field problems are promptly addressed by the Project Manager and solutions are formulated in a timely manner. Since logistics support problems are inherent in a large vehicle fleet such as the M60 Series tank system, it is encouraging that the logistics support posture for these vehicles is acceptable and that operational readiness rates have been consistently good, in fact above the DA standard.

The Project Manager and the U.S. Army Tank-Automotive Materiel Readiness Command are actively dedicated to continue a high level of support for these vehicles, even though the future tank procurements are for the M60A3 and XM1 Tank Systems.

APPENDIX 1

**M60A1 RISE TANK, COMBAT, 105MM GUN
BASELINE ARMOR RELIABILITY TEST (BART) FINAL REPORT**

BACKGROUND: The M60A1 is the basic combat tank of the Army. Its chassis is common to the M60A2 and M60A3. Its turret is common to the M60A3 except for Fire Control.

TEST STATUS: Based on approximately 2,250 miles run on each of the tanks during BART at Ft. Hood five M60A1 new (RISE) vehicles and five M60A1 overhauled vehicles performed as follows:

	System Criteria		Mission Criteria
	<u>wo/MRF</u>	<u>w/MRF</u>	<u>w/CMRF</u>
MMBF-M60A1 RISE (as tested) - M60A1 Overhaul	102 46	158 75	397 168
MMBF-M60A1 RISE (adjusted) - M60A1 Overhaul	114 59	170 91	427 172

	M60A1 RISE	M60A1 OVERHAULED
MTTR =	0.98 Hours	1.09 Hours
MR =	1.16	1.63
Achieved Availability =	75%	68%

NOTE: The adjusted values were obtained by eliminating incidents charged to roadwheel delamination, M2 & M85 machine guns, and cupola.

TEST INFORMATION: The Baseline Armor Reliability Test (BART) data is based upon approximately 2,250 miles of testing on each of five new M60A1 RISE and for overhauled M60A1 tanks at Ft. Hood, completed in November 1976.

An assessment of the six comparison test vehicles since April 1977 at APG reveals system MMBF of 244. This not directly comparable to BART, since subsystem usage is not the same.

SCORING CRITERIA: The BART criteria includes the traditional M60 system definition w/MRF's, but was also evaluated against the mission criteria which is similar to the newer XM-1 mission definition with Combat Mission Reliability Factors (CMRF).

Summary: The new M60A1 RISE tanks demonstrated comparable or increased reliability in comparison with overhauled M60A1 tanks.

M60A1 RISE TANK ICT/CPT TEST STATUS

TEST STATUS: Based upon 12,323 miles on 6 ICT vehicles run at APG from April 1977 through November 1978:

- a. MMBF (System criteria w/MRF) = 241
- b. MR, MTTR, A_a cannot be evaluated since no maintenance times were tabulated on ICTS

PROBLEM AREAS: The most frequent failures occurred on the following components (all are common tank family failure modes):

- a. Air cleaner blower motor/circuit (8 chargeable incidents).
- b. Roadwheel hub bearing (7)
- c. Roadwheel rubber delamination (6)
- d. T142 track pin/shoe (6)
- e. Torsion bar (5)
- f. Steering control linkage (4)

APPENDIX II

M60A1 TANK EVOLUTION

M60A1+

1971 TOP LOADING AIR CLEANER

1972 ADD ON STABILIZATION = M60A1 (AOS)

1974 T142 TRACK

M60A1 (AOS) +

1975 RISE ENGINE

1975 IMP ELECT

= M60A1 (RISE)

M60A1 (RISE) +

1977 CDR/GUNNER PASSIVE SIGHT

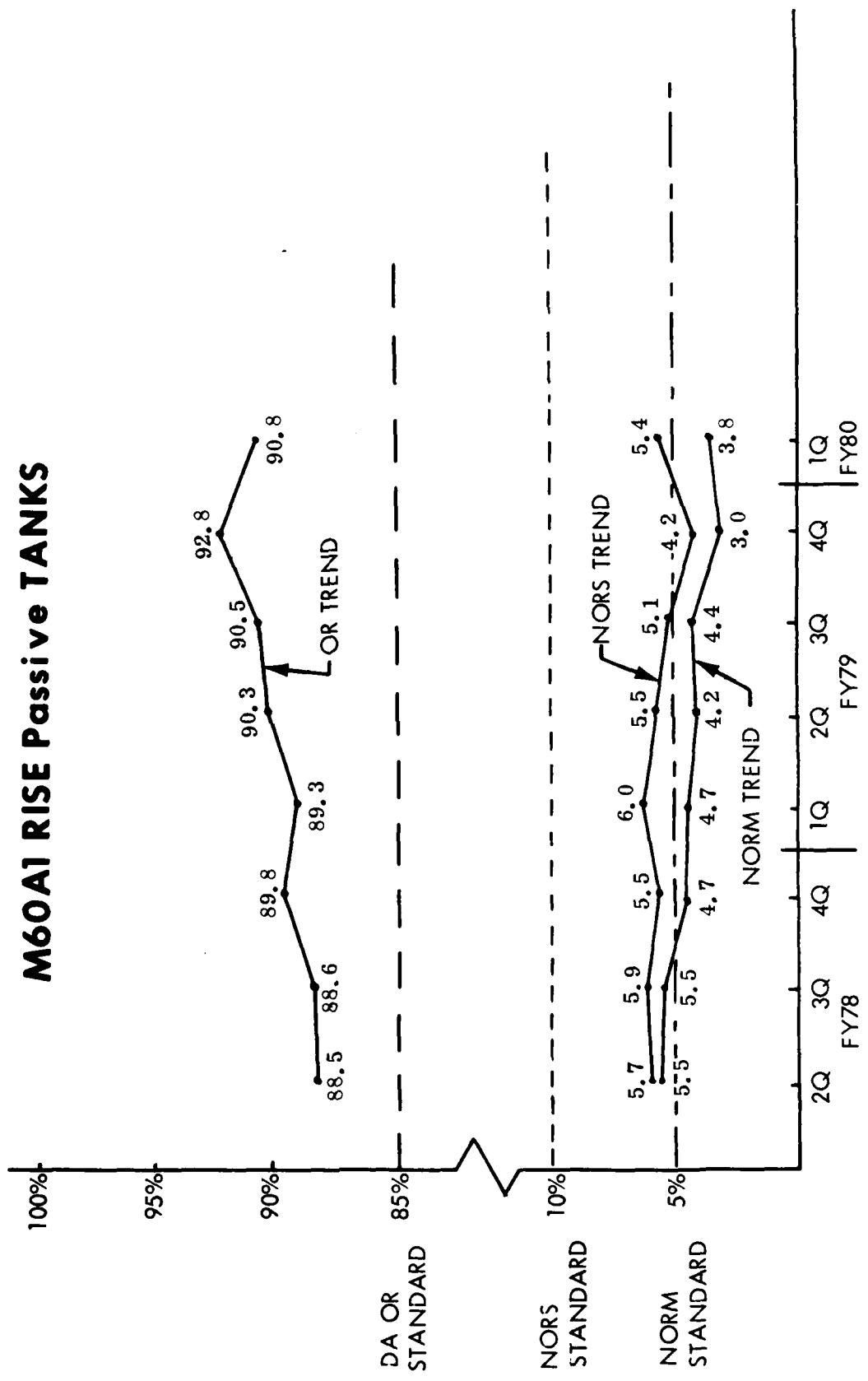
1977 DRIVER'S VIEWER

1978 SMOKE LAUNCHER

1978 M240 COAX MACHINE GUN

= M60A1 (RISE PASSIVE)

APPENDIX III
OPERATIONAL READINESS TRENDS
 for the
M60A1, M60A1 RISE, AND
M60A1 RISE Passive TANKS



APPENDIX IV

M60A1 (RISE) TANK

MAJOR ITEM EIR's/QDR's

"OPEN" STATUS

<u>TARCOM CNTRL NO.</u>	<u>NSN</u>	<u>QTY DEF</u>	<u>PROBLEM</u>	<u>STATUS</u>
789Q1288 79Q15544	1815-00-397-3316	4	Pistons-oversized, could damage engine if used.	Awaiting contractor's disposition instructions.
79Q1308	2815-00-394-9705	1	Oil pan - defective weld, welding not authorized on drawing	Under DCAS investigation
79Q1680	3020-00-252-5637	251	Sprocket - improperly heat-treated, cracked.	ACO and contractor in litigation
79Q1738	3020-00-679-4491	NA	Gear - does not meet dimensional requirements.	Contractor expected to replace defectives. Awaiting disposition instructions.

M60 FAMILY
 SECONDARY ITEM EIR's/QDR's (1000 or More Qty Def)
 JAN 77 - Nov 79

<u>TARCOM CNTRL NO.</u>	<u>NSN</u>	<u>QTY DEF</u>	<u>PROBLEM</u>	<u>STATUS</u>
79Q0470	5360-00-838-3596	11,301	Helical Spring-ends burred	Open
79D0999	3120-00-776-7606	8,329	Bearing Washer - improper packaging	Open. Return to contractor for repackaging.
79Q0728	2530-00-150-5895	6,736	Track Pad Parts Kit - bolt breaks	Closed. No exhibit. Reclassified to Condition Code A.
77Q1150	5315-00-769-9709	3,407	Pin - not to drawing	Closed. Deficient items replaced by contractor.
78Q1477 78Q0704 78Q0824 78Q0692	2540-00-706-8219	1,975	Tow Hook - out of tolerance	Closed. Contractor re-work, waiver granted.
78Q0178 78Q0287 78Q0096	5307-00-678-6891	1,662	Studs-break, hardness not to drawing.	Closed. Local disposal. Closer inspection
79Q1300	2530-00-250-0977	1,211	Wearplate - dimensions not to drawing.	Closed. Reclassified to Condition Code A and utilized.
78Q0082	5306-00-225-9087	1,000	Screw-mixed threads	Closed. Scrapped.

APPENDIX V

TABLE 1. CURRENT ASSESSMENT OF AIR CLEANER PROBLEMS

<u>COMPONENT</u>	<u>ARMORED TLAC PROBLEM (CAUSE)</u>	<u>ALUMINUM TLAC PROBLEM CAUSE</u>
HOSE CLAMP	MAINT/DESIGN (EASILY DAMAGED & DIFFICULT TO APPLY)	MAINT/DESIGN (EASILY DAMAGED & DIFFICULT TO APPLY)
INDUCTION HOSE SEAL	MAINT (LOST DURING SERVICE)	MAINT (LOST DURING SERVICE)
INDUCTION HOSE ASSY	QUALITY (RUBBER BONDING FAILURE; PERMITS DIRT ENTRY)	QUALITY (RUBBER BONDING FAILURE; PERMITS DIRT ENTRY)
BOX ASSEMBLY	QUALITY/DESIGN (NOT MFD TO SPEC/ POOR SPEC)	MAINT/DESIGN (HINGES BROKEN)
DOOR	QUALITY/DESIGN (NOT MFD TO SPEC/ POOR SPEC)	MAINT/DESIGN (COVERS & HINGES BROKEN)
DOOR SEAL	MAINT (DOOR/SEAL DAMAGED DURING SERVICE)	MAINT/DESIGN (MISSING/DAMAGED)
DOOR BOLTS	QUALITY/DESIGN (CAPTIVE BOLT INSTALLATION NOT ADEQUATE)	MAINT (BOLTS LOST & NOT REPLACED)
ELEMENT SEAL	DESIGN/QUALITY/MAINT (DAMAGED DURING SERVICE)	DESIGN/QUALITY/MAINT (DAMAGED DURING SERVICE)
ELEMENT FRAME	MAINT (BENT DURING SERVICE)	MAINT (BENT DURING SERVICE)
ELEMENT MEDIA	MAINT (TORN DURING SERVICE)	MAINT (TORN DURING SERVICE)
BLOWER MOTOR	DESIGN (LACKS DURABILITY)	DESIGN (LACKS DURABILITY)

TABLE 2. FOUR POINT PROGRAM

MAJOR ELEMENT	START- COMPLETE	COST (1,000) FY79 FY80	IMPACT
I IMPROVE MAINTENANCE IN THE FIELD	NOV 78 MAY 80	\$285 -	<ul style="list-style-type: none"> ● NEW INSTRUCTIONS, REVISED PMCS ● NEW TOOLS: VACUUM CLEANER, FILTER WASH FACILITY, GROUND HOP KIT ● REPAIR PROCEDURES FOR ALUMINUM TOP LOADING AIR CLEANERS ● ON SITE TRAINING FOR CREWS AND MAINTENANCE PERSONNEL (OPERATION CLEAN AIR)
II INCREASE INTERVAL BETWEEN MAINT ACTIONS	MAR 79 JUL 80	\$415 -	<ul style="list-style-type: none"> ● INCREASED SYSTEM CAPACITY
III IMPROVE CURRENT DESIGN	NOV 78 FEB 80	\$532 -	<ul style="list-style-type: none"> ● FILTER ELEMENT LATCHING DEVICE ● IMPROVED DOOR SEALING & HOSE CLAMPS ● IMPROVED QUALITY REQUIREMENTS AND TEST PROCEDURES
IV LONG RANGE IMPROVEMENTS	FEB 79 SEP 80	\$711 \$320	<ul style="list-style-type: none"> ● NEW DUST DETECTORS ● NEW PRE-CLEANING SYSTEM ● UNDER-ARMOR SELF-CLEANING AIR CLEANER ● ASSESSMENT OF CREW VS ORG/DS MAINT
TOTALS		\$1,943 \$320	

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