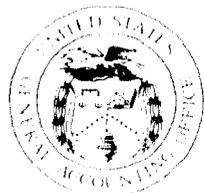


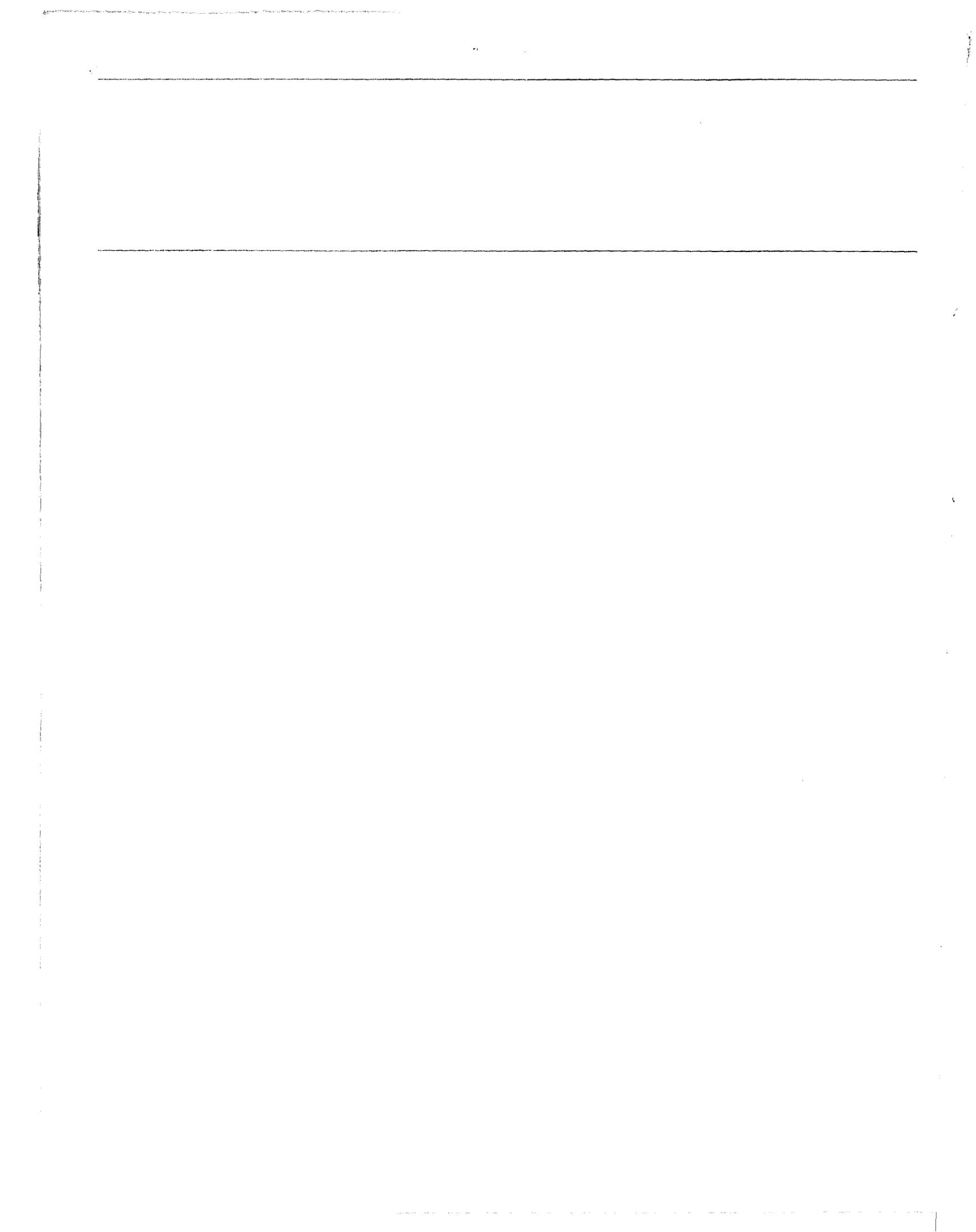
March 1991

DEFENSE
ACQUISITION

Examination of MLRS
Terminal Guidance
Warhead Program



143508



**National Security and
International Affairs Division**

B-242637

March 28, 1991

The Honorable Robert C. Byrd
Chairman, Committee on
Appropriations
United States Senate

The Honorable Sam Nunn
Chairman, Committee on
Armed Services
United States Senate

The Honorable Jamie L. Whitten
Chairman, Committee on
Appropriations
House of Representatives

The Honorable Les Aspin
Chairman, Committee on
Armed Services
House of Representatives

This report updates the status of the requirements, schedule, performance, and cost of the Army's Multiple Launch Rocket System (MLRS) Terminal Guidance Warhead (TGW) program.¹ We coordinated our examination of the program with the German Federal Court of Audit and will be issuing a joint report of our findings at a later date.

The program is a multinational cooperative development effort begun under a 1983 Memorandum of Understanding signed by the United States, the Federal Republic of Germany, France, and the United Kingdom. It is to develop a target-sensing submunition and warhead for attacking armored targets at long range. The United States is funding about 40 percent of the development, while the other three partners are funding about 20 percent each. This is also one of three competing U.S. target-sensing submunition development programs being reviewed by the Department of Defense for selection of a single option. At congressional direction, a single option must be selected by the end of March 1991. The Department of Defense intends to reprogram funds to continue this program, even if it is not selected from the competition. Also,

¹We previously reported on this program in Defense Acquisition Programs: Status of Selected Systems (GAO/NSIAD-90-30, Dec. 14, 1989) and Defense Acquisition Programs: Status of Selected Systems (GAO/NSIAD-88-160, June 30, 1988).

the fiscal year 1992 Department of Defense budget request includes \$46.8 million for this program. Because of the timing of this decision and Committee interest in the program, we are issuing the results of our work at this time.

The Office of the Inspector General, Department of Defense, is comparing the three competing U.S. programs and examining the process of selecting one system for continued development, and we are monitoring their effort as part of a separate review.

Results in Brief

The MLRS TGW has been in development for more than 6 years and has cost a total of about \$530 million (U.S. share—\$230 million; European share—approximately \$300 million). Early in development, the program experienced serious schedule slippages and technical difficulties. Although the Army has not finalized its statement of required operational capabilities, system components have been tested separately and full system demonstration is underway. However, test results to date are not sufficient to lower previous overall assessments of medium technical risk in the program. Such a change in risk assessment would require successful testing of integrated system hardware, scheduled to be done between late 1991 and late 1992.

The Army estimates total U.S. acquisition cost (development and production) at \$7 billion, although Defense Department officials believe there are considerable uncertainties in that estimate. Moreover, program costs will become even more uncertain due to likely changes in quantity requirements, production line and economic adjustment decisions, and the configuration required to accommodate a longer range delivery vehicle. For example, the Army estimated that the U.S. share of development costs could increase by \$177.8 million because of (1) a December 1990 agreement to change exchange rates and economic adjustment calculations used in the program and (2) a possible reconfiguration of the MLRS TGW submunition to allow its use in a longer range delivery vehicle. In addition, if the Army decides to use the MLRS TGW submunition in a longer range delivery vehicle rather than in the basic MLRS rocket, development of the MLRS TGW warhead structure would no longer be necessary for the United States, since only the submunition would be used.

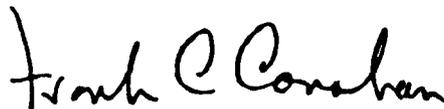
We believe the technical risks and cost uncertainties in the MLRS TGW program raise serious questions whether the program should receive continued funding through reprogramming actions in the current fiscal

year or receive the funding requested for fiscal year 1992. This is especially important if the Department of Defense selects one of the other competing systems under the congressional direction that a single option be selected.

Details on these matters are presented in appendix I along with our objectives, scope, and methodology. We discussed a draft of this report with cognizant Department of Defense and U.S. Army officials and have incorporated their comments where appropriate.

We are sending copies of this report to interested congressional committees, the Secretary of Defense, the Director of the Office of Management and Budget, and other interested parties.

This report was prepared under the direction of Joseph E. Kelley, Director, Security and International Relations Issues, who may be reached on (202) 275-4128 for further information. Other major contributors are listed in appendix II.



Frank C. Conahan
Assistant Comptroller General

Contents

Letter		1
<hr/>		
Appendix I		6
The Multiple Launch Rocket System Terminal Guidance Warhead Program	Background	6
	Requirements	11
	Schedule	12
	Performance	14
	Cost	15
	Objectives, Scope, and Methodology	18
<hr/>		
Appendix II		19
Major Contributors to This Report		
<hr/>		
Tables	Table I.1 MLRS TGW Program Schedule Changes	13
	Table I.2: September 1989 MLRS TGW Cost Estimate—U.S. Share	15
<hr/>		
Figures	Figure I.1: Multiple Launch Rocket System Terminal Guidance Warhead	7
	Figure I.2: MLRS Terminally Guided Submunition	8
	Figure I.3: Concept for Using MLRS TGW Submunitions in the Army Tactical Missile System	9

Abbreviations

AMSAA	U.S. Army Materiel Systems Analysis Activity
DOD	Department of Defense
MLRS	Multiple Launch Rocket System
TGW	Terminal Guidance Warhead

The Multiple Launch Rocket System Terminal Guidance Warhead Program

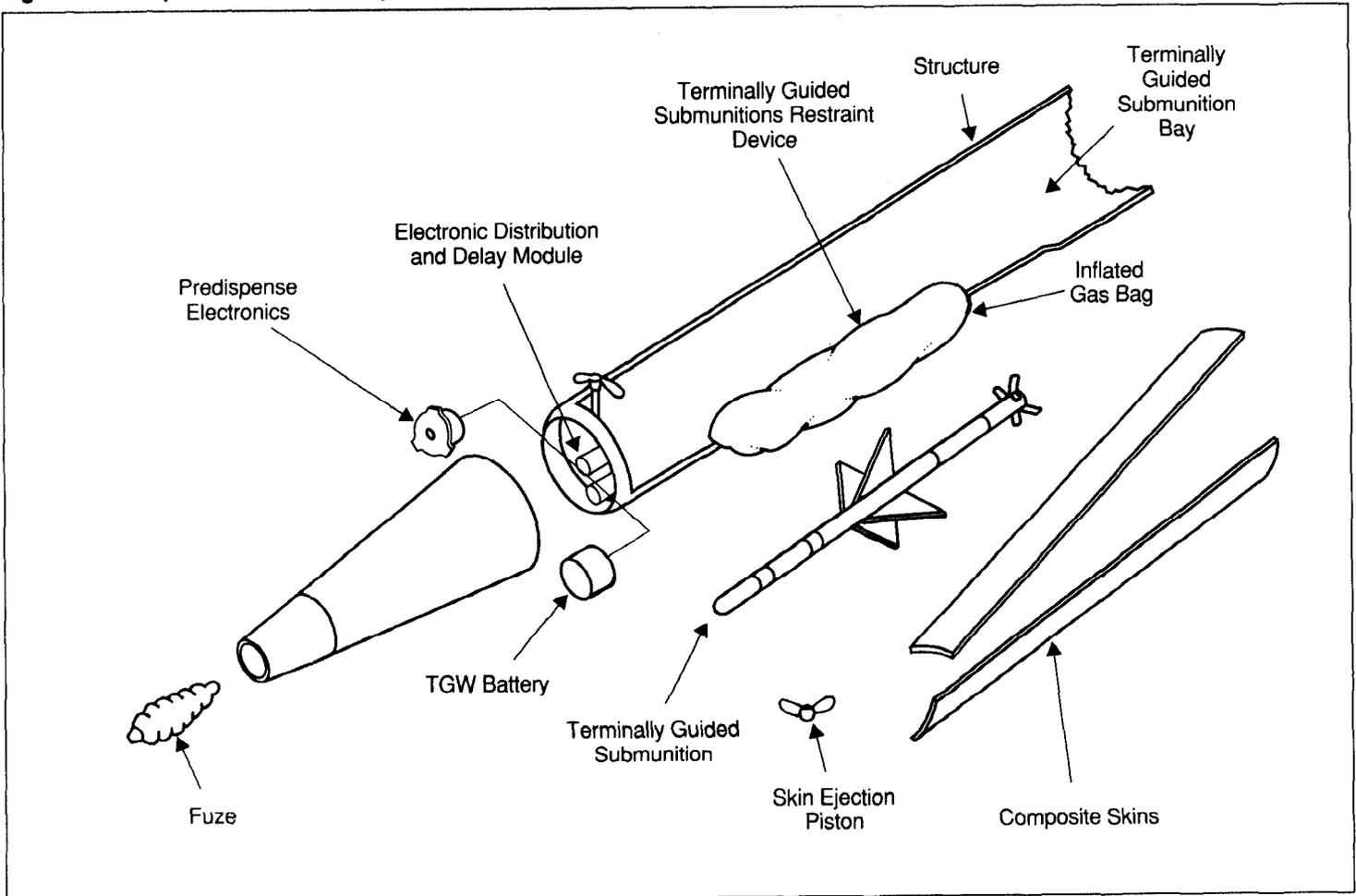
Background

The Multiple Launch Rocket System (MLRS) is an all weather, indirect fire system with up to 12 rockets. The system is to be used to defeat enemy artillery, air defense, other light materiel, and personnel targets at ranges over 30 kilometers. The objective of the MLRS Terminal Guidance Warhead (TGW) program is to develop a target-sensing submunition for attacking armored targets at long range. The submunition is to be an all-weather weapon that will use the MLRS launcher to fire from remote locations. As currently configured, the system will use the standard MLRS rocket motor to propel a warhead structure to the target area where the warhead will dispense three terminally guided submunitions. Each submunition will contain a seeker that is to activate the submunition's independent guidance and control functions and search for and engage the target. The submunitions, which use a tandem-shaped charge, will rely on miniaturized, sophisticated, and complex components to perform these functions.

Figure I.1 shows a representation of the MLRS TGW warhead, and figure I.2 shows the components of the terminally guided submunition, which is encased in the warhead structure. The U.S. Army Tactical Missile System—which is launched from a modified MLRS launcher—is being considered as an alternative delivery vehicle for the submunitions to provide greater range. Department of Defense (DOD) officials told us the U.S. Army is not considering procuring the rocket-launched version of the TGW submunitions. Figure I.3 shows how the MLRS TGW submunitions might be used in the Army tactical missile system and illustrates that the MLRS TGW warhead structure would no longer be needed if used with this delivery vehicle.

Appendix I
The Multiple Launch Rocket System Terminal
Guidance Warhead Program

Figure I.1: Multiple Launch Rocket System Terminal Guidance Warhead



Appendix I
The Multiple Launch Rocket System Terminal
Guidance Warhead Program

Figure I.2: MLRS Terminally Guided Submunition

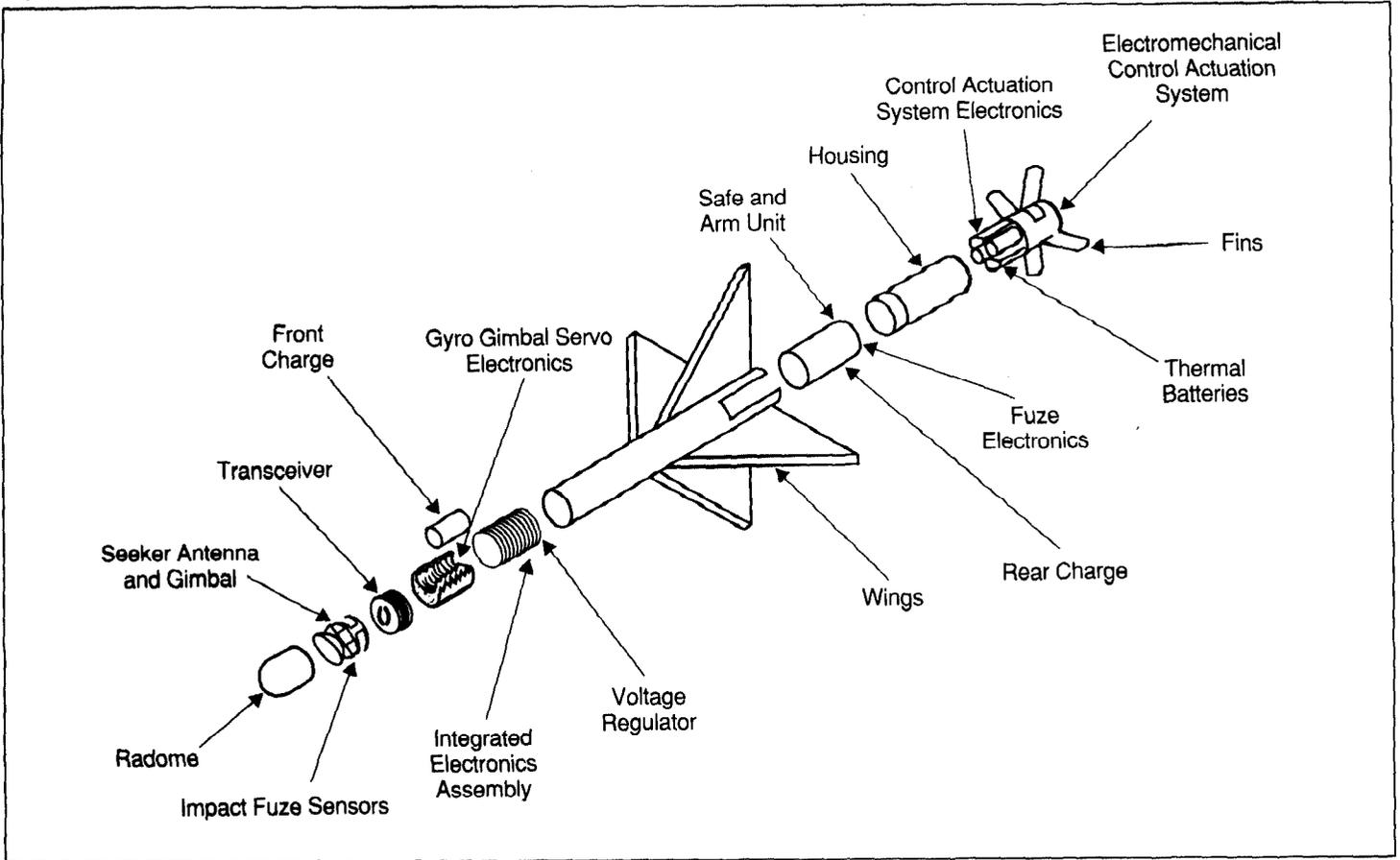
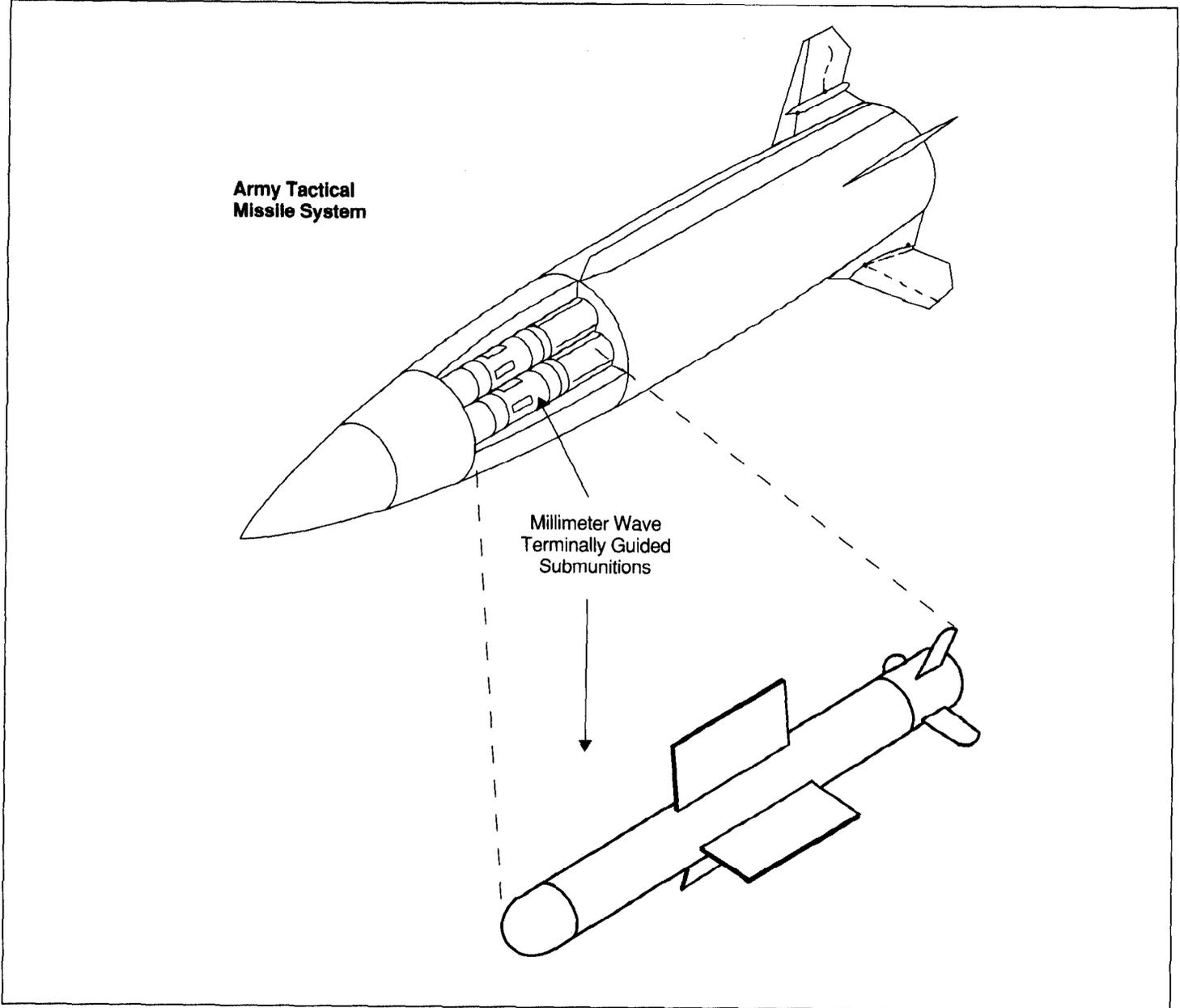


Figure I.3: Concept for Using MLRS TGW Submunitions in the Army Tactical Missile System



The program required developing technology, including an active millimeter wave radar seeker,¹ that was not yet proven. If successfully developed, the new seeker technology will provide significant advantages over other technologies, such as those of infrared systems, but like other systems will also have some limitations and disadvantages. For example, millimeter wave systems can perform better than systems using other technologies in most adverse weather and under certain battlefield conditions. However, millimeter wave systems operate reasonably on only two frequency bands and experience many normal transmission losses. According to a U.S. Army study, the acquisition range of millimeter wave devices tends to be limited by atmospheric absorption, even on clear days with high visibility. DOD officials noted that the acquisition range of other types of systems is also limited by atmospheric absorption. In addition, millimeter wave systems are generally complex and expensive to design and produce.

A four-country consortium is sharing the technology and the cost to develop the program. Because of the complexity of the technology, the Army is applying a cautious three-stage development approach to the program: a two-stage validation program (component demonstration and system demonstration substages) followed by a maturation/full-scale development stage. In late 1983, the four-nation codevelopment agreement was signed. In November 1984, the U.S. Army awarded a cost-plus-incentive-fee component demonstration contract to MDTT, Inc., a joint venture of Martin Marietta Corporation (United States), Thomson (France), Thorn EMI Electronics, Ltd. (United Kingdom), and Diehl GmbH & Co. (Germany).

In February 1989, DOD approved the start-up of the system demonstration substage for the MLRS TGW on condition that the U.S. Army address the following specific concerns: (1) perform a cost and operational effectiveness analysis comparing MLRS TGW to alternative approaches for defeating the armored threat, (2) define specific actions to be taken during the system demonstration substage to improve the ability to manufacture the submunition, and (3) prepare a test and evaluation master plan defining specific quantitative test goals for entry into full-scale development. In July 1989, the Army awarded a system demonstration contract to MDTT, Inc. In January 1991, DOD estimated that the four partners had spent \$530 million on the development program

¹An active millimeter wave radar seeker both receives and transmits on millimeter wave frequency bands.

(\$230 million—United States; approximately \$300 million—European partners).

Requirements

In 1979 and 1982, the four participating nations determined that an MLRS autonomous, anti-armor terminal guidance warhead capability was the best technical approach for jointly (1) improving munitions accuracy and lethality deficiencies and (2) providing effective field artillery to conduct deep strikes behind enemy lines. A November 1989 U.S. Army cost and operational effectiveness analysis concluded that a complementary mix of technologies, delivery vehicles, and submunitions would optimally satisfy this need but recommended further study before selecting the best option. However, in the Department of Defense Appropriations Act, 1991 (P.L. 101-511), the Congress mandated that the U.S. Army select a single option by the end of March 1991. DOD intends to reprogram funds to continue MLRS TGW development, even if it is not selected from the competition.

Although the U.S. Army had expected to approve its draft statement of required operational capabilities (defining MLRS TGW system requirements) by September 1989, as of January 1991 it had not been finalized. U.S. Army officials noted that the document did not have to be finalized until just prior to the full-scale development phase of the program, currently scheduled to begin in October 1992. U.S. project office representatives expected it to be finalized in late 1991.

MLRS TGW Quantity Requirements

For planning purposes, the four partner nations' quantity requirements for the MLRS TGW have been affected by the November 1990 Treaty on Conventional Armed Forces in Europe. If ratified and implemented, the treaty will result in reductions in the number of Warsaw Pact armored threats. While these requirements are tentative and classified, for planning purposes the U.S. Army project office is currently using an overall quantity that is 70 percent of the original estimated requirement. The German defense ministry is currently estimating its quantity requirements at substantially lower than 70 percent of its original estimate for planning purposes.

Threat Environment for MLRS TGW

While the armored threat in Central Europe is likely to decline in number, the MLRS TGW is expected to face a more difficult and challenging threat in terms of armor protection and countermeasures. According to the U.S. Army Training and Doctrine Command, the MLRS TGW is being developed to defeat a future Soviet tank (FST 2), expected

to be fielded in the mid-1990s. However, another armored threat that has already been fielded is not yet among the MLRS TGW's targets because it has not yet been fully evaluated. Details on the characteristics of the actual and projected threats and countermeasures are classified.

Delivery Vehicle for MLRS TGW Could Change

The current program calls for delivering the TGW submunitions by the MLRS rocket. However, the U.S. Army has been considering using MLRS TGW submunitions on the U.S. Army Tactical Missile System, rather than on the MLRS rocket, to increase the submunition's range. If the U.S. Army selects the MLRS TGW submunition as the target-sensing submunition of choice and decides to use the tactical missile system as the delivery vehicle, then new variables will be introduced into the development program (discussed further in sections on schedule, performance, and cost). According to U.S. Army officials, the MLRS TGW development program for use in the longer range delivery vehicle could then be further extended. U.S. Army project officials believed that the MLRS TGW submunition in its current configuration for use with the MLRS rocket could continue in development without further delays.

Schedule

From the time originally approved (see table I.1), the U.S. Army's schedule for making the initial production decision slipped nearly 6 years from April 1989 to March 1995; the slippage includes a more than 3-year delay in the scheduled completion of the system demonstration substage and beginning of full-scale development. However, potential design changes to accommodate a longer range delivery vehicle could further delay completion of the MLRS TGW submunition development program up to 1 year.

**Appendix I
The Multiple Launch Rocket System Terminal
Guidance Warhead Program**

**Table I.1 MLRS TGW Program Schedule
Changes**

Event	Original schedule, Dec. 1985	Revised schedule, Feb. 1988	Revised schedule, Jan. 1991
Army system demonstration substage decision	Feb. 1987	Nov. 1988	Feb. 1989
DOD system demonstration substage decision	Mar. 1987	Jan. 1989	Feb. 1989
DOD system demonstration substage review	a	a	a
Army/DOD full-scale development decision	Mar. 1989- Apr. 1989	Nov. 1991- Jan. 1992	Oct. 1992
Initial production decision	Apr. 1989	Jan. 1992	Mar. 1995
Initial production contract award	June 1989	Feb. 1992	Apr. 1995
Production qualification testing	Dec. 1990	Aug. 1993	June 1997
Full-rate production decision	Aug. 1991	May 1994	Oct. 1997
Full-rate production contract award	Sept. 1991	June 1994	Nov. 1997
First unit equipped		Classified	
Initial operational capability		Classified	

^aDOD established the system demonstration review milestone after February 1988. At that time, the review was scheduled for September 1989. This review was not done and, according to project officials, is no longer applicable.

Project officials attribute the 3-year delay in the schedule for completing the system demonstration substage and beginning full scale development to contractor start-up difficulties, contractor problems in developing and manufacturing submunition components, a warhead redesign required to meet an upgraded armor threat, and a delay in awarding the system demonstration contract. Since system demonstration began, however, no significant delays have occurred in the test program.

Additional delays in completing development may result if the U.S. Army selects a different delivery system. For example, it will have to modify the TGW submunition design to use the Army Tactical Missile as a delivery vehicle. A change in the delivery vehicle would require redesigning the terminally guided submunition's wing configuration and making other minor design changes. U.S. Army project office representatives estimated that the design enhancement would take 3 years and could delay completing the submunition development program for the longer range delivery vehicle by up to 1 year. In addition, the warhead structure being developed for use in the rocket version would no longer be needed for use in the Army Tactical Missile System—only the submunition would be needed.

Performance

Testing shows progress towards meeting performance goals, but U.S. Army officials agree that the most critical performance aspects have not been tested at the system level. These tests are scheduled to be conducted between late 1991 and October 1992. Currently, the U.S. Army Materiel Systems Analysis Activity (AMSAA) considers the overall performance risk to be medium.²

Testing Shows Progress, but Most Critical Tests Not Yet Begun

For the system demonstration substage, development tests performed or planned include captive flight tests³ to collect initial data, system level flight tests to collect launcher-to-target data, and submunition drop tests to collect data on the fully integrated hardware performance. To gather data on clutter and stationary and moving targets in varying terrain, countermeasures, and environmental conditions, to date, the U.S. Army has performed captive flight tests at Eglin Air Force Base, Florida; White Sands Missile Range, New Mexico; and Fort Drum, New York.⁴

At the time of our examination, the U.S. Army had not prepared any written assessments on the system demonstration substage test data or results. U.S. Army officials stated, however, that captive flight testing was successful. On the basis of captive flight test data, U.S. Army Missile Command officials believe system simulation and modeling have demonstrated that the system's software works, the system meets or exceeds stated test requirements, and it can defeat certain, selected passive and active countermeasures.

In addition, according to a responsible AMSAA official, although AMSAA had not formally reviewed the test results, they indicated some additional confidence in MLRS TGW performance might be warranted. However, he noted that the real success of the MLRS TGW could not be measured until the fully integrated hardware testing is conducted between late 1991 and late 1992. During this testing, the seeker's ability

²Technical risk is assessed as low, medium, and high. For the purposes of the MLRS TGW risk assessment, the Army defined medium risk to exist when analysis, simulation, or testing of components or subsystems uncovers shortcomings in their performance that should be corrected (1) before completion of component demonstration, or (2) during system demonstration, to provide a high probability of successful demonstration of the function they support. The European partners apparently made separate assessments of technical risk and may have reached different conclusions.

³Captive flight tests involve mounting a component, such as a seeker, or a system on an aircraft and simulating its functions and performance under various conditions.

⁴MLRS TGW project officials noted that, during the component demonstration substage, captive flight tests were conducted at six different locations and in all seasons in Germany and at Redstone Arsenal, Huntsville, Alabama.

to track and hit the target will be evaluated and overall system performance will be demonstrated.

**Overall Technical Risk
 Assessment Remains
 Medium**

In its November 1988 assessment, AMSAA concluded that TGW's overall risk—including the critical area of seeker performance—was medium. Although there have been no formal risk assessments since that time, an AMSAA official noted that TGW's risk will remain medium until critical testing is done on the integrated hardware. He recognized added confidence could result from captive flight testing but believed the results would be insufficient to warrant changing the original risk assessment.

Additional integrated hardware testing data would be needed before AMSAA could change its risk assessment, and unless directed to do so, AMSAA does not plan to perform another risk assessment until the next milestone decision, currently planned for October 1992.

Cost

The estimated U.S. costs of developing and producing the MLRS TGW are about \$7 billion (then-year dollars), but the cost estimates are subject to considerable uncertainties. According to DOD cost analysts, the current production estimate may be understated. In addition, potential changes in key cost factors, such as production quantities, the number of production lines, exchange rates, and the potential redesign efforts discussed above, could significantly increase the development cost estimates and alter the production cost estimates. The U.S. Army is also attempting to reduce costs by improving the ability to manufacture key MLRS TGW components.

Most Recent Cost Estimate

The estimated acquisition cost of the U.S. portion of the MLRS TGW is \$7 billion (see table I.2). This acquisition cost was based on a September 1989 baseline cost estimate that was validated by the U.S. Army Cost and Economic Analysis Center.

**Table I.2: September 1989 MLRS TGW
 Cost Estimate—U.S. Share**

Dollars in millions		
Item	Fiscal year 1990 constant dollars	Then-year dollars
Development	\$473.5	\$482.3
Production	4,985.1	6,528.1
Total	\$5,458.6	\$7,010.4

Based on this estimate, the total development cost to the four partners would be about \$1.2 billion.

Cost Estimate May Be Understated

The DOD Cost Analysis Improvement Group has not reviewed the most recent estimate. However, the group analyzed the U.S. Army's January 1989 estimate, which varied little from the September 1989 estimate shown in table I.2. According to the group's Chairman, at that time the group believed the U.S. Army's January 1989 production cost estimate could be understated by as much as 50 percent. The Chairman stated that the group questioned the estimate in the areas of (1) estimating methodology and assumptions, (2) exchange rate projections during the production phase, and (3) seeker production cost.

Group officials acknowledged that they had not analyzed the U.S. Army's current estimate but believed the concerns they expressed regarding the January 1989 estimate were probably still valid. They stated that the system had not matured sufficiently to warrant greater confidence in the production estimate.

A U.S. Army MLRS TGW project cost official disagreed with the group's position. In his opinion, the maturity of the seeker and hardware design and more reliable vendor quotes on some items should increase overall confidence in the production estimate. Group officials noted, however, that at this stage of a program, vendor quotes are not highly reliable, and they expressed less confidence in them.

In addition to the production cost uncertainties, a recent change in the program could increase the U.S. development costs. In December 1990, the partners agreed to change the basis for calculating economic and exchange rate adjustments. The U.S. project office estimates that those changes could increase the cost of the U.S. development share by \$21.8 million (fiscal year 1990 constant dollars). On the basis of those adjustments, the current estimate of the U.S. development cost share could increase from \$473.5 million to \$495.3 million.

Potential Program Changes Could Alter Cost Estimates

The U.S. Army's September 1989 cost estimate may be based on outdated assumptions. Since that time, the U.S. Army has tasked MDTT, Inc. to consider lower quantities and an additional production facility in planning the program's completion. In addition, the U.S. Army's possible decision to use TGW submunitions in conjunction with the U.S. Army Tactical Missile could affect development costs. These potential

programmatic changes could significantly change the U.S. Army's current development and production estimates and introduce additional uncertainty in MLRS TGW costs.

Quantity and Production Changes

The U.S. Army has tasked MDTT, Inc., to consider the effects of producing only 70 percent of the baseline quantity included in the September 1989 estimate and producing the reduced quantity at two complete production facilities (instead of having two seeker production lines and one integration facility). The MLRS TGW project office has unofficially estimated that under these new conditions, production and U.S. unit costs would decrease when compared to the current estimate.

Although neither we nor the Cost Analysis Improvement Group audited or assessed the unofficial project office estimate,⁵ we noted that reducing quantities normally increases unit cost. An MLRS TGW project office cost official told us that the lower unit cost was attributable to (1) a more mature hardware cost estimate; (2) reduced production start-up costs, since the United States would only be responsible for its production facility; and (3) the opportunity to produce the entire system more efficiently, since the seeker would not have to be delivered, disassembled, and retested prior to final integration.

Cost Analysis Improvement Group officials have not reviewed this estimate or its assumptions and did not refute its conclusions. They stated, however, that it would be unusual for unit prices to decrease with a lower production base and they would have to carefully review the accompanying analysis to be convinced.

Potential Design Change

As mentioned earlier, the U.S. Army may adapt the TGW submunition for use on the U.S. Army Tactical Missile. The MLRS TGW project office estimated the additional development effort for the submunition would cost about \$156 million more (fiscal year 1990 constant dollars) than completion of the current design development.

Other Cost Considerations

DOD is currently funding initiatives designed to improve the ability to manufacture and reduce the cost of millimeter wave technology. The initiatives are to develop affordable millimeter wave circuitry and manufacturing methods for DOD systems. However, according to project officials, the MLRS TGW is the primary focus. To date, the initiatives have

⁵The unofficial estimate was provided to us on January 28, 1991, and was subject to change.

not progressed sufficiently to quantify savings. Consequently, current TGW cost estimates do not consider the potential effects of the initiatives.

Objectives, Scope, and Methodology

We updated our prior work by examining the requirements, schedule, performance, and cost aspects of the MLRS TGW program. We reviewed relevant program documents such as system threat analyses, selected acquisition reports, cost and operational effectiveness analyses, contract documents, test and evaluation plans and assessments, various cost estimates, and budget exhibits. We did our work at the offices of the Under Secretary of Defense for Acquisition, the Assistant Secretary of Defense for Program Analysis and Evaluation, the U.S. Army, and the Defense Intelligence Agency in Washington, D.C.; the U.S. Army Missile Command, Huntsville, Alabama; and the Army Materiel Systems Analysis Activity, Aberdeen Proving Ground, Maryland.

We and the German Federal Court of Audit coordinated work and shared information we obtained on the program. The Federal Court of Audit has drafted a report on the program comparing it with a competing German national system in development. We plan to issue a joint report at a later time incorporating the Federal Court of Audit's findings on the program. We also contacted the United Kingdom's National Audit Office and France's Court of Accounts to determine their interest in participating in the coordinated effort. However, these organizations did not participate.

We did not examine or compare MLRS TGW with the other two competing development programs or monitor the selection process because of ongoing work being performed by DOD's Office of the Inspector General. We monitored the Inspector General's efforts under a separate review. For the system demonstration substage, fully updated, assessed, and validated test and cost data on the MLRS TGW were not available at the time of our examination.

We discussed a draft of this report with cognizant DOD and U.S. Army officials and incorporated their comments where appropriate. We did our work from November 1990 through January 1991 in accordance with generally accepted government auditing standards.

Major Contributors to This Report

**National Security and
International Affairs
Division, Washington,
D.C.**

Stewart L. Tomlinson, Assistant Director
Davi M. D'Agostino, Project Manager
Peter J. Berry, Deputy Project Manager

**Atlanta Regional
Office**

Thomas W. Gilliam, Regional Management Representative
John T. Gilchrist, Site Senior
Leon S. Gill, Evaluator

Ordering Information

The first five copies of each GAO report are free. Additional copies are \$2 each. Orders should be sent to the following address, accompanied by a check or money order made out to the Superintendent of Documents, when necessary. Orders for 100 or more copies to be mailed to a single address are discounted 25 percent.

**U.S. General Accounting Office
P.O. Box 6015
Gaithersburg, MD 20877**

Orders may also be placed by calling (202) 275-6241.

