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United States General Accounting Office

Report to the Chairman, Committee on
Armed Services, U.S. Senate

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June 1988

DOD ACQUISITION PROGRAMS

Status of Selected Systems

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United States
General Accounting Office
Washington, D.C. 20548



National Security and
International Affairs Division

B-226470

June 30, 1988

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

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Dear Mr. Chairman:

In response to your September 28, 1987, letter and subsequent agreements with representatives of your office, we have reviewed 23 defense acquisition programs. Our objectives were to provide current information on each program's requirements, schedule, performance, cost, and funding support. Although our principal focus was on those programs that the Committee may consider for milestone authorization, as requested, we also reviewed programs that were of particular interest to the Committee.

The Acquisition Cycle

Major Department of Defense (DOD) acquisitions typically proceed through four phases, with each phase preceded by a senior management review either at the military service or the DOD level. These reviews are referred to as "milestone decisions." The "milestone 0" decision considers whether a system should proceed into the concept exploration phase, during which alternative system concepts are identified and evaluated. Following a "milestone I" decision, a system proceeds into the demonstration and validation phase, during which a few test articles are fabricated to see if they can perform generally as expected. A "milestone II" decision is then made on whether one or more systems should proceed into full-scale development. In this phase, several test articles, or prototypes, are made and undergo numerous tests to ensure that the design meets the system requirements. After full-scale development is completed, a "milestone III" decision is made to determine whether the system should be produced and fielded. Frequently, DOD and the services divide the production decision into two increments—"milestone IIIA," which considers a system for low-rate initial production, and "milestone IIIB," which considers a system for full-rate production.

Within this general program acquisition framework, DOD tailors the acquisition phases for a particular program to that program's needs and risks. In doing so, DOD can combine phases, such as demonstration and validation and full-scale development, and can run two phases concurrently. For instance, it can start production before development is complete.

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Milestone Authorization

Milestone authorization is the process of authorizing funding for either the full-scale development (milestone II) or the full-rate production (milestone IIIB) phase of defense acquisition programs, for multiyear periods (not to exceed 5 years). Legislation enacted in October 1986 and codified in chapter 144, title 10, of the United States Code established milestone authorization to enhance program stability; if DOD commits itself to managing a program to agreed upon cost, schedule, performance, and other requirements, the Congress will commit itself to stable, multiyear funding authorization. The legislation required the Secretary of Defense to (1) designate a number of programs as "Defense Enterprise Programs" to receive streamlined management and (2) nominate selected Defense Enterprise Programs as milestone authorization candidates. The Congress amended the legislation in 1987 to enable the House and Senate Committees on Armed Services to consider defense acquisition programs for milestone authorization that have not been designated as Defense Enterprise Programs.

In March 1987, the Secretary of Defense designated 10 acquisition programs as Defense Enterprise Programs and nominated 3 of these for milestone authorization—the Army Mobile Subscriber Equipment, the Navy Trident II D-5 Missile, and the Air Force Medium Launch Vehicle. The Congress subsequently approved milestone authorization for the Army and Navy systems, as well as two others the Congress had considered—the Navy T-45 Training System and the Army Tactical Missile System. According to DOD officials, because the Secretary of Defense designated the 10 Defense Enterprise Programs and 3 milestone authorization candidates as part of the fiscal year 1988/1989 biennial budget request, no new designations or nominations will be made until the Secretary submits the fiscal year 1990/1991 budget request.

Acquisition Programs Reviewed

Most of the programs we reviewed were either approaching a full-scale development decision or a production decision. Although legislation does not provide for milestone authorization of a program scheduled for an initial production phase (milestone IIIA), your office requested that we include programs approaching that phase because of the significance of the decision to initiate production of a system. Table 1 shows the 23 programs we reviewed, as well as the dates of recently completed and upcoming milestone decisions.

Table 1: Milestone Decisions for 23 Programs

Acquisition program	Milestone decision	Date
Army programs		
Multiple Launch Rocket System's Terminal Guidance Warhead (MLRS TGW)	II	Jan. 1992
Forward Area Air Defense Command, Control and Intelligence System (FAAD C2I)	a	a
Line-of-Sight Forward Heavy Weapon System (LOS-F-H)	IIIB	Dec. 1989
Fiber Optic Guided Missile (FOG-M)	II	June 1988
Advanced Antitank Weapon System-Medium (AAWS-M)	II	Mar. 1989
Sense and Destroy Armor System (SADARM)	II	Mar. 1988
Tube-launched, Optically-tracked Wire-guided (TOW) Missile (TOW 2B version)	IIIB	May 1990
Advanced Field Artillery Tactical Data System (AFATDS)	II	Aug. 1989
Army Command and Control System Common Hardware and Software (ACCS CHS)	IIIA	Aug. 1988
Single Channel Ground and Airborne Radio System (SINCGARS)	IIIB	Oct. 1988
Navy programs		
SSN-21 Seawolf Submarine	IIIA	June 1988
AN/BSY-2 Submarine Combat System	II	Mar. 1988
V-22 Osprey Aircraft	IIIA	Dec. 1989
MK-50 Torpedo	IIIA	Feb. 1989
Surface Antisubmarine Warfare Program (Surface ASW)	II	Dec. 1989
Airborne Self-Protection Jammer (ASPU)	IIIA	Feb. 1989
Air Force programs		
C-17 Aircraft	IIIA	Oct. 1988
Small Intercontinental Ballistic Missile (Small ICBM)	b	b
Peacekeeper Rail Garrison	II	May 1988
Short Range Attack Missile (SRAM) II	IIIA	July 1991
Titan IV Expendable Launch Vehicle	c	c
Advanced Medium Range Air-to-Air Missile (AMRAAM)	IIIB	Mar. 1989
Sensor Fuzed Weapon (SFW)	IIIA	Aug. 1989

^aFAAD C2I is comprised of several elements, which are in different acquisition phases.

^bSmall ICBM is in full-scale development, but DOD proposes to terminate the program. However, DOD is requesting limited funding to allow the next administration to decide on the program's future.

^cTitan IV is already in production, and the Air Force does not plan another milestone decision.

Impact of Defense Budget Reductions

In December 1987, the Congress and the administration arrived at a fiscal year 1989 budget summit agreement that specified defense reductions of \$33 billion. The DOD budget request for fiscal year 1989 is

\$299.5 billion, reduced from the \$332.4 billion included in the fiscal year 1988/1989 budget request of January 1987.

Of the \$33 billion reduction, about \$22 billion occurred in the research, development, test and evaluation, procurement, and military construction accounts, which fund weapon acquisitions. According to DOD, these budget reductions will allow production of key systems to continue, while terminating programs that are not affordable, of low priority relative to other program requirements, or for which viable alternatives exist. Some research and development efforts or planned procurements were deferred, and several new program starts were delayed for several reasons, including technical difficulties and congressional action.

Of the 23 programs, 8 received budget reductions in the amended fiscal year 1989 budget request. These included AFATDS, FAAD C2I, FOG-M, LOS-F-H, MK-50, SADARM, SFW, and the Small ICBM.

Costs of the Programs Reviewed

Of the 23 programs, 9 are in the early development phases that precede full-scale development, 9 are in full-scale development, and 4 are in production. The FAAD C2I elements are in various phases of acquisition. The cost estimates in the following tables are based on information provided by DOD. Table 2 shows the cost estimates for acquisition programs in early development phases. For these programs, full-scale development is the next phase that could be approved for milestone authorization.

Table 2: Cost Estimates for Programs in Early Development (Escalated Dollars)

Dollars in millions

Program	Early development cost	Full-scale development cost	Production cost	Total cost
MLRS TGW	•	\$433	\$11,166	\$11,599
FOG-M	\$105	477	2,570	3,152
AAWS-M	137	398	4,934	5,469
SADARM	•	643	4,945	5,588
TOW	•	312	3,742	4,054 ^a
AFATDS	103	185	742	1,030
AN/BSY-2	173	1,642	7,300 ^b	9,115
Surface ASW	63	895	^c	
Rail Garrison	•	2,871	4,515	7,386 ^d

^aDevelopment of the TOW 2B has recently begun, but the development and procurement costs presented are for all TOW versions. The TOW Project Office estimates do not differentiate between the costs of different versions or distinguish early development costs from full-scale development costs.

^bThese costs are for 28 combat systems and are funded through the SSN-21 program.

^cProcurement costs have not yet been estimated.

^dIncludes \$921 million for military construction. Excludes estimated \$3.2 billion missile cost.

Table 3 shows the cost estimates for acquisition programs in full-scale development. For these programs, initial production is the next acquisition phase.

Table 3: Cost Estimates for Programs in Full-Scale Development (Escalated Dollars)

Dollars in millions				
Program	Development cost	Initial production cost	Full-rate production cost	Total cost
ACCS CHS	\$40	•	\$869	\$909 ^a
SSN-21	2,200	\$1,700 ^b	37,600 ^b	41,500 ^b
V-22	2,663	7,826	12,511	23,000
MK-50	1,432	743	4,472	6,647
ASPJ	577	910	3,305	4,792
C-17	4,948	10,300	20,447	35,695 ^c
Small ICBM	3,352 ^d	•	•	•
SRAM II	1,083	188	1,122	2,393
SFW	154	410	2,650	3,213 ^e

^aThe Army does not consider this program as being in development but rather as an "off-the-shelf" acquisition. We show it here because its next phase will be initial production.

^bIncludes costs to procure the AN/BSY-2 combat system.

^cIncludes military construction costs

^dIncludes \$200 million requested in fiscal year 1989. DOD proposes to terminate this program due to affordability concerns.

^eTotal does not add due to rounding.

Table 4 shows the cost estimates for acquisition programs in production. For these programs, up to the next 5 years of production could be approved for milestone authorization.

Table 4: Cost Estimates for Programs in Production (Escalated Dollars)

Dollars in millions					
Program	Development cost	Initial production cost	Cost for 5 years of full-rate production	Cost to complete production	Total cost
LOS-F-H	\$256	•	•	\$5,462	\$5,718 ^a
SINGARS	199	\$397	\$2,200	2,409	5,205
Titan IV	^b	^b	1,890	^b	12,671 ^c
AMRAAM	1,151	1,544	4,799	3,705	11,199
FAAD C2I	•	•	•	•	3,476 ^d

^aThe program office was not able to provide a more detailed breakout of this information. Total provided is in constant fiscal year 1988 dollars.

^bFurther breakdown of the Titan IV cost estimate was impractical.

^cIncludes military construction costs

^dThe elements of FAAD C2I are in different phases of acquisition, and therefore it was impractical to present the cost estimate in greater detail.

Status of the Programs Reviewed

We pursued the following areas of inquiry in evaluating the 23 acquisition programs:

- Is there an established need for the program?
- Does the program represent a significant increase in capability?
- Is the program the clear choice to fulfill the need?
- Has the schedule slipped in the past few years?
- Are there any indications of future schedule slippage?
- Has demonstrated performance indicated that the program will meet requirements?
- Are there indications of significant obstacles to achieving desired performance?
- Has the program experienced cost growth in the past few years?
- Are there any indications of future cost growth?
- Has the program been free from cuts within DOD due to budget constraints?
- Does the program office believe that funds to complete the program are adequate?

The relevance of these questions differs, depending on the program's current acquisition phase. For example, for programs in early development, information on how achievable their schedules, performance, or cost estimates are is likely to be less concrete than such information for programs nearing or in production. In particular, systems in these early phases have not demonstrated performance capabilities mainly because they are not far enough along to have items available for testing. Also, early development programs are less likely to represent consensus solutions to needs because pursuing competitive alternatives is common in early development.

Table 5 summarizes the status of the 23 programs in these areas as of spring 1988. The information in the table is intended to convey the general status of a program; detailed information on each program is provided in the appendixes.

Table 5: Status of the Programs Reviewed

Program	Need established	Increase in capability	Program clear choice	Recent schedule slippage	Future slippage indicated
In early development					
MLRS TGW	yes	yes	yes	yes	yes
FOG-M	yes	yes	yes	yes	yes
AAWS-M	yes	yes	yes	no	yes
SADARM	yes	yes	yes	yes	yes
TOW 2B	yes	yes	unknown	yes	no
AFATDS	yes	yes	yes	yes	yes
AN/BSY-2	yes	yes	yes	no	yes
Surface ASW	yes	yes	yes	yes	no
Rail Garrison	yes	yes	unknown	no	unknown
In full-scale development					
ACCS CHS	yes	yes	yes	yes	yes
SSN-21	yes	yes	yes	no	no
V-22	yes	yes	yes	yes	no
MK-50	yes	yes	yes	yes	no
ASPJ	yes	yes	yes	yes	yes
C-17	yes	yes	yes	yes	yes
Small ICBM ^a					
SRAM II	yes	yes	yes	yes	no
SFW	yes	yes	yes	yes	yes
In production					
LOS-F-H	yes	yes	yes	yes	unknown
SINCGARS	yes	yes	yes	yes	no
Titan IV	yes	yes	yes	yes	yes
AMRAAM	yes	yes	yes	yes	yes
Other					
FAAD C2I	yes	yes	yes	yes	yes

^aDOD proposes to terminate this program

Performance demonstrated	Significant performance obstacles	Recent cost growth	Future growth indicated	Free from funding cuts	Funding adequate
no	yes	yes	yes	yes	no
no	no	yes	no	no	unknown
no	unknown	no	no	yes	yes
no	no	yes	yes	no	no
no	unknown	yes	yes	no	yes
no	no	no	yes	no	yes
no	yes	no	yes	no	yes
no	yes	no	no	yes	yes
no	no	no	no	no	yes
partial	no	no	no	no	unknown
no	no	no	no	yes	yes
no	no	no	no	no	yes
partial	no	yes	no	yes	yes
partial	yes	no	no	yes	yes
no	no	yes	no	no	no
no	no	no	no	yes	no
partial	no	yes	yes	yes	yes
no	yes	yes	yes	no	yes
partial	no	no	no	no	yes
partial	no	yes	yes	no	yes
partial	no	yes	yes	yes	yes
no	unknown	yes	yes	no	no

Objectives, Scope, and Methodology

We reviewed programs that (1) are scheduled for full-scale development or production decisions in fiscal year 1989, (2) were designated as Defense Enterprise Programs last year but not approved for milestone authorization, or (3) were of particular interest to the Committee.

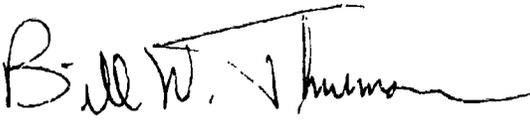
We reviewed relevant program documents such as operational requirements, selected acquisition reports, and operational effectiveness analyses. We also interviewed responsible DOD and military service program officials. In addition, we had ongoing work in 17 programs, which we

drew upon for this review. We conducted our work at DOD and the Departments of the Army, the Navy, and the Air Force at the Pentagon, Arlington, Virginia; Army Armament Research and Development Center, Picatinny Arsenal, New Jersey; Army Missile Command, Huntsville, Alabama; Communications and Electronics Command, Fort Monmouth, New Jersey; Naval Air Development Center, Warminster, Pennsylvania; Naval Underwater Systems Center, New London, Connecticut; Navy Operational Test and Evaluation Force, Norfolk, Virginia; Space Division, Air Force Systems Command, Los Angeles, California; Armament Division, Air Force Systems Command, Eglin Air Force Base, Florida; Aeronautical Systems Division, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio; and Ballistic Missile Office, Air Force Systems Command, Norton Air Force Base, California.

To expedite the report's issuance, we did not request official agency comments. However, we did discuss the report with DOD and program officials whose comments have been considered in the final report. We performed our work from October 1987 to March 1988 in accordance with generally accepted government auditing standards.

We are sending copies of this report to the Chairmen, House Committee on Armed Services, House and Senate Committees on Appropriations, Senate Committee on Governmental Affairs, and the House Committee on Government Operations; the Secretary of Defense; the Secretaries of the Army, the Navy, and the Air Force; and the Director of the Office of Management and Budget. Copies will be made available to other interested parties upon request.

Sincerely yours,

for 

Frank C. Conahan
Assistant Comptroller General

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Abbreviations

AAWS-M	Advanced Antitank Weapon System-Medium
ACCS	Army Command and Control System
ADATS	Air Defense Antitank System
AFATDS	Advanced Field Artillery Tactical Data System
AMRAAM	Advanced Medium Range Air-to-Air Missile
ASPJ	Airborne Self-Protection Jammer
ASW	Antisubmarine Warfare
C2I	Command, Control and Intelligence
CAIG	Cost Analysis and Improvement Group
CHS	Common Hardware and Software
DOD	Department of Defense
EPLRS	Enhanced Position Locating and Reporting System
FAADS	Forward Area Air Defense System
FOG-M	Fiber Optic Guided Missile
GAO	General Accounting Office
ICBM	intercontinental ballistic missile
IFF	Identification Friend-or-Foe
IOC	Initial Operational Capability
ITT	International Telephone and Telegraph
IUS	Inertial Upper Stage
JTIDS	Joint Tactical Information Distribution System
LOS-F-H	Line-of-Sight Forward Heavy
MLRS	Multiple Launch Rocket System
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NUS	No Upper Stage
OSD	Office of the Secretary of Defense
PHID/NCTR	Positive Hostile Identification/Noncooperative Target Recognition
SADARM	Sense and Destroy Armor
SFW	Sensor Fuzed Weapon
SINGARS	Single Channel Ground and Airborne Radio System
SRAM	Short Range Attack Missile
TGW	Terminal Guidance Warhead
TOW	Tube-Launched, Optically-Tracked, Wire-Guided

Army Programs

Multiple Launch Rocket System's Terminal Guidance Warhead

The goal of the Multiple Launch Rocket System's (MLRS) Terminal Guidance Warhead (TGW) program is to develop a target-sensing submunition to attack armored targets at long range. A four-country consortium—the United States, the United Kingdom, the Republic of France, and the Federal Republic of Germany—is sharing technology and the estimated development cost of \$1 billion (escalated dollars). The United States is funding 40 percent of the development. While procurement quantities are tentative, the Army estimates the U.S. portion of MLRS TGW development and procurement costs at \$11.6 billion (escalated dollars).

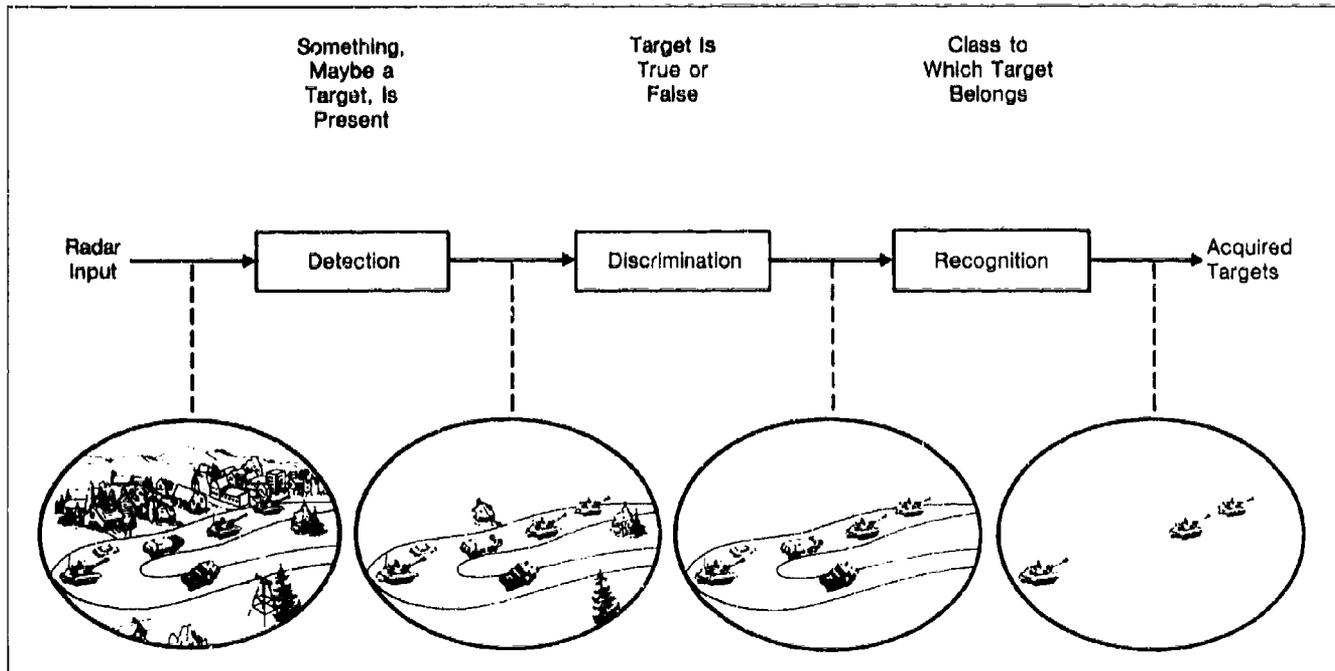
In 1982 the four countries determined that MLRS TGW was the best technical approach to gaining battlefield leverage against a superior armored threat. Development is currently in the component demonstration subphase of a two-part validation program, with a scheduled January 1989 decision on whether to proceed to the second part, system demonstration.

The TGW concept calls for unproven target seeker technology. While Army and Department of Defense (DOD) officials agree that TGW development is high risk, their views vary on whether the technology will be proven within current schedule and cost estimates and whether it should be shared within a consortium. Critical contractor technology demonstration tests are scheduled for completion by November 1988. Funding to date has been adequate, but the project office estimates a shortfall of \$127 million (escalated dollars) beginning in fiscal year 1990 for both system demonstration and follow-on technology maturation efforts.

Background

The MLRS TGW will be an all-weather weapon, launched from remote locations using the basic MLRS launcher. The system will use the standard MLRS rocket motor to propel a warhead structure to the target area where it will dispense three terminally guided submunitions. Each submunition will contain a seeker that will activate the submunitions' independent function to guide and control the warhead and search for and engage the target. The submunitions being developed rely upon miniaturized, sophisticated, and complex components to perform these functions. When proven, the new technology, specifically for the seeker, will provide significant advantages over other technologies. Figure I.1 shows an artist's conception of the MLRS TGW.

Figure I.1: Artist's Conception of the MLRS TGW



The TGW offers improved accuracy and lethality. It will supplement, rather than replace, existing equipment or munitions. The Army plans to use it in conjunction with other munitions against armored targets behind enemy lines.

Because MLRS TGW calls for developing technology that is not yet proven, the Army designed a three-phase developmental approach: a two-phase validation program followed by maturation. The validation program includes component demonstration and system demonstration sub-phases. The Army contends that this approach will demonstrate sufficient system maturity to initiate concurrent full-scale development and initial production during the maturation phase.

In November 1984, the Army awarded a cost-plus-incentive-fee component demonstration contract to MDTT, Inc., the joint venture of Martin Marietta Corporation (United States), Brandt Armaments (France), THORN EMI Electronics, LTD (United Kingdom), and DIEHL GmbH & Co. (Germany). The contract includes options for the system demonstration subphase and for the maturation phase. Major government reviews

are scheduled after each phase to determine whether the program should continue.

Requirements

In 1979 and 1982, the four countries determined that an autonomous, anti-armor terminal guidance warhead capability for the MLRS was the best technical approach to improving munitions accuracy and lethality deficiencies and providing an effective field artillery to conduct effective deep attack. August 1984 and April 1987 Army Cost and Operational Effectiveness Analyses concluded that the MLRS TGW and the Sense and Destroy Armor Munition were the preferred munitions mix to satisfy this need. In addition, a December 1986 System Threat Assessment Report for the MLRS TGW validated the need to develop munitions to counter a superior armored threat.

The Army is drafting a set of specific operational requirements for the MLRS TGW and an updated cost and operational effectiveness analysis to determine whether the weapon's expected performance warrants its cost. The Army plans to complete both of these efforts before the November 1988 Army review to decide whether to proceed to the system demonstration subphase.

Schedule

The MLRS TGW development program has slipped more than 33 months—from an 81.5- to a 115-month program. Project officials attribute this slippage, which occurred primarily during the component demonstration subphase, to contractor start-up difficulties, contractor problems in developing and manufacturing submunition components, and a warhead redesign required to meet a superior armored threat.

Table I.1 compares the Army's original and current schedule estimates for key upcoming program milestones. As shown in the table, the MLRS TGW schedule calls for beginning maturation and initial production concurrently.

Table I.1: MLRS TGW Program Schedule Changes

Event	12/31/85 schedule	2/4/88 schedule
Army system demonstration phase decision	Feb. 1987	Nov. 1988
DOD system demonstration phase decision	Mar. 1987	Jan. 1989
System demonstration phase initiated	Mar. 1987	Feb. 1989
Army/DOD maturation phase decision	Mar./Apr. 1989	Nov. 1991/Jan. 1992
Maturation phase initiated	June 1989	Feb. 1992
Initial production begun	June 1989	Feb. 1992
Production qualification testing	Dec. 1990	Aug. 1993
Full-rate production initiated	Sept. 1991	June 1994
Initial operational capability		classified

Project officials said that, initially, the Army had overestimated both the extent of available technology and the contractor's ability to manage the consortium. These factors, combined with technical difficulties and a threat change, led to restructuring the component demonstration contract in 1987. The Army extended component demonstration from 28.5 months to 51 months and included contractor cost and risk-sharing requirements for further cost or schedule extensions. Problems encountered in component demonstration also affected the system demonstration schedule, increasing the time required from 25 to 36 months.

Project officials maintain that recent progress from a schedule and technical standpoint is favorable and consider the schedule risk for component demonstration as now moderate to low. The Army has scheduled tests from March to December 1988 to evaluate the progress in seeker guidance technology and the likelihood of meeting the current schedule.

Unlike views expressed by project officials, DOD's Cost Analysis and Improvement Group (CAIG) contends that the MLRS TGW program has serious problems and a low probability of success. In an October 1987 review, the CAIG concluded that the schedule was too optimistic based on its own analysis and expressed reservations about the program's achieving its technical objectives because the technology was too risky. The Defense Acquisition Board will consider the varying positions at the January 1989 review to determine whether the program should proceed to system demonstration.

Performance

DOD, Army, and contractor officials consider seeker technology critical to system performance and its development the highest risk area for the

MLRS TGW. Difficulties in developing and manufacturing the submunition's components raise uncertainties about whether the program can meet the technical objectives of component demonstration. While recent test results show progress, the Army has not conducted sufficient tests to determine whether the seeker technology will meet Army requirements or whether technical solutions to current problems are available.

In August 1987, the Army modified the component demonstration contract to allow for a redesign of the TGW warhead because of ongoing technical difficulties, a threat change, and concern that the design would not meet performance specifications. This redesign reduced the number of submunitions in each warhead from six to three. A project official stated that this change should not significantly affect battlefield performance but stated that twice the number of rockets will now be required to deliver the same quantity of submunitions to the target area.

When the program began in 1984, the Army identified two critical functions for successful component demonstration: (1) dispensing the submunitions over the target area and (2) achieving the maturity of the seeker's technology and performance. Between February and November 1987, wind tunnel and sled tests showed problems with the dispensing function, but more recent tests indicate that, for the most part, these problems have been resolved. Submunition seeker testing began in August 1986. While preliminary tests showed that many components and subcomponents were not performing adequately, more recent analyses indicate progress, particularly with the seeker's ability to detect targets. The contractor characterizes current performance as a significant advancement in technology, and, according to an Army official, simulated government tests using the contractor's data confirm the seeker's target detection capability. The CAIG, on the other hand, based on its own review, contends that no major breakthrough has occurred in this area.

Project officials disagree with the CAIG assessment. They believe that the November 1988 and January 1989 schedule decision points will allow the Army to establish that the technology has matured sufficiently to continue to system demonstration. The seeker has not met the required performance levels for all environments, but additional captive flight and drop tests to determine whether the seeker can detect targets are scheduled from March to December 1988. One project official said that the results from ongoing analyses of completed tests and from the scheduled tests are critical in demonstrating whether the seeker technology can be developed for the MLRS TGW.

DOD and Army officials also disagree about the benefits of jointly developing the MLRS TGW in a consortium with three other countries. The CAIG maintains that the program should be a U.S.-advanced development program. Its position is that, while the unproven seeker technology is necessary to resolve current mission deficiencies, most of the more critical technology, such as software algorithms, is going from the United States to the European countries. In contrast, the Army cites technology exchange among all four countries as a major benefit resulting from joint development. Its view is that the European countries have contributed extensively in both hardware technology and progress in target detection.

Cost The Army currently estimates that MLRS TGW development will cost about \$1 billion (escalated dollars), with the United States funding 40 percent. This estimate has increased 44 percent since the program's inception in 1984. Project officials believe that the current cost estimate of \$11.6 billion (escalated dollars) is reasonable, but the CAIG considers it too optimistic. Table I.2 compares March 1983 and September 1987 Army baseline cost estimates for U.S. development and procurement in constant fiscal year 1988 dollars.

Table I.2: MLRS TGW Cost Estimate
(In Constant Fiscal Year 1988 Dollars)

Dollars in millions		
Item	3/31/83 Estimate	9/30/87 Estimate
Development	\$256.8	\$383.6
Procurement	6,361.8	8,081.6
Total acquisition	\$6,618.6	\$8,465.2

The project office considers the September 1987 cost estimate valid based on the Army's October 1987 Cost and Economic Analysis Center review. It estimated that the current component demonstration sub-phase can be completed at the contract estimate of \$217.1 million. This estimate increased about 118 percent over the original award of \$99.8 million. However, the contract limits the U.S. government's maximum liability to \$200.1 million.

The project office more recently estimated the U.S. share of development costs at \$432.8 million (\$404.6 million in constant fiscal year 1988 dollars) and the total cost for the MLRS TGW development at \$1.03 billion (escalated dollars). Total acquisition cost estimates beyond the September 1987 estimate were not available.

While cost estimates have been prepared, we believe that it is too early in the system's development to accurately estimate the MLRS TGW's acquisition costs. Estimated procurement quantities are tentative. DOD will not authorize a procurement quantity until the system demonstration decision. Estimated procurement costs were based on a classified quantity generated in simulated battle requirements and on a comparison with other systems' historical cost data. Estimated quantities for the submunitions have not changed, but due to the 1987 redesign, twice the original number of rockets will now be required to deliver the same number of submunitions. The Army estimates that the cost per kill will remain about the same. On the other hand, a 1987 cost and operational effectiveness analysis for the Army's Sense and Destroy Armor Munition indicates only half the amount of the MLRS TGW submunitions originally estimated are required. The Army has yet to reconcile these quantity differences and revise its cost estimates.

According to project officials, to date, the MLRS TGW program has incurred no funding problems, and funding to complete component demonstration should be adequate. However, the Army estimates a funding shortfall of about \$127 million in fiscal years 1990 through 1994 for system demonstration and maturation. Future program funding appears heavily dependent upon technology maturation.

Recent GAO Reports

None.

Forward Area Air Defense Command, Control and Intelligence System

The Army is acquiring the Forward Area Air Defense Command, Control and Intelligence (FAAD C2I) system to automate command and control of its short-range air defense weapons. The system is to automatically detect and identify incoming aircraft and provide targeting and tracking information on enemy aircraft to forward area air defense units. The Army's estimated system cost is \$3.5 billion (escalated dollars). The FAAD C2I consists of command and control computer equipment, a ground sensor, an aerial sensor, and aircraft identification devices. The various FAAD C2I elements are in different phases of acquisition.

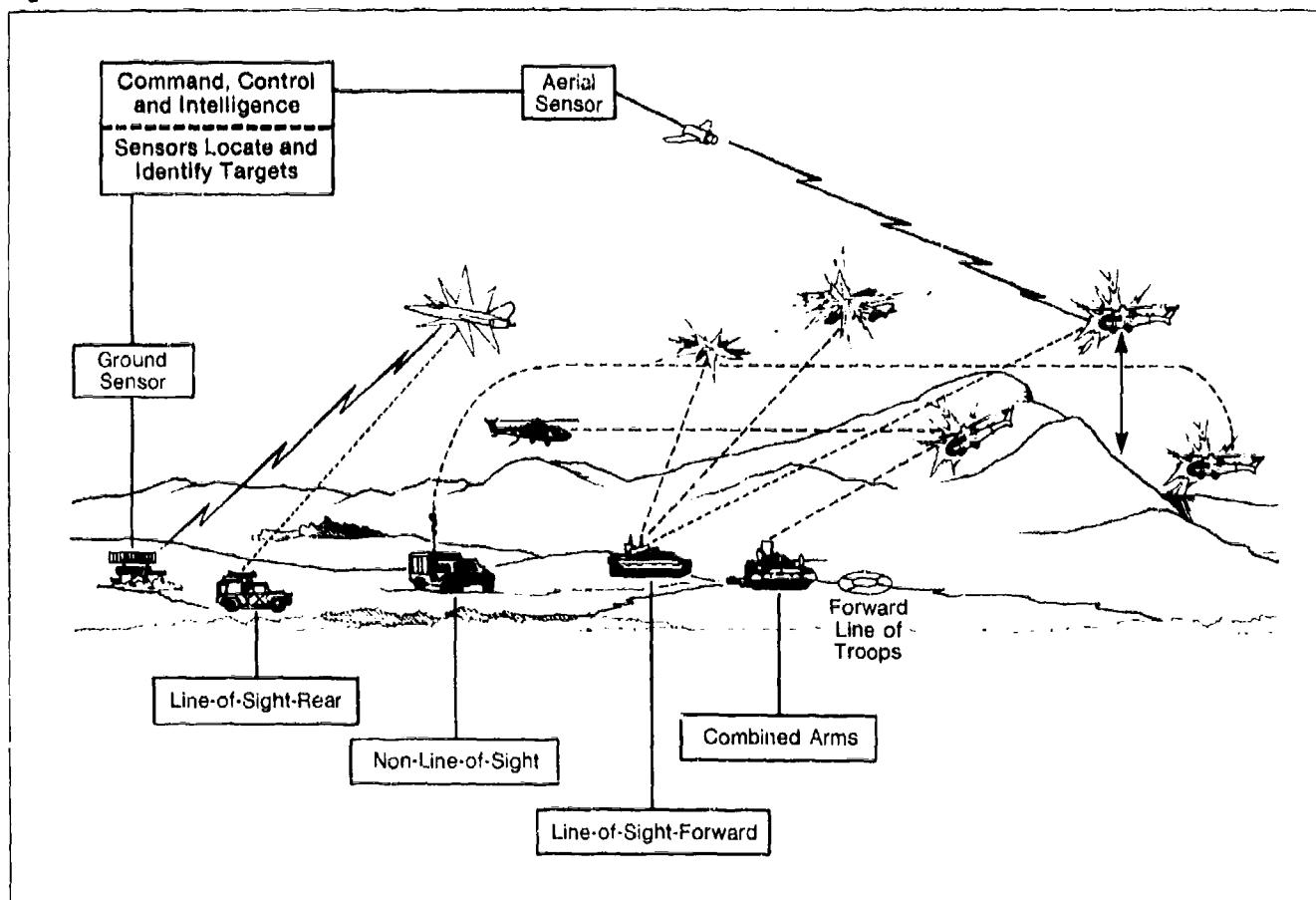
According to the Army, it urgently needs FAAD C2I to replace the existing manual system. While the Army expects FAAD C2I to provide a significant improvement in air defense effectiveness, no testing has been done to determine whether it will meet performance expectations. The system acquisition schedule, which is marked by a high degree of concurrent development, testing, and production, has been delayed, and further delays seem likely. The Army's cost estimate is incomplete and unstable. The priority of some system components seems questionable because of recent funding reductions.

Background

FAAD C2I is part of the overall Forward Area Air Defense System (FAADS), which is to provide new weapons for strengthening air defenses in forward combat zones. The Army initiated FAADS to fill the void when DOD terminated the Sergeant York air defense gun in 1985. Although the Sergeant York was terminated, both DOD and the Congress recognized that the Army still had a requirement to improve its forward area air defense capabilities. After the termination, the Army formed a working group to recommend actions and develop an acquisition strategy to overcome its air defense deficiencies. The Army concluded that these deficiencies could not be solved with any one system and should be approached with a combination of integrated weapon systems. The FAADS implements this approach.

The FAADS consists of five elements—four kinds of air defense weapons and a command and control network. These elements are (1) a line-of-sight forward heavy weapon system, which is to be a tracked vehicle that will use missiles and a gun to protect tanks and personnel carriers from enemy aircraft within its sight in the division's forward areas, (2) a line-of-sight rear missile and gun to protect the division's rear units from aircraft within its sight, (3) a non-line-of-sight missile to attack

Figure I.2: FAADS Elements



targets hidden by terrain from the operator's view, (4) weapons mounted on tanks, infantry fighting vehicles, and helicopters to attack aircraft targets in the forward area, and (5) a command, control, and intelligence network (FAAD C2I) through which the other FAADS elements are connected to receive information such as the locations of targets. Figure I.2 shows the FAADS elements.

FAAD C2I, the network segment of the five-part FAADS, will be integrated with the Army Command and Control System (ACCS), a larger system to automate the battlefield functions of air defense, maneuver, fire support, combat-service support, and intelligence. The basic C2 component

is to include the computers, software, and related items necessary to automate the command and control functions. It is to utilize computer equipment and common software to be acquired under ACCS. System-unique software is being developed under the FAAD C2I program, but it must be integrated with the ACCS computers and software.

The ground sensor component is to be a radar for detecting and tracking aircraft throughout the forward combat area. The Army will procure the sensor as a nondevelopmental, or "off-the-shelf," item.

The aerial sensor component is to provide increased air surveillance for targets that might avoid detection by the ground sensor. The Army has not defined the type of aerial sensor it will use. It is studying various aircraft platforms to carry the sensor, including fixed-wing and rotary-wing aircraft, remotely piloted vehicles, and balloons.

The system's aircraft identification component is to consist of two elements for distinguishing between friendly and threat aircraft. One, which is called Identification-Friend-or-Foe (IFF), identifies aircraft by recognizing electronic signals transmitted by friendly aircraft. The Army intends to use the Mark XV system now being developed for use by U.S. and North Atlantic Treaty Organization (NATO) forces as the IFF for FAAD C2I. The other element identifies hostile aircraft by comparing the characteristics of incoming aircraft with a library of known aircraft characteristics. The Army calls this element Positive Hostile Identification/Noncooperative Target Recognition, or PHID/NCTR.

The Army's acquisition strategy for FAAD C2I calls for concurrent development, testing, and production. The Army has scheduled some system components for production well before completing their development and testing. The Army considers this strategy essential to expedite system deployment.

The ground and aerial sensors will detect and provide tracks on low-altitude enemy aircraft. FAAD C2I aircraft identification elements—PHID/NCTR and IFF—located on the ground sensor will distinguish between enemy and friendly aircraft. These data are to be transmitted through the basic C2 component to the battalion air battle management operations center via the Joint Tactical Information Distribution System (JTIDS). The air battle management center will correlate these air tracks with information acquired via JTIDS from other friendly data sources. The correlated information will be provided to the FAAD basic C2 component via the JTIDS network. The basic C2 component will broadcast the

air tracks over the Enhanced Position Locating and Reporting System (EPLRS) to the FAAD fire units. To ensure accurate aircraft identification, the fire units will also be equipped with aircraft identification elements.

FAAD C2I's progress depends on the progress in other programs. In addition to relying on the ACCS program for computers and software and on the Air Force-led Mark XV program for its IFF component, FAAD C2I will rely on the EPLRS and JTIDS programs to provide the communications for linking together various system components. Finally, the PHID/NCTR aircraft identification component also involves several technology programs managed outside the FAAD C2I program.

Requirements

The Army seems convinced that a FAAD C2I system is needed to replace the existing manual system but does not seem convinced that the FAAD C2I, as currently defined, is the best alternative for meeting the need. Recent budget decisions indicate that the Army is wavering on what the system is to consist of or whether all components are essential. The aerial sensor, already behind schedule, will be further delayed because the Army recently chose not to request funds for its full-scale development in fiscal year 1989. Program officials told us that the aerial sensor might be cancelled because of funding constraints.

In addition, when recently faced with a potential budget reduction, the Army offered to exclude the Mark XV from FAAD C2I. Program officials told us that if the Mark XV is deleted, FAAD C2I will use an improved version of the existing Mark XII system, which costs less but is less capable.

Finally, after the Army and DOD approved the production of the ground sensor, the Army withdrew approval of the sensor's basic requirements document. The withdrawal consequently prevented release of the request for proposal for the production contract. The sensor program manager told us that this action stemmed from concern over the ground sensor's susceptibility to threat anti-radiation missiles and that the Army had amended the requirements document to address the threat concern. In addition, the Under Secretary of the Army issued a memorandum in late 1987 expressing concern over the number of battlefield sensors already fielded or being developed under various Army programs. These concerns appear to have been resolved since the Army reapproved the requirement for the sensor in January 1988. However, the amended fiscal year 1989 budget submitted in February 1988 deleted production funding for the sensor.

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Program officials stated that the system cost and operational effectiveness analysis, which is supposed to demonstrate the best alternative for meeting the need, had not yet been approved.

Schedule

The latest FAAD C2I schedule information available at the program office shows that acquisition milestones for most system elements have slipped since program approval in August 1986. Further delays seem likely because of expected slippage in the ACCS, EPLRS, and JTIDS programs.

Table I.3 compares the acquisition milestones when the FAAD C2I program was approved in August 1986 to the program office's latest schedule estimate. As indicated, the various program elements are expected to proceed through the acquisition cycle at different times.

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Table I.3: FAAD C2I Schedule Changes

Program/Event	As of Aug. 1986		As of Feb. 1988	
	Start	Complete	Start	Complete
Basic C2				
Software development	Sept. 1986	Aug. 1990	Sept. 1986	Oct. 1992
Production integration	Sept. 1988	"	Jan. 1990	Aug. 1993
Operational testing	Jan. 1990	Mar. 1991	June 1992	Oct. 1992
Initial operational capability	Sept. 1991	•	Apr. 1993	•
Ground Sensor				
Operational testing	Jan. 1990	"	June 1992	Oct. 1992
Production	Apr. 1988	Feb. 1994	Jan. 1990	Aug. 1993
Initial operational capability	Sept. 1991	•	Apr. 1993	•
Aerial Sensor				
Development	Oct. 1988	Jan. 1990	Jan. 1990	Feb. 1993
Operational testing	"	"	Feb. 1995	Sept. 1995
Production	May 1989	"	Mar. 1993	Mar. 1997
Initial operational capability	"	•	Dec. 1996	•
Aircraft Identification, IFF				
Development	Apr. 1988	Mar. 1990	Sept. 1988	June 1992
Operational testing	Apr. 1990	June 1991	Jan. 1992	Mar. 1993
Production	July 1991	"	July 1992	"
Initial operational capability	"	•	Oct. 1994	•
Aircraft Identification, PHID/NCTR				
Development	Jan. 1988	Sept. 1990	Aug. 1988	Sept. 1990
Operational testing	"	"	Nov. 1989	Mar. 1990
Production	Oct. 1990	"	Aug. 1989	"
Initial operational capability	"	•	Oct. 1990 ^b	•

"Could not be established at program office

^bThe initial operational capability date for one of four PHID/NCTR systems to be fielded.

Basic C2

The 2-year slip in the basic C2 schedule resulted in part from a delay in the ACCS program, and the Army expects further delays in ACCS. The Army did not select the ACCS computers for basic C2 as originally planned, and the current basic C2 schedule depends on the Army's awarding a contract for the ACCS computers in April 1988. FAAD C2I officials expect the ACCS contract award to slip beyond April 1988 because of additional problems in selecting the ACCS computers and said that the anticipated slip would impact the basic C2 schedule. The status of the computer acquisition is discussed on p. 68. Pending delivery of ACCS

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computers, the Army is using substitute computers in the basic C2 software development program. According to an Army program risk analysis, if the Army acquires ACCS computers that differ from the substitute computers being used, it will need additional time to rewrite the basic C2 software to be compatible with ACCS hardware.

Ground Sensor

Another reason for the basic C2 delay was the previously mentioned delay in approving the ground sensor requirement, which also deferred the sensor program. The Army cannot operationally test the basic C2 element until the ground sensor is available.

A factor that could further delay both the basic C2 and the ground sensor schedules is the potential delay in receiving the EPLRS and JTIDS communications equipment. The Army needs the EPLRS equipment by November 1988 and the JTIDS equipment by March 1989 for integration with FAAD C2I. However, EPLRS is having production and reliability problems, and JTIDS is having design problems. As a result, FAAD C2I officials are not confident that the equipment will be available.

Aerial Sensor

The delay in the aerial sensor schedule reflects the Army's decision not to request funds for the sensor's development. FAAD C2I officials told us that further deferrals could result in cancellation of the sensor program.

Aircraft Identification

The delay reflected in the aircraft identification IFF schedule stemmed from an Air Force decision to defer full-scale development of the Mark XV to solve design problems. FAAD C2I program officials expect further delays in this program. Based on information from the FAAD C2I program officials, the future of the Mark XV program is uncertain. They said that, during recent budget reviews, the Army and the other services recommended elimination of the Mark XV program. The Office of the Secretary of Defense (OSD) is expected to decide in 2 or 3 months whether to continue the program.

Information on changes in the aircraft identification PHID/NCTR schedule is classified.

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Concurrent Schedule

As indicated in table I.3, FAAD C2I acquisition is also based on concurrent development, testing, and production. For example, ground sensor procurement is to begin (1) over 2 years before the Army completes operational testing to determine its suitability for combat use and (2) over 2 years before basic C2 software development is to be completed. The FAAD C2I schedule makes no allowance for problems that might emerge, such as unfavorable test results.

Performance

The Army has not tested any of the FAAD C2I system. Thus, there is no firm basis for determining whether it will meet performance expectations. However, potential problems appear to be emerging. First, the Army is concerned that an "off-the-shelf" ground sensor will not meet user requirements, as indicated by the previously mentioned delay in approving the sensor requirements document. The Army now plans to improve the initial sensor's performance through a design modification program or replace it with a more capable sensor.

In addition, initial FAAD weapon systems will not have the aerial sensor component or complete aircraft identification components. The Army has deferred the aerial sensor and will field it after most FAAD weapon systems have already been fielded. Similarly, the status of the Mark XV IFF is uncertain, and the projected availability of all the PHID/NCTR systems has not been established. While the capability to accurately distinguish between friendly and threat aircraft would seem to be a fundamental necessity for any air defense command and control system, the Army believes that FAAD C2I, even without these elements, will still provide a significant improvement over the current manual system.

Cost

The Army's program cost estimate of \$3.5 billion (escalated dollars) represents an increase of \$836 million over the \$2.6 billion estimated in August 1986 when the program was approved. According to the Army, this increase is primarily due to estimating the cost of the aircraft identification program to completion, versus the single year estimate in 1986. As with the \$2.6 billion estimate, the current \$3.5 billion estimate excludes substantial cost. It is also likely to increase because it does not reflect recent budget reductions which, according to program officials, will result in a program stretch-out and attendant cost increase.

Table I.4 compares the August 1986 estimate to the program office's current estimate.

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Table I.4: FAAD C2I Cost Changes

Dollars in millions			
Cost element	8/86 estimate	Current estimate	Change
Development			
Basic C2	\$465.2	\$435.6	\$(29.6)
Ground sensor	35.0	35.7	0.7
Aerial sensor	136.2	255.0	118.8
Aircraft identification	305.6	200.0	(105.6)
Total development	\$942.0	\$926.3	\$(15.7)
Procurement			
Basic C2	304.3	260.2	(44.1)
Ground sensor	533.6	461.3	(72.3)
Aerial sensor	665.0	720.0	55.0
Aircraft identification	195.2	1,108.0	912.8
Total procurement	\$1,698.1	\$2,549.5	\$851.4
Total program and net increase	\$2,640.1	\$3,475.8	\$835.7

As indicated in table I.4, the major increase was in the procurement cost for the aircraft identification element. The \$912.8 million increase resulted from an increase in the number of PHID/NCTR units to be procured. The decrease of \$105.6 million in the development cost estimate for the aircraft identification element was not due to a projected cost reduction but resulted from a transfer of fund reporting responsibility to another Army organization outside the FAAD C2I program.

The decline in the basic C2 cost was due to a relaxation of requirements for basic C2 components, supplied by the ACCS program, to withstand harsh environmental conditions. To compensate for the less stringent requirements, the Army plans to improve the shelters in which the basic C2 components will be housed. The improved shelters are funded elsewhere by the Army, and the related costs are excluded from the FAAD C2I estimate.

The decrease of \$72.3 million in the ground sensor procurement estimate resulted from deleting the cost of government-furnished equipment and sensor spare parts from the revised estimate. Program officials said that these costs are supposed to be reported by other Army organizations.

Excluded Costs

In September 1987, we reported that the \$2.6 billion estimate was understated by at least \$3.2 billion because it excluded

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- \$900 million for equipping the Army National Guard with the basic C2 and the ground sensor,
- \$608 million to fully equip corps missile battalions with the basic C2 and the ground sensor,
- \$1.7 billion for war reserves for the basic C2 and the ground sensor, and
- at least \$7.5 million caused by a basic C2 schedule slip stemming from a delay in the ACCS program.¹

DOD agreed that the estimate was probably understated though not to the extent we reported. DOD stated, however, that it had asked the Army to prepare a new estimate to address the excluded items. The Army's current estimate does not include requirements to field FAAD C2I to the National Guard, war reserves, or to fully equip corps missile battalions. DOD will review this estimate as part of the next budget cycle. The Army's current \$3.5 billion estimate includes \$7.5 million for the ACCS program delay but does not include any amounts for the other excluded items.

In addition, the \$3.5 billion estimate does not consider recent reductions reflected in the revised fiscal year 1989 budget submission. Based on information furnished by the program office, the initial budget submission was for \$343.4 million, while the revised submission requested \$148.6 million, or a reduction of \$194.8 million. This action reflects deferral of ground sensor production and aerial sensor development. According to program officials, the stretch-out caused by these reductions will result in an overall cost increase. However, no official estimates of this increase are available at this time.

Program officials believe that, until recently, funding for this system has been adequate. However, they indicated that recent funding cuts will delay the program. Based on the Army's apparent willingness to cancel the Mark XV program and its decision to defer development of the aerial sensor, the priority of those system elements would seem to be questionable in periods of constrained budgets.

Recent GAO Reports

Battlefield Automation: Better Justification and Testing Needed for Common Computer Acquisition (GAO/IMTEC-88-12, Dec. 31, 1987).

¹Battlefield Automation: Army Air Defense Command and Control System Acquisition and Budget Issues (GAO/NSIAD-87-208, Sept. 28, 1987).

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Battlefield Automation: Army Command and Control Systems Acquisition Cost and Schedule Changes (GAO/NSIAD-88-42FS, Dec. 9, 1987).

Battlefield Automation: Army Air Defense Command and Control System Acquisition and Budget Issues (GAO/NSIAD-87-208, Sept. 28, 1987).

DOD Acquisition Programs: Status of Selected Systems (GAO/NSIAD-87-128, Apr. 2, 1987).

Aircraft Identification: Improved Aircraft Identification Capabilities: A Critical Need (GAO/C-NSIAD-86-18, Aug. 11, 1986).

Line-of-Sight Forward Heavy Weapon System

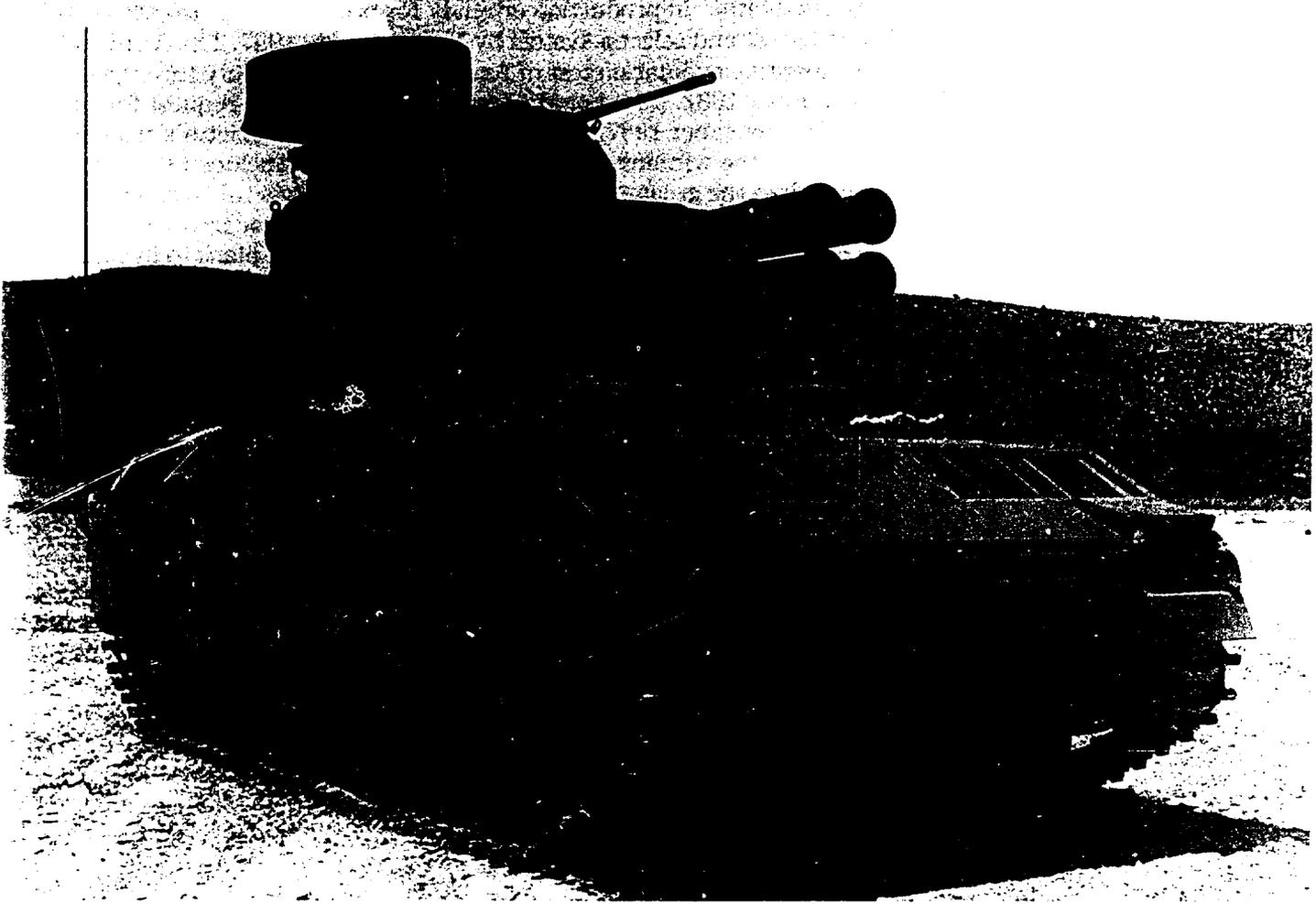
The line-of-sight forward heavy (LOS-F-H) air defense system will be a tracked vehicle that uses missiles and a gun to attack enemy aircraft. The LOS-F-H system is scheduled to enter full-rate production between October and December 1989. The Army estimates acquisition costs at \$5.7 billion (1988 dollars) for 562 units.

The LOS-F-H is one of the five FAADS elements, which are discussed on p. 23. To field air defense capability as soon as possible, the Army has chosen to develop the LOS-F-H, a system that relies heavily on components requiring minimal development and that does not meet all requirements but has the growth potential to do so. According to the Army, competitive testing has provided enough information to help select a winner out of four candidates for the LOS-F-H system. However, the testing was too limited to gauge how well the winning system, Martin Marietta's Air Defense Antitank System (ADATS), will perform the mission. Estimated costs have increased since 1986, mainly because the LOS-F-H was not well-defined at that time. Costs are expected to increase again based on contract proposals. Both the Army and the Office of the Secretary of Defense consider the program a high priority, although DOD reduced the program's fiscal year 1989 budget request. Fielding of the LOS-F-H has slipped 1 year due to the limited availability of funds within DOD.

Background

The LOS-F-H will be located in forward battle areas and will be used to protect tanks and infantry fighting vehicles from enemy helicopters and fixed-wing aircraft. The system will use radar and optics to find targets and is line-of-sight in the sense that it can only fire at targets within its view. Figure I.3 depicts the winning candidate as it appeared during the competitive test.

Figure I.3: Early Test Version of the Army's Line-of-Sight Forward-Heavy Air Defense System



To overcome air defense deficiencies, the Army intends to acquire all FAADS elements rapidly by relying heavily on nondevelopmental items, that is, subsystems or components ready for production or requiring minimal additional development. Having made an assessment of industries' interests in competing for the LOS-F-H system, the Army adopted an acquisition strategy to procure a nondevelopmental system that currently comes nearest to meeting its full system requirements but also has the growth potential to completely meet those requirements with further development.

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In fiscal year 1987, the Congress directed DOD to acquire and evaluate systems either in production or ready for production for the LOS-F-H role and to test and select a system by November 26, 1987. The Army held a competitive evaluation test of four candidates from July through early November 1987. Based on the test and responses to a request for proposal, in November 1987, the Army selected Martin Marietta's system, ADATS, as the winning candidate. The Army also concluded that the ADATS had the greatest potential to meet the Army's full system requirements for the LOS-F-H. The first 160 systems to be procured will not have a gun or a passive sensor, but eventually the Army plans to include a 25 mm Bushmaster gun and a passive sensor in each of the 562 units scheduled for procurement. The Army plans to field the ADATS beginning in November 1991.

Requirements

After the Army established the need for the FAADS, the Defense Intelligence Agency and Army intelligence validated the LOS-F-H threat. A formal set of requirements, which the Army approved in March 1987, establishes the need and specific requirements for the LOS-F-H system. The requirements call for an armored tracked vehicle that integrates a missile/gun combination; communications equipment; and detection, identification, and tracking sensors. The system is to be capable of operating day and night in adverse weather and in battlefield environments where electronic and physical countermeasures are prevalent.

A cost and operational effectiveness analysis for the entire FAADS system was initiated in February 1986, but the results have not yet been published. According to a member of the analysis study team, the analysis focused on performance requirements, since reliable cost data for the FAADS elements were not available. As a result, the analysis was not a true cost-effectiveness comparison with alternative systems.

Schedule

The Army is currently planning to conduct various preproduction tests with ADATS. The testing will cover tactics and doctrine, missile firings, and acquisition and tracking. The Army plans to complete this testing using a refurbished unit that was previously used in the competitive evaluation tests as well as one of four new prototype units fabricated to some extent with production tooling. The Army scheduled testing for a period of about 1 year beginning in April 1988. At the completion of this testing, the Army will test the four new prototypes from April to June 1989 to verify training, doctrine, tactics, and logistics. The Army will follow this testing with an operational test with these same units from

July to October 1989 to confirm the system's operational suitability and effectiveness prior to the full production decision planned for no later than December 1989.

According to the Army, if the Congress approves the amended fiscal year 1989 request of about \$50 million for research and development and \$110 million for production, ADATS could be fielded beginning in 1991. This is a 1-year slip from the date included in the April 1987 acquisition plan, due to overoptimism about funds available for the program within DOD. If procurement funds are not approved for fiscal year 1989, the Army believes that fielding of the system could slip an additional year.

The fiscal year 1988 Authorization Act restricted procurement funds from being obligated or expended for the LOS-F-II system until the results of the operational tests were completed and reported to the House and Senate Committees on Armed Services. However, the fiscal year 1988 Appropriations Act rescinded this restriction and provided funds to permit concurrent operational testing and procurement of long-lead items to hasten fielding.

The Army plans to award three firm fixed-price production contracts prior to the start of operational testing. The first two contracts provide for advance procurement and low-rate production for five units. The third contract, leading to full-rate production, will provide long-lead items for 20 units. The decision on whether to enter full-rate production will not be made, however, until completion of the operational test. The Army and OSD believe that the current acquisition schedule is low risk since ADATS will not enter full-rate production until it completes operational testing.

Performance

The only Army testing completed on the LOS-F-II to date is the competitive evaluation test held in 1987. While the Army judged ADATS to have won the competition, it has not completed the final assessment of the test results. There was some risk involved in selecting ADATS, because it is a system that has not been fielded and is therefore an unknown quantity. The other candidates had already been fielded in some form. However, Army and OSD officials believe that the ADATS should have no problem meeting the Army's full system performance requirements because the system, as tested, is close to meeting such requirements and, therefore, will require few changes. Detailed results of the test are classified.

The competitive test had several major test limitations including the following:

- Reliability, availability, and maintainability were not formally tested.
- Flight profiles, or patterns, were not fully representative of those anticipated from threat aircraft.
- Dry runs were flown by drone (unmanned) aircraft so that candidates were alerted as to the flight profile prior to the live-fire shots.
- Visibility was excellent and not representative of battlefield conditions.
- The directions the aircraft could come from were limited due to test range constraints imposed to ensure laser safety.
- Mobility, survivability, vulnerability, and transportability were not fully tested.
- The test environment (for instance, foliage and humidity) was unlike the European environment where the system will be initially deployed.
- Contractor personnel rather than Army crews fired the weapon systems.
- Candidates tested were not fully representative of systems contractors proposed to deliver to the Army for further testing.

Army test officials recognize these limitations and intend to correct them in the follow-on tests, particularly the operational test.

Cost

Estimated acquisition costs for the LOS-F-H system have increased substantially since 1986. A comparison of the 1986 and 1987 estimates is shown in table I.5. The 1986 estimates are given in 1987 constant dollars, and the 1987 estimates in 1988 constant dollars.

Table I.5: Comparison of LOS-F-H Acquisition Costs

Dollars in millions			
Item:	1986 estimate	1987 estimate	Increase
Research and development	\$124	\$256	\$132
Procurement	3,500	5,462	1,962
Total	\$3,624	\$5,718	\$2,094
Unit program cost	\$6.4	\$10.2	\$3.8

According to Army officials, the initial program cost estimate of \$3.6 billion for the LOS-F-H system was based on the General Electric Blazer system, which did not participate in the competitive evaluation test and is not representative of the system the Army currently requires. The

first baseline cost estimate of a system representative of the LOS-F-II requirements was completed in August 1987 and amounted to \$5.7 billion. The 1987 estimate was based on the estimated cost of a generic system, not a specific manufacturer's system. Both estimates were based on the purchase of 562 units. The next baseline cost estimate, to be completed in August 1988, will include Martin Marietta's proposal for ADATS, and the Army expects it to be greater than the 1987 estimate. OSD has not completed any independent cost estimates of the system.

According to Army officials, the FAADS program is currently a high priority at the Army and OSD levels. They indicated that at both levels the FAADS program is considered one of the top defense acquisition programs on the basis of need. Whether it will continue to remain a top priority is unknown. However, as a part of the FAADS program, the LOS-F-II, while continuing to receive funding support, is not immune from cuts, as evidenced by OSD's recent reduction of the Army's requested \$135 million for procurement to \$110 million for fiscal year 1989. According to the Army, the affordability issue has to be continually examined and may be a major issue when the cost to include the 25 mm Bushmaster gun in the ADATS is reevaluated.

Recent GAO Report

DOD Acquisition Programs: Status of Selected Systems (GAG/NSIAD-87-128, Apr. 2, 1987).

Fiber Optic Guided Missile

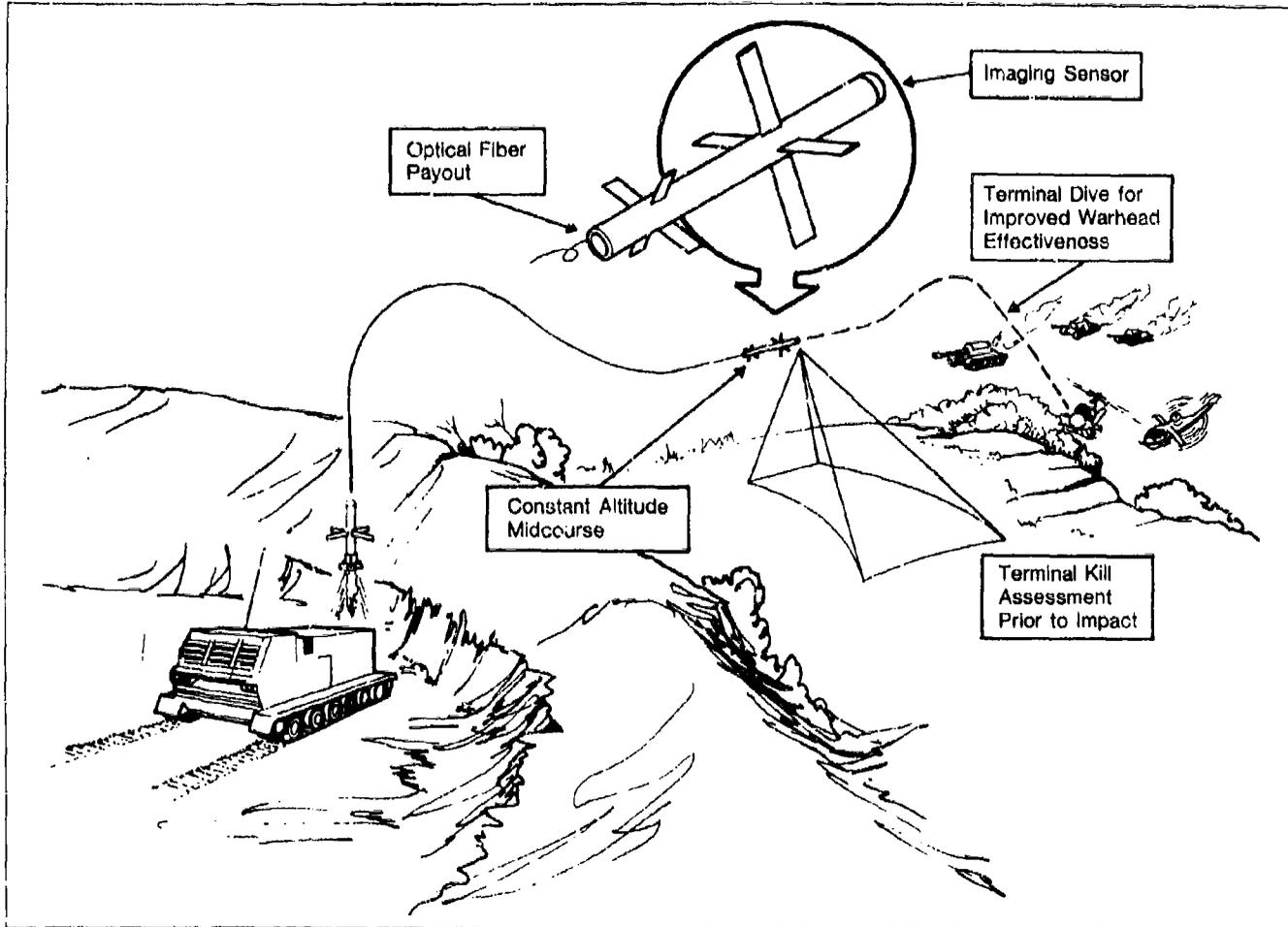
The Army's fiber optic guided missile (FOG-M) is the non-line-of-sight component of the FAADS (see p. 23). The FOG-M system is intended to protect ground troops and vehicles by attacking enemy helicopters and tanks hidden from view by the terrain. The program office estimates that developing and producing 403 fire units, 16,550 missiles, and associated equipment for the FOG-M will cost about \$3.2 billion (escalated dollars). This estimate considers recent budget reductions and program changes, but the Army has not approved it. The decision on whether the FOG-M should enter full-scale development is scheduled for June 1988.

The Army considers the FOG-M to be the best means of meeting the non-line-of-sight air defense requirement. However, the Army has frequently changed its approach to developing the weapon in the past year. Most recently, the Army decided to drop plans to develop a less capable FOG-M system first, to meet an early fielding date, in favor of accelerating development and fielding of a more capable system. As a result, the FOG-M schedule has also changed frequently. The latest schedule has a high degree of concurrence and is susceptible to change. It is too early to determine whether FOG-M will meet its performance requirements. The Army has not yet conducted operational testing of the system but has demonstrated the feasibility of the technology. FOG-M's initial effectiveness may be diminished because of delays in the FAADS aerial sensor, which is one means to find targets for the FOG-M. The system's cost estimate has fluctuated with changes in the acquisition approach and may change again because adequate funding is not available in fiscal years 1988 and 1989 to implement the program as planned.

Background

The FOG-M system consists of a missile, a launcher, a gunner station, and communication and navigation equipment, as shown in figure I.4.

Figure I.4: Major Components of the FOG-M System



The FOG-M is to be mounted on vehicles such as the High Mobility Multi-Purpose Wheeled Vehicle or potentially on the chassis for the Bradley Fighting Vehicle. The FOG-M will be deployed in the forward area of the battlefield, but it will operate from concealed positions, out of direct enemy view. The Army plans to deploy missiles with all-weather, day-and-night capability. The FOG-M will receive target location information from its own sensor and from the FAADS C2I network, which contains a ground and aerial sensor. This information will be automatically entered into the FOG-M's computer system and displayed on the gunner's station display. Upon receiving a command to fire, the gunner will select the

target and enter the sequence of missiles to be launched toward the target area. Once launched, the gunner will control the missile through a fiber optic line that links the missile with the gunner's station. The gunner will locate targets through a video display, which will portray what the missile seeker sees as the missile cruises at low altitudes. These images will pass through the fiber link to the gunner's console monitor so the gunner can guide the missile to the target.

From 1984 through 1987, the Army conducted a technology demonstration of existing FOG-M hardware through flight tests. In November 1987, the Army released requests for proposals for (1) further development and low-rate production of an initial system for early fielding and (2) full-scale development of a more capable system. However, the Congress decided not to appropriate the funds to implement this approach. The Congress agreed that the baseline system should be carried through initial operational evaluation and that the Army should use lessons learned from testing this system to accelerate the development and fielding of the more capable system. However, the Congress felt that budget constraints would prevent the Army from achieving the necessary flexibility to field both systems within 24 months of each other.

The program office subsequently changed the FOG-M acquisition strategy to develop only the more capable system. The Army has not approved the acquisition plan that includes this approach but intends to do so before the June 1988 Defense Acquisition Board decision on full-scale development.

Requirements

The 1985 Forward Area Air Defense Working Group concluded that FOG-M offered the most potential for meeting the non-line-of-sight requirement to counter the low altitude air threat. At the working group's recommendation, DOD considered a ground-launched version of the Advanced Medium Range Air-to-Air Missile (AMRAAM) but concluded that the system showed limited utility for meeting the non-line-of-sight requirement and that further evaluation for this purpose could adversely affect the Air Force's compressed AMRAAM test schedule. The Army approved the FOG-M system's requirements in October 1987.

Schedule

The FOG-M program schedule has changed several times during the last 18 months. According to the deputy project manager, the schedule defined in the October 1987 plan—the program schedule when we began our review—is unworkable because of recent budget reductions

and program changes. As a result, the project office developed a highly concurrent program schedule in February 1988. The schedule, however, is not supported by an approved acquisition plan, and it is susceptible to change. Table I.6 compares the FOG-M schedules developed during 1987 through February 1988.

Table I.6: Recent FOG-M Program Schedules

Event	May 1987 schedule	Oct. 1987 schedule	Feb. 1988 schedule
Full-scale development decision	May 1987	May 1988	June 1988
Initial operational evaluation completed	Sept. 1988	Jan. 1989	Mar. 1989
Initial production decision	Nov. 1989	Mar. 1989	Jan. 1990
Initial production contract awarded	Nov. 1989	Apr. 1991	Jan. 1991
First unit equipped	July 1991	May 1991	Feb. 1992
Initial operational testing and evaluation completed	July 1992	July 1992	July 1992
Full-rate production decision	Oct. 1992	Jan. 1993	Jan. 1993
Full-rate production contract awarded	Oct. 1992	Jan. 1993	Jan. 1993
Initial operational capability	classified		

In response to the Senate Committee on Appropriations' recommendation, the Army restructured the program in November 1986 to add an engineering development phase and delay initial production. Although not shown in table I.6, this action delayed initial production by 1 year and the date for equipping the first unit by 18 months. More recently, the full-scale development decision was delayed about 14 months, and the first unit equipped date was delayed about 8 months because of Army program changes, funding reductions, and congressional guidance.

The revised program schedule includes a high level of concurrence to meet the early fielding date for the more capable system. The Army will award the system's full-scale development contract before completing the initial operational evaluation; initial production is scheduled to begin before engineering development is complete; and the Army will deploy the system before completing initial operational tests. The deputy project manager maintains that concurrent development and production are acceptable because the Army has planned a technology risk reduction program and field testing during the development phase.

The project office believes that the revised program schedule risk is low to medium. We believe that this assessment could be somewhat optimistic because (1) fiscal year 1988 funding and the budget request for fiscal year 1989 do not permit completion of the work planned for those 2 years, and (2) the program is highly concurrent and does not allow time to resolve potential problems. If the Army encounters problems during development of key components or testing, schedule delays could result.

Performance

It is too early to evaluate whether the FOG-M will meet its performance requirements. The Army has demonstrated the feasibility of a fiber optic guided missile, but no operational testing has been accomplished to date. Regardless of FOG-M's performance, developmental delays encountered by the FAADS aerial sensor could reduce its effectiveness when deployed.

During the 1984-87 technology demonstration, the Army conducted 14 flight tests. Seven of the 14 were successful, 1 was partially successful, and 6 were unsuccessful. The last two flights, designed to test multiple airborne rounds controlled by an operator, were unsuccessful because of a broken data link on one flight and incorrect wiring on another. According to a project test official, the Army has resolved the problems encountered in all test flights.

The Army currently plans to conduct an initial operational evaluation of the FOG-M prototype beginning in August 1988. The purpose of this evaluation is to determine whether the system is potentially effective and suitable for use in combat by typical military users. The Army plans to apply lessons learned from the evaluation to the full-scale development effort.

The current program includes some risk, such as developing a new, variable, high-speed motor; extending the range of the fiber optic link; improving missile navigation; and integrating an imaging infrared seeker. However, the Army plans to reduce the risks of the efforts through flight tests during development and initial production. According to the project official responsible for program support, the basic technology for this program is considered low to medium risk.

The Army has extended the FAADS aerial sensor development schedule and may cancel the sensor altogether because of funding constraints. The FOG-M will rely on the aerial sensor as a primary means for obtaining target information. The Army plans to equip the first units with FOG-M in

February 1992, but the sensor, if continued, will not begin initial production until March 1993. Without the aerial sensor, the FOG-M's opportunity to engage targets will be limited.

Cost

Program cost estimates have undergone many revisions as the program's scope and schedule have changed. The project office currently estimates FOG-M total acquisition to cost about \$3.2 billion (escalated dollars). The Army has not approved or validated the current estimate. Program cost will continue to be subject to change until the program stabilizes.

Table I.7 shows the FOG-M's more recent acquisition cost estimates (in constant fiscal year 1988 dollars). Procurement quantities have remained stable, and all estimates are based on procurement of 403 firing units and 16,550 missiles.

Table I.7: FOG-M Acquisition Costs
(In Constant Fiscal Year 1988 Dollars)

Dollars in millions			
Item	May 1987 estimate	Oct. 1987 estimate	Feb. 1988 estimate
Development	\$532.6	\$503.5	\$555.7
Procurement	1,957.1	2,271.3	2,180.1
Total	\$2,489.7	\$2,774.8	\$2,735.8
Acquisition cost per fire unit (including missiles)	\$6.18	\$6.89	\$6.79

Project officials consider the risk of cost growth of the revised program to be low to medium.

According to project officials, the FOG-M program has sustained funding reductions in its fiscal years 1988 and 1989 budget requests. For fiscal year 1988, the Congress appropriated \$58 million for research and development instead of \$131.6 million, as requested, on the basis that constrained budgets would not allow development and production of both FOG-M versions. In fiscal year 1989, the project office initially requested \$166.5 million for research and development and \$65.9 million for procurement, but according to FOG-M project officials, the Army and DOD reduced the research and development request to \$118.5 million and deleted the \$65.9 million procurement request because of budgetary constraints.

Recent GAO Report

DOD Acquisition Programs: Status of Selected Systems (GAO/NSIAD-87-128,
Apr. 2, 1987).

Advanced Antitank Weapon System- Medium

The Advanced Antitank Weapon System-Medium (AAWS-M) is a joint Army and Marine Corps program to replace the Dragon weapon system. AAWS-M is a medium-range manportable anti-armor missile designed for use in rough terrain, rapid deployment, and air assault operations. It is intended to defeat tanks and other targets expected on the battlefield of the 1990s. The Army is investigating three design concepts to meet the AAWS-M requirement. The full-scale development decision is scheduled for March 1989.

According to DOD, the AAWS-M will offer significant improvements over the Dragon, and the Army considers the program a high priority. The project office reports no significant schedule, test, or cost problems to date. However, there are still many uncertainties about the program. For example, the most critical technology demonstration tests and assessments are pending, and \$12.6 million in fiscal year 1988 obligational authority is unavailable until the Army tests an interim weapon and certifies test completion and evaluation to the Senate and House Committees on Armed Services.

Based on the most costly of the three possible concepts, the combined Army and Marine Corps AAWS-M requirement is estimated to cost \$5.5 billion (escalated dollars) for the development and production of 91,125 missiles and 6,879 command and launch units and associated equipment. However, these estimated costs will be uncertain until the Army (1) selects one of the three competing concepts, (2) approves an authorized acquisition objective—the actual number of systems it plans to procure—and (3) determines the type of contract to be used in full-scale development.

Background

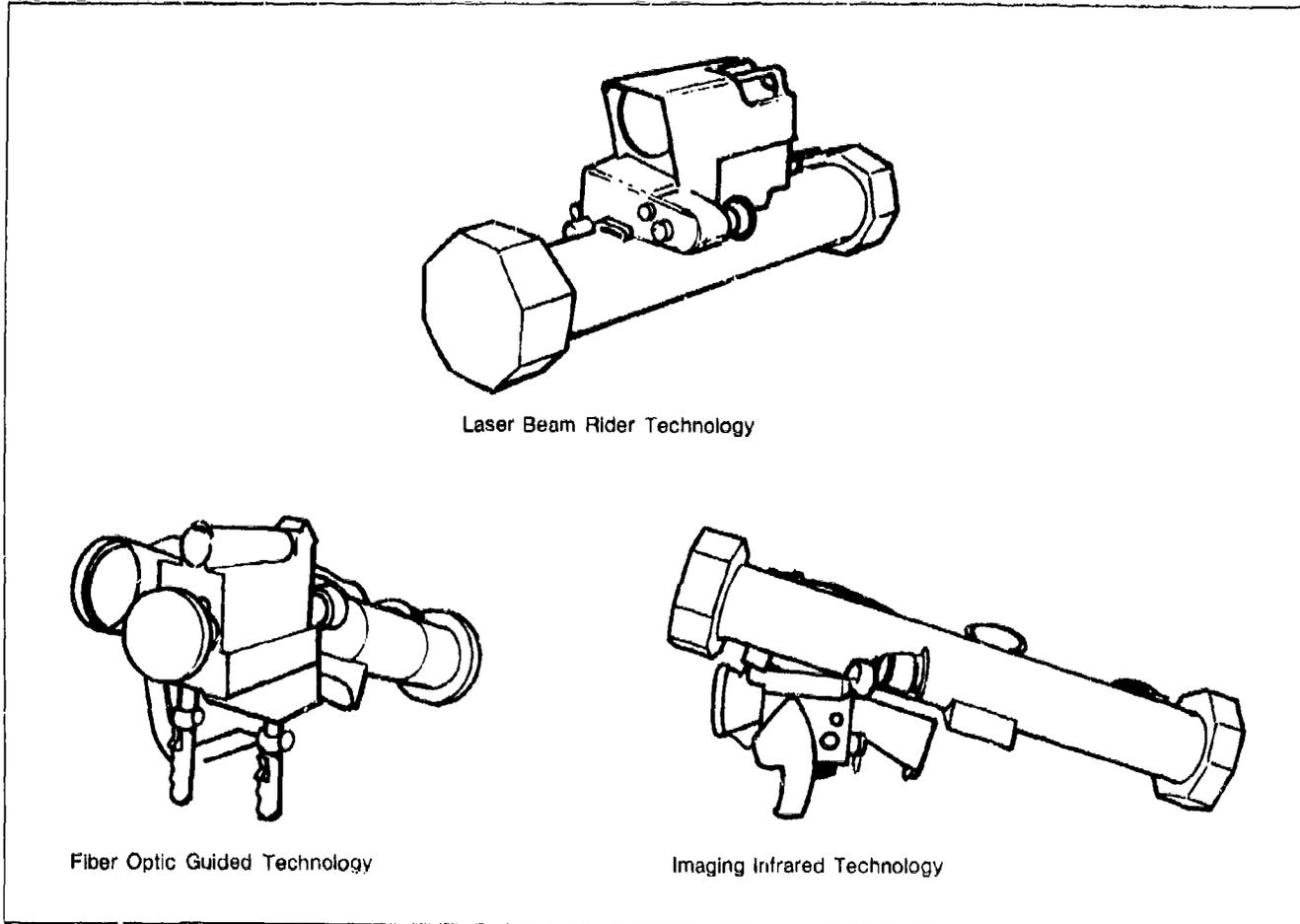
The AAWS-M consists of a container/launch tube, which houses the missile round, and a command and launch unit. This unit is reusable and provides day and night target surveillance and acquisition capability.

Currently, the Army is investigating three system technologies for the AAWS-M. In August 1986, it awarded separate firm fixed-price contracts to each of three contractors—each contractor competing with a different technological approach. The Army plans to select one of the three approaches and award a full-scale development contract in March 1989. The three contractors and their technological approaches are as follows:

- Ford Aerospace Corporation is developing a laser beam rider, in which the gunner maintains sight on the target while the missile "rides" the beam to impact.
- Hughes Aircraft Company is developing a fiber optic guidance system, a generic guidance technology using a viewing screen through which the gunner sees images transmitted by an infrared camera in the nose of the missile through a fiber-optic line. The line connects the launcher with the missile. The gunner fires the missile and may then lock onto the target with the infrared camera or guide the round manually via the viewing screen until impact.
- Texas Instruments Incorporated is developing an imaging infrared system, in which an infrared sighting and tracking device detects the thermal energy emitted by a target. This enables the gunner to locate the target through the sight and lock onto the target before firing.

The three concepts are illustrated in figure I.5.

Figure I.5: Three AAWS-M Concepts



Requirements

The Army has characterized the AAWS-M as its highest priority development program for its light infantry forces. The need for the AAWS-M is well documented. In April 1986, the Army and Marine Corps approved a joint operational requirement for the AAWS-M based on a threat analysis. According to DOD, if the AAWS-M meets these requirements, it will offer significant improvements over the Dragon in performance, susceptibility to counterfire, sustainability of fire, and gunner and system survivability.

Schedule

AAWS-M is currently in a 27-month technology demonstration phase with full-scale development scheduled to begin in March 1989. Although critical tests remain during the demonstration phase, project office reports through January 1988 disclose no significant schedule changes or technical problems. Table I.8 shows the current AAWS-M schedule.

Table I.8: Current AAWS-M Schedule

Event	Date scheduled
Technology demonstration decision	Apr. 1986
Technology demonstration contract awards	Aug. 1986
Completion of critical flight, warhead, and force-on-force tests	May through Aug. 1988
Full-scale development decision and contract award	Mar. 1989
Completion of initial operational testing	Feb. 1992
Initial production contract award	Apr. 1992
Completion of follow-on operational testing	Nov. 1993
Full-rate production contract award	Aug. 1994
First unit equipped	1st quarter, fiscal year 1993
Initial operational capability	Classified

The project office believes that the most critical technology demonstration tests and assessments are pending. These include (1) warhead lethality assessments to determine kill probabilities against threat targets, (2) evaluations under simulated battle conditions to estimate system effectiveness in an operational environment, and (3) 18 missile flights for each contractor to demonstrate, in degraded visibility conditions, flight characteristics such as range, accuracy, and performance. According to the deputy project manager, the risk of meeting the technology demonstration schedule is high, because of the limited amount of time allotted to successfully accomplish these test objectives and evaluate the three contractor concepts. Once this phase is successfully completed, he estimates the schedule risk for the full-scale development phase as low to moderate.

Another factor affecting AAWS-M's schedule risk is the Senate and House Armed Service Committees' requirement for the Army to test an existing system as an interim capability. Although fully endorsing the AAWS-M, the Congress limited the fiscal year 1988 obligation of funds to \$18 million of the \$30.6 million appropriation until the Army certifies test completion and evaluation of the foreign-produced Milan II as an interim system. The Congress directed the testing because of concern that soldiers be adequately supplied with an interim medium anti-armor capability until the AAWS-M is deployed.

Final testing of the Milan II was completed in March 1988 with a final report to the Congress planned for September 1988. Army officials believe that expedited evaluation and certification could occur before the \$18 million authorization limit is reached, but they acknowledge that such a schedule is optimistic.

Performance

Until critical testing is conducted, an assessment of the system's expected performance will not be feasible. According to the deputy program manager, system performance for all three concepts is currently on track. Two categories of tests are complete or essentially complete: (1) command and launch unit laboratory and field tests and (2) safety tests to assess gunner exposure to noise levels, system recoil, debris, toxicity, and thermal hazards. Testing of the component subsystems is mostly complete. While specific results of these tests are competition-sensitive, more general project office reports show no significant problems on these tests.

Cost

AAWS-M's estimated costs have not increased significantly, but upcoming decisions could change the estimate. These decisions, which are scheduled prior to full-scale development, include (1) selecting the winning contractor concept for full-scale development, (2) establishing an Army-authorized acquisition objective (number of systems to be procured), and (3) determining whether full-scale development will be a cost-plus or fixed-price contract.

According to the AAWS-M project manager, the estimated cost of specific contractor concepts and the actual range of estimated costs are competition-sensitive. Therefore, only the estimated cost of the highest-cost concept is provided. Table I.9 shows current AAWS-M acquisition costs (escalated dollars) based on the highest-cost concept.

Table I.9: AAWS-M Acquisition Costs and Quantities

Dollars in millions	
Item	Estimated costs
Advanced development	\$137
Full-scale development	398
Procurement	4,934
Total acquisition costs	\$5,469
Quantities	
Missiles (Army)	58,000
Missiles (Marine Corps)	33,125
Command and launch units (Army)	5,000
Command and launch units (Marine Corps)	1,879

AAWS-M's estimated acquisition cost has not significantly changed since April 1986, when DOD approved technology demonstration. The estimated Army acquisition cost for the lowest-cost concept increased by less than 0.01 percent, and the estimated cost for the highest-cost concept decreased by less than 0.01 percent.

However, the acquisition cost could change considerably when the Army selects a system concept. Specifics concerning concept cost are competition-sensitive, but the cost difference between the lowest- and highest-cost concepts is significant. Selection of the winning concept will better define acquisition costs.

Also, the AAWS-M cost estimate cannot be firm until the Army determines its authorized acquisition objective. The current estimate is based on a specified quantity of Army missiles and command and launch units, but this number could change when the Army establishes an authorized acquisition objective before entering full-scale development. The Marine Corps' procurement cost is based on an approved acquisition objective.

Similarly, the Army's decision on the type of contract it will use for full-scale development could affect the AAWS-M acquisition cost estimate. The AAWS-M's system concept paper states that a cost-plus-incentive-fee contract will be used for full-scale development, and the highest-cost estimate includes \$47.1 million (escalated dollars) to allow for the risk of possible cost increases associated with this type of contract. The project office, however, is now planning a fixed-price contract in order to reduce cost risk during full-scale development.

According to the deputy project manager, development funding through the fiscal year 1988 appropriation (if fully released) and the Army's planned funding through fiscal year 1993 will provide adequate overall funding to complete the planned development program. In addition, the development program appears to have the support of high-level Army and DOD officials.

Recent GAO Report

Antitank Weapons: Current and Future Capabilities (GAO/PEMD-87-22, Sept. 17, 1987).

Sense and Destroy Armor System

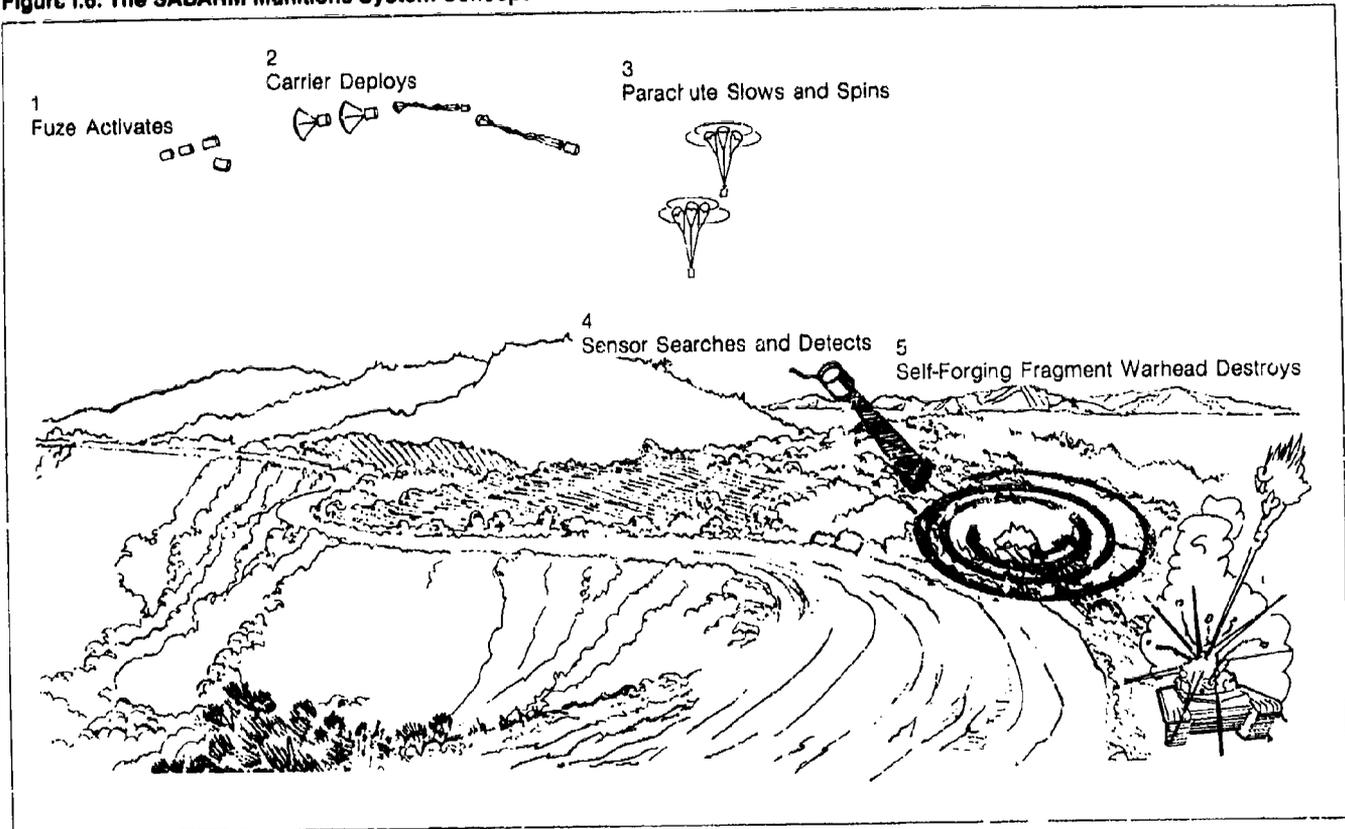
The Sense and Destroy Armor (SADARM) program is a new system of target-sensing munitions fired from a cannon or rocket launcher to counterattack enemy artillery. DOD held a full-scale development milestone review in March 1988 and approved the program in May 1988. The Army forecast SADARM's development and production in the \$5 billion range but could not make a reliable estimate until DOD defined the program's structure and scope at the time of the full-scale development decision.

Although the Army originally required SADARM to destroy moving tanks and artillery vehicles, it now requires SADARM to attack only stationary artillery because of the munition's limited capability against moving targets. While the Army considers the need to attack stationary targets valid, the need to destroy moving tanks and artillery still exists. Lack of consensus between the Army and OSD on the program's structure and scope have led to changes in program direction and delays in the program's development, which are not yet resolved. Program officials are restructuring the program to satisfy congressional concern that SADARM's development schedule is too short for adequate testing and sound decisionmaking. Program officials assess SADARM's technical risks as low to medium, but most demonstrations of performance have not yet been conducted; one of three potential SADARM carriers has been successfully fired while carrying a submunition. A funding shortfall in fiscal year 1989 may further increase costs and extend the schedule.

Background

The SADARM munition system consists of a cylindrically shaped submunition that can be carried by a projectile shot out of a cannon or by a rocket shot out of a rocket launcher. The submunitions are stacked inside the warhead section of the projectile or rocket. The SADARM program includes a 5.3-inch submunition and a 6.9-inch submunition and three potential munitions to serve as carriers—a 155 mm howitzer projectile, an 8-inch howitzer projectile, and the Multiple Launch Rocket System (MLRS) rocket. Depending on the size of the submunition and carrier, from two to six submunitions can be delivered by one carrier. The SADARM concept is shown in figure I.6.

Figure I.6: The SADARM Munitions System Concept



Once fired, the submunitions are to separate in midair from the carrier at a point down range. A deceleration device, acting like a parachute, is to control the rate of fall and spin and the orientation of the submunition over the target. The descending submunition, using a dual-mode (millimeter wave and infrared) sensor, will search for a target in a decreasing spiral pattern. The millimeter wave acts like a radar, and the infrared detects heat emitted from a target. After the sensor detects the target, an explosive device (referred to as the lethal mechanism) will fire a bullet-shaped penetrator at the top of the target to destroy it. If no target is detected, the submunition is to self-destruct just before it hits the ground.

The Army envisions SADARM munitions as a new capability complementing existing field artillery munitions. SADARM's potential advantages

over conventional munitions against targets are improved probability of kill and a lower volume of munitions required.

In 1980, the Army awarded competitive advanced development contracts to Honeywell, Inc., and Aerojet Electro Systems Corporation for the 8-inch projectile and the 6.9-inch submunition. In 1983, while the development effort was in progress, the Army decided to terminate the 8-inch munition. This decision was based on a study of the Army's force structure, which concluded that 8-inch howitzers would be replaced with 155-mm howitzers and the MLRS. In addition, the SADARM product manager stated that the accuracy of predicting a target location was not sufficiently precise to be used by SADARM. In April 1986, the Army decided on the 5.8-inch submunition for the 155-mm howitzer projectile and the 6.9-inch submunition for the MLRS rocket. However, in August 1986, DOD directed the Army to include the 8-inch projectile in the program. One reason that DOD wanted to procure the 8-inch munition was that it was to carry the larger submunition, which is more effective at penetrating armor.

In September 1986, the Army awarded competitive cost-plus-incentive-fee contracts to Honeywell and Aerojet for full-scale development of the two submunition sizes, the larger one for the MLRS rocket and the smaller submunition for the 155-mm projectile. The Army also awarded an initial integration contract for the rocket to the LTV Aerospace and Defense Company, deferring full-scale development until later in 1987. Shortly after contracts were awarded, DOD designated SADARM as a major program on the basis of its cost and congressional interest. Because of this designation, full-scale development milestone reviews for the program occurred in November 1987 and March 1988.

Requirements

The need for SADARM, according to a 1980 Army requirements document, grew out of a perceived Warsaw Pact armored vehicle threat against NATO. The Army intended to use SADARM as an anti-armor munition against moving tanks, armored personnel carriers, self-propelled artillery, and air defense guns. The Army and DOD terminated SADARM as an antitank effort in 1984 due to target location errors related to moving tanks and the perception that the 8-inch howitzers, which would fire the larger submunition, would be phased out of Europe. Subsequently, in 1985, the Army reinstated SADARM's development as a counter-battery weapon after reevaluating its use against self-propelled howitzers, primarily stationary targets. In March 1986, the Army approved a formal set of requirements for SADARM to meet this need.

In June 1987, the Army reduced all SADARM requirements related to moving targets. The Army made this change, according to program officials, because of difficulties in employing SADARM against moving vehicles. According to the product manager, SADARM can spot and engage moving targets if they are inside its 150 meter diameter search area. The difficulty in using SADARM against moving targets is in making an accurate determination at the firing battery of where to shoot the munitions to intercept a moving target.

The Army now defines SADARM's role as "counter-battery" rather than "anti-armor." In its new role, SADARM is intended to provide an enhanced capability for primary use against stationary self-propelled howitzers and secondary use against stationary lightly armored vehicles. A 1987 threat analysis shows that SADARM will only provide interim capability against armored targets—other than self-propelled howitzers—until the Army fields Copperhead II and the MLRS Terminal Guidance Warhead.

Schedule

The SADARM is experiencing schedule delays primarily due to contemplated changes in program scope and structure. The Army and DOD disagree on the scope of the program, and the schedule may be revised again based on the effects of the Defense Acquisition Board's full-scale development decision.

In September 1986, the Army planned a 56-month full-scale development effort for SADARM. The Army was falling behind on this schedule. The Congress criticized the schedule as having artificially short deadlines that required hasty financial and technical decisions and did not allow adequate time for testing. Based on a November 1987 full-scale development review, the Army has proposed restructuring the program around a 78-month schedule to address congressional concerns and to change the program's scope. These schedules are compared in table I.10.

Appendix I
Army Programs

Table I.10: SADARM Full-Scale Development Schedule Comparison

Event	56-month schedule	78-month schedule
Contract award		
Submunitions and projectiles	Sept. 1986	Sept. 1986
Rocket	Sept. 1987	June 1988
Operational testing complete		
Submunitions and projectiles	Mar. 1991	Aug. 1991
Rocket	Sept. 1990	Feb. 1993
Initial production decision		
Submunitions and projectiles	May 1989	none
Rocket	Oct. 1988	Sept. 1991
Full-rate production decision		
Submunitions and projectiles	June 1991	Sept. 1991
Rocket	Dec. 1990	Mar. 1993
First unit equipped		
Submunitions and projectiles	Dec. 1991	Mar. 1993
Rocket	Feb. 1991	Sept. 1993

The revised schedule reflects decisions to extend competition during full-scale development, expand live firings, and conduct developmental and operational testing before initiating production. The schedule also reflects the Army's proposal to continue development of only the 5.8-inch submunition for use with the 155-mm projectile and the MLRS rocket and to field the projectile before the rocket. The 78-month schedule reflects the termination of the 6.9-inch submunition and the 8-inch SADARM projectile. According to program officials, the revised schedule reflects the Army's decision to again attempt to terminate the 8-inch SADARM. According to program officials, the 8-inch howitzer's slow speed and lack of top armor will not allow it to survive on the battlefield. The schedule does not reflect the Secretary of Defense's May 1988 program direction.

The 78-month program schedule is not considered firm because of possible program redirection by DOD and funding shortages. The Secretary of Defense formally approved full-scale development of the SADARM for 155-mm howitzer and MLRS applications in May 1988. In approving the program, the Secretary directed that (1) two sizes of submunitions be developed to maximize lethality against the full spectrum of armored targets and (2) a joint OSD/Army study be conducted on the cost-effectiveness of 8-inch howitzer alternatives to help determine whether the SADARM program should include an 8-inch howitzer application.

In preparing the fiscal year 1989 amended budget, DOD reduced SADARM funds by \$26.3 million. Unless the Army can reprogram funds from other programs into SADARM, program officials stated that the SADARM

development schedule would stretch to 90 months, deferring key events such as developmental and operational testing, production decisions, and fielding dates another year.

Performance

Little demonstration of SADARM's performance has occurred. The only live firings to date are those of the 8-inch projectile and 6.9-inch submunition in 1984 and 1985. The 1984 firing of one contractor's design was unsuccessful, while the 1985 firing of the other contractor's design succeeded in hitting the target. Tests required by the Congress of an 8-inch projectile reflecting more recent designs have not taken place and are no longer scheduled due to indecision about the program. Gun firings of the larger submunitions have not taken place because of the Army's decision to go with the small submunition, according to program officials. Program officials stated that they will reschedule these tests once the final decisions on the program's scope are made.

The smaller 5.8-inch submunition has not undergone demonstration testing. The 155-mm and MLRS SADARM carriers have not been exposed to live firings while carrying a 5.8- or 6.9-inch submunition. Only components of the carriers have been tested.

The Army considers technical risks of the SADARM program as medium or lower. Sensor, lethal mechanism, and other individual submunition components are considered low risk. Submunition integration and performance in the rocket are considered medium risk. LTV, using its own funds, is currently developing the preliminary design for the front end of the rocket warhead, which may have to change depending on which submunition size is approved for MLRS. The MLRS fire control system, rocket pod container, fuze, and rocket motor are considered low risk, while the warhead section is considered a medium risk. Program officials believe that performance of the submunition in the rocket presents a higher risk than the submunition's performance in the projectile because the submunition has never been tested in a rocket.

Cost

The Army can not reliably estimate costs for SADARM since the scope of the program—the sizes of submunitions and carriers—is undecided. Estimated costs for the 56-month and 78-month programs as of February 1988 are shown in table I.11 and provide a sense of the program's magnitude. For the 56-month schedule submunition quantities were estimated at 600,000, and for the 78-month schedule submunition quantities were estimated at 483,664.

Appendix I
Army Programs

Table I.11: SADARM Estimated Costs
(In Escalated Dollars)

Dollars in millions		
Item	56-month schedule	78-month schedule
Research and development	\$365.1	\$643.4
Procurement	4,933.0	4,944.6
Total	\$5,298.1	\$5,588.0

According to the product manager, development costs have increased principally due to more competition and increased testing. In compliance with congressional guidance, two submunition contractors are to be funded throughout the full-scale development effort. In the 56-month schedule, two submunition contractors were to compete for design selection through the 30th month. The winning contractor would then advance further in full-scale development. Under the 78-month schedule, both contractors would participate in all testing, which would continue until just before the production decision.

Estimated costs will change depending on whether the schedule extends to 90 months and on the effects of the full-scale development decision. According to program officials, aside from the above estimates independent cost estimates have been prepared but have not been formally issued. According to program officials, the SADARM program faces a funding shortage of \$26.3 million in fiscal year 1989, which could extend the program schedule by 1 year and increase costs.

Recent GAO Report

DOD Acquisition: Case Study of the Army's Sense and Destroy Armor Projectile Program (GAO/NSIAD-86-458-4, Aug. 25, 1986).

Tube-Launched, Optically-Tracked Wire-Guided Missile System

The Tube-Launched, Optically-Tracked, Wire-Guided (TOW) Command-Link Guided missile is an antitank weapon system. The Army fielded the basic TOW missile in 1970 and has improved the missile over the years. The Army is currently producing and fielding a fourth generation missile—the TOW 2A, which the Army believes will meet its requirements. The Army recently awarded a research and development contract for a more advanced TOW 2B missile, which will provide a greater capability against advanced threats. The Army will hold a program review in May 1990 to determine whether the TOW 2B should enter production. The program office estimates TOW acquisition costs at \$4.1 billion (escalated dollars), over half of which have already been spent.

According to the project manager, the Army needs the TOW 2A and 2B because previous versions cannot defeat threats with reactive armor or the evolving threats of the 1990s.² TOW 2A production deliveries are ahead of schedule, while administrative delays and funding reductions have delayed TOW 2B milestones by about 1 year. Initially, the TOW 2A failed to meet one of its performance requirements, but after subsequent system improvements, the Army currently estimates that the TOW 2A will meet its requirements. Although the TOW 2B is in early development, the Army also estimates that it will meet requirements, based on computer simulation analyses. Program cost estimates for the entire TOW program have increased since last year because the Army added missile quantities and a classified modification program. Costs may increase further if the Army adds more missiles or does not award a multiyear procurement contract as desired.

Background

The TOW is a crew-portable or vehicle-mounted weapon system primarily designed to attack armored vehicles. The weapon system consists of a missile, launcher, optical sight, and night sight.

The missile is connected to its launcher by wire. After firing the missile, the gunner keeps the sight's crosshairs on the target while the launcher automatically transmits course corrections through the wire to the missile. The Army uses the TOW on the Cobra helicopter, the Improved TOW vehicle, the M151 Jeep, the Bradley Fighting Vehicle, the armored personnel carrier, and the High Mobility Multi-Purpose Wheeled Vehicle.

²Reactive armor is armor made up of a thin layer of explosive placed between small metal plates and attached to armored vehicles. When hit by antitank rounds, the explosive detonates, disrupting the jet necessary for the rounds to penetrate the vehicle's main armor.

**Appendix I
Army Programs**

The Marine Corps and approximately 40 foreign countries also use the TOW.

The Army has fielded several versions of the TOW weapon system. It fielded the initial TOW system in 1970, and in 1979 it began producing an improved TOW with a more effective warhead. In 1979, the Army initiated another TOW product improvement program—the TOW 2—to improve the missile's lethality and performance against countermeasures. In November 1983, the Army approved the TOW 2A program as an interim measure to counter a Soviet threat containing reactive armor, and in May 1985 it approved TOW 2B to provide a greater capability against more advanced threats. TOW 2A production began in fiscal year 1987 and will continue until the TOW 2B is ready for production. The Army recently awarded a contract to the Hughes Aircraft Company to develop the TOW 2B weapon system. The TOW 2A and TOW 2B are depicted in figures I.7 and I.8.

Figure I.7: The TOW 2A Missile

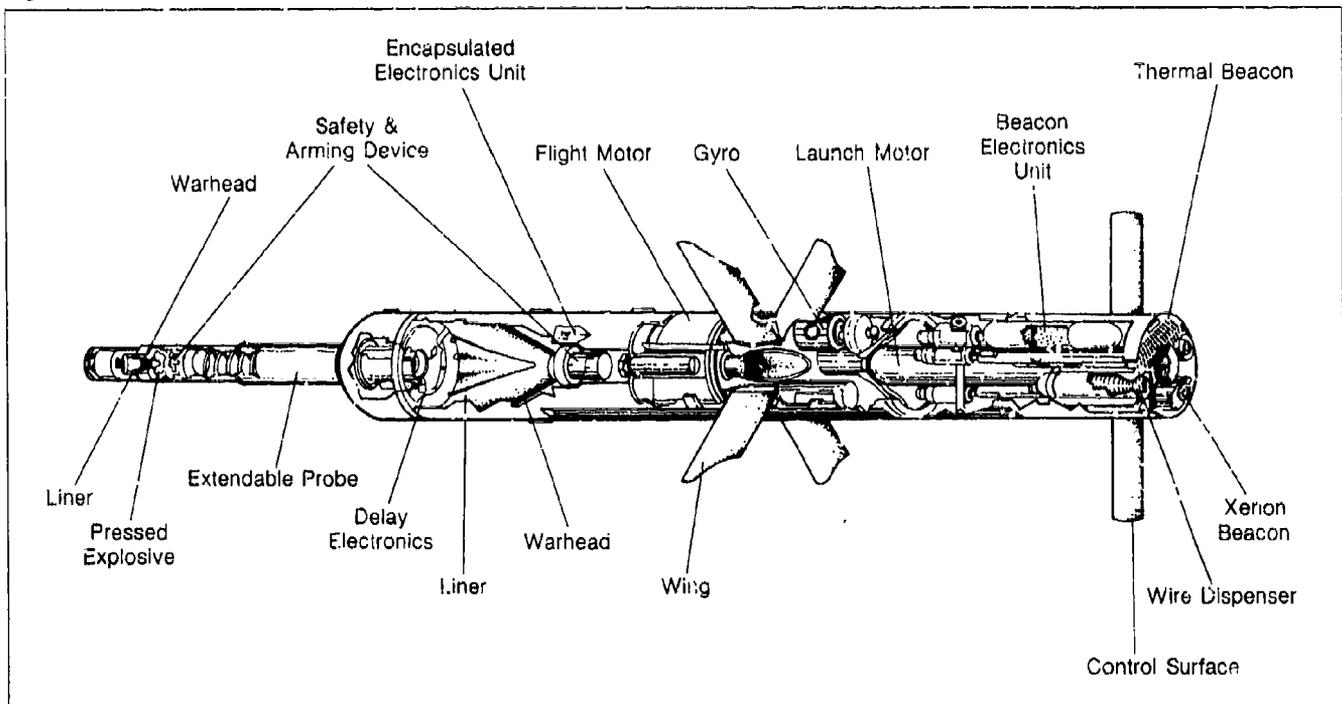
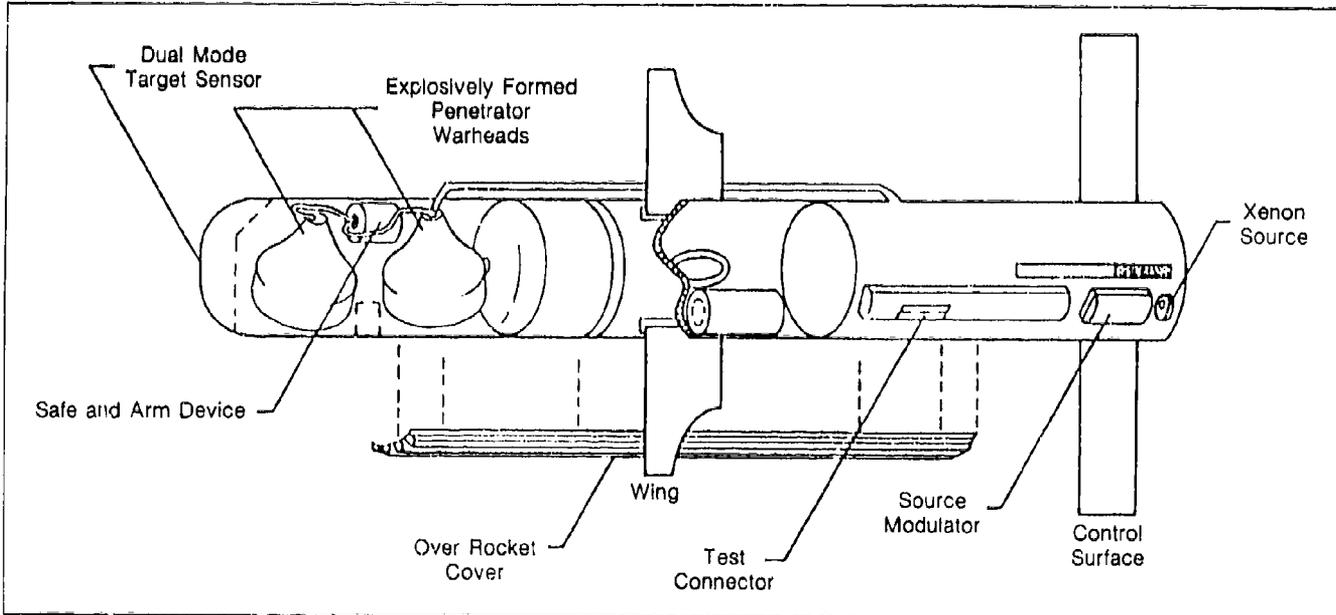


Figure I.8: The TOW 2B Missile



Requirements

The need for improved TOW performance appears to be valid, but the Army has not prepared all the requirements documents normally expected for such a major acquisition. In addition, the program has not received the DOD reviews normally expected of major acquisitions.

According to the TOW project manager, the TOW 2 missile and its predecessors cannot defeat tanks equipped with reactive armor. In approving the TOW 2A and TOW 2B programs to counter these threats, the Army's Infantry School prepared a general set of performance requirements. Because DOD did not designate the initial TOW program as a major acquisition program, the Army did not prepare more specific program requirements for the TOW 2A and TOW 2B—normally contained in the Decision Coordinating Paper and the Required Operational Capability document. Because the TOW was not a major program, the Army, rather than DOD, held decision milestones and program approval reviews. After the initial TOW, Army officials designated all subsequent TOW versions as product improvements or engineering change proposals to existing TOW production contracts and decided that the additional requirements documents, including cost and operational effectiveness analyses, were not required.

Schedule

The TOW 2A's production schedule initially slipped about 7 months because warhead shipments from the Iowa Army Ammunition Plant were erratic due to chronic shortages of component parts. Despite these problems, the contractor met its fiscal year 1986 contractual delivery requirements for TOW 2A. The fiscal year 1986 deliveries were completed in February 1988, 1 month ahead of schedule.

The current TOW 2B schedule reflects a 1-year slip. The Vice Chief of Staff of the Army directed the Missile Command to initiate the TOW 2B program during fiscal year 1986 with deliveries beginning in fiscal year 1990, but the current schedule shows that missile deliveries will begin in May 1991, as shown in table I.12.

Table I.12: Current TOW 2B Program Schedule as of March 1988

Event	Current schedule
Research and development contract award	Sept. 1987
Engineering flight testing complete	May 1989
System qualification testing complete	May 1990
Army production decision	May 1990
Production contract award	May 1990
Missile production cut-in	Apr. 1991
First missile delivery	May 1991
Initial operational capability	classified

Project officials attribute the schedule delay to disagreements over the need for a requirements document, delays in reviewing the product improvement program documentation, funding reductions, and indecision regarding the contractual approach for developing the TOW 2B missile.

The Army considered compressing the TOW 2B schedule, but a joint Army Missile Command and TOW contractor review of the situation reaffirmed the TOW project manager's position that (1) the TOW 2B development schedule already contains the maximum prudent concurrence and (2) any additional schedule compression would increase risks to an unacceptable level. Army headquarters officials have verbally agreed that the schedule should not be compressed.

Performance

Prior to fielding the TOW 2A system, the Army Materiel Systems Analysis Activity conducted an independent evaluation and concluded that the

TOW 2A had failed to meet a major performance requirement. Consequently, it would not support fielding the TOW 2A without the Army Training and Doctrine Command's acceptance of the performance degradation. The Command responded that the missile performance was acceptable and that expeditious fielding of the missile was mandatory. According to project officials, based on warhead penetration testing, the TOW 2A is capable of defeating the threat for which it was intended. In addition, the Army Missile Command subsequently made software improvements to the TOW 2A system, and the Systems Analysis Activity currently estimates that the TOW 2A system with these improvements will meet performance requirements. This estimate is based on computer simulations using warhead penetration test data.

The TOW 2B development program has just begun, and data is limited. However, the Ballistics Research Laboratory has conducted some computer simulations, and its preliminary assessments indicate that the TOW 2B will meet performance requirements against the more advanced threat.

Cost

The unit cost of a TOW missile has not increased significantly since the last program estimate in December 1986. Additional missile quantities and a TOW retrofit program have increased total acquisition costs, and costs could increase further if (1) the total quantities of TOW missiles to be procured continue to increase and (2) the Army does not award a multiyear contract for further TOW procurement.

Table I.13 shows the total acquisition cost estimate for the TOW program in escalated dollars. These February 1988 figures are based on actual costs and the project office's best estimate, but the Department of the Army has not approved them. Actual quantities procured for fiscal year 1985 and prior were 197,076, and 99,468 are estimated to be procured for fiscal years 1986 through 1994—a total of 296,544 missiles.

Table I.13: TOW Acquisition Costs

Dollars in millions			
Item	Fiscal year 1985 and prior	Fiscal years 1986-1994	Total
Research and development	\$219.0	\$92.7	\$311.7
Procurement (less modifications)	1,669.0	1,292.1	2,961.1
Modifications	357.2	423.5	780.7
Total	\$2,245.2	\$1,808.3	\$4,053.5

Since the December 1986 estimate, research and development costs have increased by \$43.8 million, and modification costs have increased by \$198.0 million for fiscal years 1986 through 1994. The project manager attributed these increases primarily to a TOW 2 retrofit program, which has not yet been approved. (Details regarding this program are classified.) Procurement costs also increased, but the increase appears related primarily to quantity increases rather than to unit cost increases. For example, missile unit costs during fiscal years 1988 through 1992 were estimated to be \$10,961 in the current estimate versus \$10,915 in the December 1986 estimate.

TOW procurement quantities could increase further, causing a corresponding increase in the cost estimate. For example, Army officials plan to increase TOW procurement quantities to 12,000 per year for fiscal years 1990 through 1992—an increase of 5,882 missiles over the quantity included in the latest estimate. In addition, the Army is uncertain as to when it will discontinue TOW production because a fielding date for its replacement has not been established. The current estimate assumes that TOW missiles will be procured through fiscal year 1994, but the project manager does not know whether production will continue after that. Production beyond fiscal year 1994 will increase the overall costs.

The current cost estimate is based on awarding a multiyear contract, but before an award can be made, the Secretary of Defense must certify that the contract is less costly than second source competition. As of March 1988, OSD's Cost Analysis Improvement Group was evaluating a cost comparison but had not certified the estimates. Therefore, as a contingency, the TOW project office is negotiating both a multiyear contract and a fiscal year 1988 annual contract. If the certification is not made, the TOW project office plans to award annual contracts—estimated to cost at least 12 percent more than the multiyear procurement.

The TOW program has incurred funding reductions in the past several years. As a result of the Gramm-Rudman-Hollings Act, the program received reductions of \$1.2 million in fiscal year 1986 and \$9.3 million in fiscal year 1987. In addition, the Army reduced \$22.4 million from the fiscal year 1987 funding request.

The TOW 2B research and development program also experienced funding problems when OSD and the Office of Management and Budget reduced the fiscal year 1987 funding request and deleted the planned amounts for fiscal years 1988 and 1989. Requests for fiscal years 1988

and 1989 were later restored, but the action delayed awarding the TOW 2B research and development contract.

On the other hand, the Appropriations Conference Committee increased the TOW procurement request during fiscal year 1988 budget deliberations. The Committee approved the requested amount and agreed to provide another \$28.5 million to the Army and \$11.5 million to the Marine Corps for additional missiles.

Recent GAO Reports

Defense Budget: Potential Reductions to Missile Procurement Budgets (GAO/NSIAD-87-206BR, Sept. 10, 1987).

Antitank Weapons: Current and Future Capabilities (GAO/PEMD-87-22, Sept. 17, 1987).

Procurement: Assessment of DOD's Multiyear Contract Candidates (GAO/NSIAD-87-202BR, Aug. 31, 1987).

Defense Budget: Potential Reductions to Army and Marine Corps Missile Budgets (GAO/NSIAD-86-158BR, Aug. 6, 1986).

NATO Munitions: Information on Army and Air Force Munitions in Support of NATO (GAO/C-NSIAD-86-14FS, Feb. 28, 1986).

Army Command and Control Systems Common Hardware and Software

The Army Command and Control Systems (ACCS) program is designed to improve the coordination and control of combat forces through automated management of five key battlefield areas—fire support, air defense, combat support, intelligence/electronic warfare, and maneuver control. ACCS common hardware and software (CHS) refers to common, compatible, off-the-shelf computer hardware and software that four of the five battlefield control systems will use.³ CHS is scheduled for a production decision in August 1988. The CHS program does not receive any funding of its own—funds are obtained from the programs that will use CHS. The Army estimates that it would cost \$909.2 million to procure the 25,607 computer systems required by the battlefield areas. However, the Army's planned contracts would allow users to buy up to 118,259 computers, which would bring acquisition costs up to \$3.4 billion.

The Army believes the common CHS acquisition to be more economical than purchasing separate computer systems but has not yet demonstrated this. The Army plans to conduct limited testing of contractors' computer systems before awarding the first ACCS contract in August 1988. However, the testing will not determine whether the proposed systems satisfy critical specifications or battlefield control system requirements. The Army plans to meet battlefield control system critical specification requirements with CHS through in-plant benchmark tests, development testing of each battlefield control system, and technology improvements. The Army has revised the CHS schedule to provide for a slower buildup to full-rate production, which represents an improvement over previous plans to proceed to higher production rates more quickly. Program costs are difficult to estimate because the quantities to be procured can vary significantly. CHS funds have been reduced in the past few years as a result of cuts in the battlefield control system programs, and future funding shortfalls in these programs are expected.

Background

The CHS computer hardware includes hand-held, portable, and transportable units and peripheral devices to be used with the portable and transportable units. Except for the hand-held unit, the hardware is to be provided in two versions: (1) off-the-shelf, or commercial, and (2) ruggedized—rather than militarized—versions of computer hardware

³In 1986, the Army exempted the intelligence and electronic warfare control system—the All Source Analysis System—from the CHS acquisition because of its security requirements and advanced stage of development using nonstandard programming languages.

intended for more stringent operating conditions.⁴ The hand-held unit, expected to weigh less than 8 pounds, will be ruggedized and will be used by personnel in forward battlefield areas as a data entry device. The portable unit (which will have features similar to commercial personal computers) will be used as a stand-alone system or as a network workstation. The transportable unit, while small enough for two people to carry, will be larger and have greater processing and storage capacity than the portable unit.

The software to be acquired includes operating systems, data base management systems, programming tools for the Ada computer language, as well as programs for communication, training, and problem diagnosis. In August 1988, the Army plans to award a 1-year firm, fixed-price contract for the software procurement and additional software development, with a number of options for additional procurement.

Requirements

The CDS acquisition strategy is to maximize the use of off-the-shelf commercial computer hardware and software to ease the maintenance burden and lower the acquisition cost of using modern computers in battlefield functional areas. The program managers for the battlefield systems are to use the CDS contract to acquire the computer systems they need for system development, testing, and deployment. The Army believes that the consolidated buy will be more economical than buying separate systems for each battlefield control area.

The Army has published an abbreviated cost-benefit analysis that supports the consolidated procurement of CDS but has not done the supporting studies and trade-off analyses. The Army does not plan to do a CDS cost and operational effectiveness analysis but intends to do this analysis for each battlefield control system that will use CDS.

Schedule

The Army issued a request for proposal for the first CDS contract in May 1987. On the basis of the proposals and limited pre-award testing, the Army plans to award the contract in August 1988. This represents a 1-year delay from its original schedule, caused primarily by problems in defining the system's requirements.

⁴Although ruggedized hardware has been adapted to enhance its capabilities in a stressful environment, it is often less tolerant of adverse operating conditions than militarized hardware. Militarized hardware is specifically designed and built for use under adverse conditions.

The Army has revised the CHS acquisition strategy and now anticipates committing itself to a 1-year base quantity with options for additional quantities in the next 4 years, instead of acquiring a 5-year base quantity as originally planned. Under this strategy, the Army plans to fund the first year of CHS purchases with research and development funds and plans limited procurement for the four battlefield control systems in the second and third years. The revised CHS strategy calls for buying fewer quantities to support the operational testing and management reviews scheduled before each battlefield control system begins production, rather than committing to immediate full-rate production of CHS. The slower approach to full-rate production contained in the revised schedule represents an improvement over the approach in the previous schedule.

The CHS was to first support the air defense and fire support systems. The deployment schedules for both systems have slipped over 1 year, and neither will be deployed before 1992. The two battlefield systems have potential for further delay because both have critical development and testing to complete and because the Army's command and control systems' development historically has not met schedules. The revised CHS schedule is expected to address the delays in the battlefield control systems.

The combat service support control system program has neither an approved set of requirements nor sufficient funding for a CHS procurement. No CHS acquisitions are planned for deployment of this system until fiscal year 1992. The Army decided not to begin the major deployment phase of CHS for the maneuver control system until 1993.

Performance

The Army does not know whether its acquisition strategy will provide hardware and software that will meet the individual battlefield systems' requirements because pre-award testing will only verify contractor statements about basic hardware and software capabilities. For example, the pre-award testing will not determine whether proposed CHS can execute battlefield functions such as fire support calculations and aircraft tracking.

Software designed to work with Army tactical communication systems must be developed to ensure that the CHS will perform as required. Because offerors are not expected to have all communications software for the pre-award demonstration, the successful offeror will be allowed

up to 10 months to complete the communications software after the Army awards the contract.

The deputy program executive officer agreed that there were some risks associated with developing the communications software after procuring the hardware but overall believed the risk was not high. To obtain an outside perspective, we asked an independent consultant to assess the technical risks associated with the CDS acquisition. He found that communications interface software was an area of high risk. He concluded that undeveloped technologies, an inadequate industry skill base, and undefined or indefinite CDS requirements make it highly unlikely that the contractor will successfully develop interfaces between CDS and Army tactical communications systems.

Cost

The Army has identified requirements for 25,607 CDS computers at a cost of \$909.2 million. The battlefield control systems will bear these costs. The Army plans to reprogram \$40 million in research and development funds for the first contract year, but specific quantities to be purchased and the costs of the contract options for CDS purchase in the following 4 years are not yet available. Under the old schedule, the Army estimated the 5-year base quantity of 4,259 computers to cost \$200 million.

The Army plans to eventually award CDS contracts that will allow users to buy up to 118,259 computers at an estimated cost of \$3.4 billion. The deputy program executive officer believes that, after a contract is awarded, other Army users will come forward and place orders for CDS equipment. The orders are expected to be primarily for the commercial versions and will sustain the production line while initial battlefield control system orders are minimal. Because of the nature of the acquisition, whereby users can order computers through the CDS contracts with their own funds, acquisition costs are difficult to estimate. The Army believes that it can control CDS requests by ensuring that such requests go through the normal acquisition process. The program executive officer for command and control systems intends to review and approve CDS user requirements before procurement options are exercised.

According to program officials, DOD and the Congress have cut funds for the battlefield control systems in the past few years, and the Army is revising the systems' future financial requirements. Since the systems supply funds for the CDS acquisition, funding reductions in these programs reduce CDS funds. Even before the funding cuts, the battlefield

control systems faced funding shortfalls in future years based on DOD funding projections. For example, one of the systems, the Maneuver Control System program, was \$31.1 million short in fiscal year 1990.

Recent GAO Reports

Battlefield Automation: Better Justification and Testing Needed for Common Computer Acquisition (GAO/IMTEC-88-12, Dec. 31, 1987).

Battlefield Automation: Status of Army Command and Control Systems Acquisition Cost and Schedule Changes (GAO/NSIAD-88-42FS, Dec. 9, 1987).

Tactical Computers: Army's Maneuver Control System Acquisition Plan Is Not Cost-Effective (GAO/IMTEC-86-26BR, Sept. 3, 1987).

Battlefield Automation: Status of the Army Command and Control System Program (GAO/NSIAD-86-184FS, Aug. 26, 1986).

Tactical Computers: Army's Maneuver Control System Procurement and Distribution Plan (GAO/NSIAD-86-21FS, May 23, 1986).

Advanced Field Artillery Tactical Data System

The Advanced Field Artillery Tactical Data System (AFATDS) will be the Army's future automated fire support command and control system. It will process information received from sensors and observers and determine optimum targets and firepower. AFATDS is in the concept evaluation phase of development with software maturation phases (analogous to full-scale development) scheduled to start in August 1989. The Army plans to acquire 65 division-equivalent AFATDS sets at an estimated cost of \$1.0 billion (escalated dollars).

The Army has told the Congress that AFATDS is the only viable solution to its fire support command and control automation requirements. However, the program's technical and management problems led the Congress to direct the Army to procure another system for the light divisions. In addition, these problems have contributed to

- increased risks in meeting scheduled milestones,
- delays in testing system performance, and
- congressional reductions in the Army's AFATDS funding requests for fiscal years 1987 and 1988.

Total program acquisition costs have decreased as a result of a decision to buy less rugged equipment, but technical problems and schedule delays are causing development costs to rise.

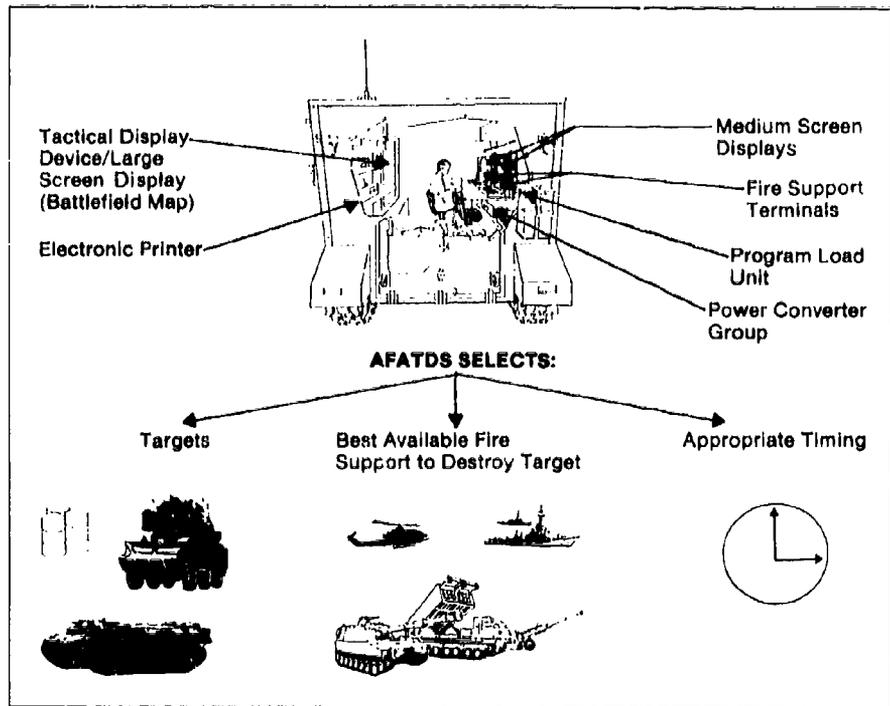
Background

AFATDS is expected to replace the automated Tactical Fire Direction System, which is now obsolete. AFATDS will be an automated software-driven network configured to perform battery to corps fire support functions. Operating as the fire support node of the Army Command and Control System, it will process information transmitted from outside sources such as sensors and forward observers and rapidly tell the commander the optimum targets to attack and optimum weapons or vehicles to use, such as field artillery, naval gun fire, and attack helicopters. AFATDS is also supposed to offer improved mobility, survivability, trainability, maintainability, interoperability, and continuity of operations needed to provide timely and effective fire support to the ground forces engaged in battle.

The system's major components include the fire support terminals, a program load unit, a power converter group, an electronic printer, and large and medium screen displays. The hardware will be acquired through the Army's Common Hardware and Software program (see

p. 68) but will be funded by the AFATDS program. Component configurations will differ, depending on battlefield unit. Figure I.9 shows the configuration for a heavy division's artillery battalion fire direction center.

Figure I.9: AFATDS Fire Direction Center



Magnavox is the prime contractor for the AFATDS concept evaluation phase, operating under a cost-plus-fixed-fee contract, which was capped at \$46.1 million. The Army also plans to award cost-plus-fixed-fee contracts in the follow-on software maturation phases scheduled to begin in 1989.

Requirements

The Army started the AFATDS program in response to direction from the Congress to develop a cost-effective successor to the automated Tactical Fire Direction System. Although the Army approved the need for AFATDS in 1981, the Army has only prepared a draft set of system requirements and has yet to perform a cost-effectiveness analysis. Required Army and DOD milestone I reviews (to approve the start of concept evaluation) were not carried out because the Vice Chief of Staff of the Army decided the reviews were not necessary. The Army has reported to the Congress,

as recently as the fiscal year 1988 budget hearings, that AFATDS is the only viable solution for meeting light division fire support requirements by fiscal year 1990 and heavy division requirements by fiscal year 1991.

Recently, problems in the AFATDS program have impacted the Army's plans and strategies for meeting fire support command and control requirements. The resulting program delays will preclude the Army from achieving deployment in fiscal years 1990 and 1991. Consequently, the Congress legislatively mandated that the Army procure an alternative system to give the light divisions a near-term capability. Under this new strategy, the Army will deploy the already fielded Light Field Artillery Tactical Data System to the light divisions.⁵

Schedule

The concept evaluation phase will be followed by a number of software maturation phases during which upgrades, or new software versions, will be developed. Some of the upgrades will be incorporated into the initial system fielded, while other upgrades will not be incorporated until later in production. Scheduled concept evaluation events have slipped significantly, delaying full-scale development and fielding, due to technical as well as management problems. Table I.14 compares the AFATDS program's current and original schedules.

Table I.14: AFATDS Program Schedule Changes

Event	9/06/85 schedule	3/18/88 schedule
Contract award	May 1984	May 1984
Concept evaluation phase complete	Feb. 1987	Apr. 1989
Defense Acquisition Board review	None	June 1989
Software development complete		
Light division	Jan. 1990	Apr. 1992
Heavy division	Jan. 1991	July 1993
Fielding		
Light division	Jan. 1990	Aug. 1992
Heavy division	Jan. 1991	Sept. 1993

Originally, the concept evaluation phase was to be a 33-month effort with system fielding to the light divisions scheduled for January 1990. The phase is now estimated to last 59 months, leading the Army to propose a revised fielding date of fiscal year 1992. However, the Army was still using the earlier fielding date in January 1988 to support the need

⁵This system, also referred to as Light Tacfire, has been fielded at the 9th Infantry Division.

to award a common hardware acquisition contract with fiscal year 1988 funding.

Magnavox attributes the delays primarily to compiler, communication modem, and system software problems. The Army believes that the delays might have been compounded by the contractor's (1) temporary loss of about 20 percent of its programmers, (2) contracting for more than it could produce within cost and schedule constraints, and (3) lack of management controls to accurately assess program progress. Magnavox and the Army believe that corrective actions taken should reduce the risk of further delays. However, in March 1988, the contractor stated that problems had not been corrected and that another delay of about 1 year was expected.

Performance

The Army has not tested or determined the system's performance. Therefore, until the Army completes concept evaluation testing for AFATDS in April 1989, AFATDS capabilities will remain projections. Even after the completion of the tests, interpretation of test results will be hampered because the Army has not established performance criteria, such as the time required to perform specific functions, to evaluate the system.

Cost

The Army's estimated AFATDS acquisition cost has decreased because of changes in the type of equipment needed. Table I.15 compares the original 1984 cost estimates for AFATDS to the revisions of March 1988 (escalated dollars). Both estimates are for 65 division-equivalent sets.

Table I.15: AFATDS Estimated Acquisition Costs

Dollars in millions			
Item	1984	1988	Change
Development	\$230	\$288	\$58
Procurement	1,876	742	(1,134)
Total	\$2,106	\$1,030	(\$1,076)
Acquisition cost per set	\$32.4	\$15.8	\$(16.6)

Anticipated program costs have decreased about \$1 billion. The \$1.1 billion reduction in procurement cost can be attributed to changing hardware specifications from militarized to a mix of less expensive commercial and ruggedized equipment. The \$58 million increase in development cost resulted from a change in acquisition strategy from

developing hardware to procuring off-the-shelf hardware. In addition, capping contractor reimbursements at \$35.6 million has kept the government's share of costs from escalating.

The original contract provided a concept evaluation phase effort to be completed in 33 months at a cost of \$33.9 million, with the contractor absorbing \$10.2 million of those costs. In October 1985, the Army renegotiated the concept evaluation contract. The amended contract increased costs to \$46.1 million but capped the government's share at \$35.6 million and reduced the scope of work. The Army has paid Magnavox the maximum amount authorized. However, in April 1987, Magnavox submitted a \$9 million claim for costs it believes were incurred for a series of events for which the Army was responsible. The claim is being reviewed by the Army, and if paid, the amount would exceed the \$46.1 program cap. In addition, development problems and associated schedule delays have driven estimated costs for concept evaluation from \$46 to \$78 million, although it is not certain who will be responsible for funding the increase.

According to program officials, both the Congress and DOD have reduced AFATDS funding. While the Congress generally supports the need for AFATDS, it cut funding in fiscal years 1987 and 1988 because development problems had delayed the completion of concept evaluation, obviating the need to fund the next development phase. The Congress also reduced procurement funding from \$77.7 million to \$26 million in fiscal year 1988 and stipulated that concept evaluation must be successfully completed and approved by the Congress before the Army obligates these funds.

DOD reduced the Army's fiscal year 1989 AFATDS budget request. Development funding dropped from \$25.8 million to \$17.7 million, and procurement funding from \$78.7 million to \$57.7 million.

Recent GAO Reports

Battlefield Automation: Field Artillery Data Systems Acquisition Problems and Budget Impacts (GAO/NSIAD-87-198BR, July 31, 1987).

Fire Support System: Army's Plans to Improve Its Fire Support Capabilities (GAO/NSIAD-86-116, Sept. 19, 1986).

Fire Support System: Status of the Fire Support System's Development (GAO/NSIAD-86-212FS, Sept. 15, 1986).

Appendix I
Army Programs

Fire Support System: Army's Plans to Improve Its Fire Support Capabilities (GAO/NSIAD-86-115BR, May 5, 1986).

Single Channel Ground and Airborne Radio System

The Single Channel Ground and Airborne Radio System (SINGARS) is a new family of very high-frequency anti-jam radios that will be used by troops on the ground, in vehicles, and aboard aircraft. The radios will be smaller and lighter than the current, Vietnam-era equipment. Eventually, the Army expects to buy almost 300,000 SINGARS radios in several configurations. The Army's total acquisition cost is about \$5.2 billion (escalated dollars)—a unit cost of about \$17,800. The Air Force, the Navy, and the Marines also plan to buy a total of about 40,000 SINGARS radios at a cost of about \$0.5 billion. The radio is now in initial production, and the Army is scheduled to award a full-rate production option in fiscal year 1989. The Army has requested \$267.2 million for fiscal year 1989 to fund production of 17,100 radios.

The Army and DOD support the SINGARS program as the best solution to their combat radio needs. Production of the SINGARS has experienced several delays due to major reliability problems. The Army recently reported that tests have shown that the radio's reliability and performance have met requirements, and it expects to proceed into full-rate production. However, the radio is now undergoing tests (from April through May 1988) in an operational environment. Since most of the estimated research and development funds have been appropriated and production will proceed under competitive, fixed-price contracts, the Army believes the current cost estimates to be firmer than they were in the program's early stages. Estimated program costs have actually decreased since 1986 for several reasons, including the use of more reliable information. In recent years, the Congress significantly reduced SINGARS funding requests because the system was experiencing reliability and production problems.

Background

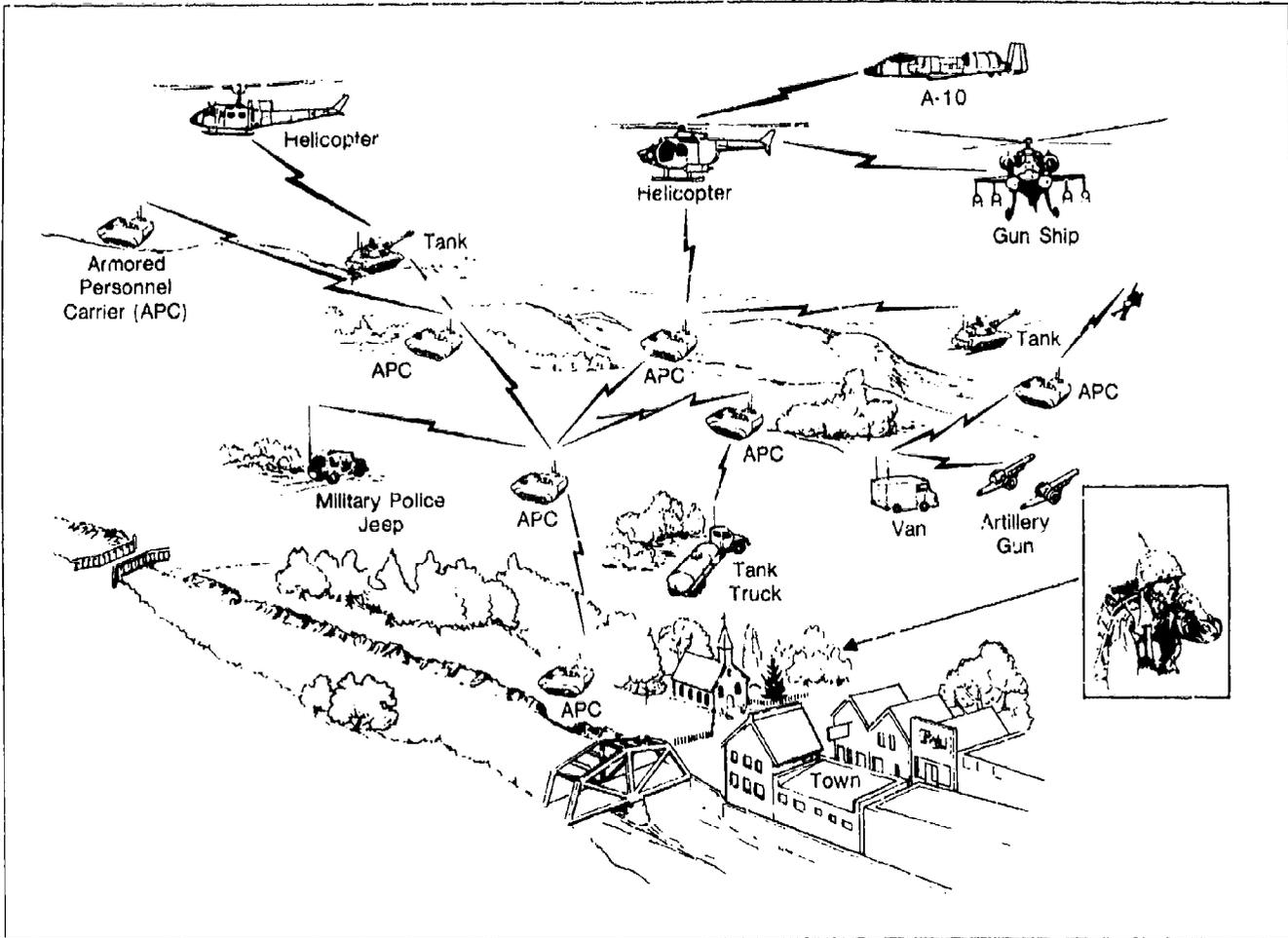
Advanced development of SINGARS began in 1978. The Army is acquiring the system to provide the next generation of lightweight, secure combat radios. The radio will be used for voice communications and for communications among battlefield computers serving the mission areas of air defense, fire support, combat support, intelligence, and maneuver control. The radio will replace the current series of Vietnam-era radios, including the VRC-12 vehicular radio, the PFC-77 transportable radio, and the ARC-114 airborne radio.

The SINGARS program is one of three major programs in the overall Army Command and Control System plan to improve Army battlefield communications at different levels. It is the primary combat radio and will provide point-to-point communications for lower level Army units

such as platoons. Mobile Subscriber Equipment, the second program, will provide mobile telephone service to higher level Army units such as divisions and corps. The third program is the Army Data Distribution System, which will provide real-time data communications for battle-field computer systems. SINGARS is the most expensive of the programs.

The SINGARS program includes several concurrent efforts. The primary focus is on the production by the prime contractor—the International Telephone and Telegraph Corporation (ITT)—of the ground versions of SINGARS. The Army is also developing an airborne model and hopes to begin fielding this version along with the ground radios. The Army has been developing an integrated communications security device, which is now a separate module, into the main SINGARS unit. Lastly, the Army is also developing a remote control unit for SINGARS, which will make it possible for the soldier to operate the radio from a distance. Figure I.10 shows how SINGARS might be used to provide communications for a variety of units on the battlefield.

Figure I.10: Representative Communication Links Provided by SINGARS on the Battlefield



Requirements

The requirement for SINGARS is based on a long-standing need to replace outdated, unreliable, and heavy equipment with technologically advanced radios that can counter the battlefield threat. By using a technique called frequency-hopping, SINGARS will be able to operate more effectively than current radios in environments where signal jamming is used.

The Army approved the requirement for SINGARS in 1974 and outlined the need for a new radio to provide additional capacity, overcome the

electronic warfare threat, and replace big, heavy equipment that was becoming more difficult to maintain. According to an Army program official, periodic reevaluations of the threat have been made, and the most recent one—done 1-1/2 years ago—showed that SINGARS will have the capability to operate effectively in the projected environment. The Army plans to buy 292,000 SINGARS.

Schedule

Although production of SINGARS ground models has been delayed several times during the last 3 years, recent tests suggest that the contractor has resolved the major reason for the delay. Delays resulted mainly from failure to meet Army reliability specifications during first article testing. When the tests began, the mean time between failure achieved with initial production units was only a fraction of the required 1,250 hours. The tests, which were to be completed in 1985, were not successfully completed until January 1988. According to the Army, the system has now met the reliability standard, and the service began to accept SINGARS production models in late January. To help achieve greater reliability, the Army has an incentive fee fund of \$30 million, which it could award to ITT for producing radios that exceed the specified reliability.

The follow-on operational test and evaluation scheduled during April through May 1988 at Fort Sill, Oklahoma, are to determine the operational suitability of SINGARS. In October 1988, the Defense Acquisition Board will review the program to determine whether it should proceed into full-rate production.

Some areas of risk remain in the program's schedule, and any delays will affect the Army's ability to adhere to its fielding plans. In order for the Army to meet its program schedule, the contractor must build up and maintain a higher production level of SINGARS ground units—about 1,300 radios a month—which will be a challenge. To build up to higher rates, the contractor must overcome producibility problems it encountered on the initial production units. To help control production costs, the Army plans to obtain a second source for the radios. The Army is now evaluating proposals and has scheduled an award for June 1988. The second source program has already slipped about 6 months. Concerned about this program, the Congress directed that the \$52 million it provided for obtaining a second source not be obligated until the Army provides information about its contract plans. In addition, delays may occur in acquiring the integrated communications security device to be used on all SINGARS models because additional development is required to integrate the device into the radio.

Performance

The follow-on operational test is to demonstrate whether the equipment not only meets the Army's specifications but provides the significant improvement in battlefield communications that DOD envisioned when it approved the requirement.

While the Army must still test SINGARS in an operational environment, it has indications from other sources, such as the following, that the radio is performing as required:

- In November 1987, the ground radios passed the first article production reliability test. According to a report from the SINGARS project office, the tests resulted in only two failures in about 5,350 hours.
- A January 1988 Army report indicated that first article testing of the airborne radios showed they were performing satisfactorily.
- A limited number of SINGARS placed in Korea became operational in December 1987, and preliminary results indicate that the radio is performing well in both the single channel and frequency-hopping modes. According to the officer in charge of this project, the mean time between failure has been about 4,000 hours, far exceeding the Army's 1,250-hour requirement.

The Army has experienced a delay in developing a remote control unit for the radio and has reduced its fiscal year 1989 budget request because of it. However, Army program officials believe the delay will not affect the fielding of the radio, since the Army intends to field the radio and the remote control unit separately.

Most of the estimated funds for the development of SINGARS have been appropriated, and future funding for the program will be mostly for full-rate production. The main contract for SINGARS equipment, which the Army recently renegotiated with ITT, is firm fixed-price with options for additional radios each year. The Army will negotiate a similar contract with the selected second source producer.

Cost

The Army's estimated acquisition cost for SINGARS is \$5.2 billion. Since the Army has completed most research and development and production will include fixed price contracts, the Army believes the current cost estimates to be more reliable than estimates in the program's early stages. Table I.16 shows SINGARS program cost estimates in escalated dollars as of December 31, 1987.

Appendix I
Army Programs

Table I.16: SINGARS Estimated Program Costs and Quantities

Dollars in millions		
Item	Cost	Quantities
Research and development	\$199.0	
Procurement, Army	5,005.9	291,524
Total Army acquisition cost	\$5,204.9	
Procurement, Air Force	55.1	4,476
Procurement, Marine Corps	411.1	33,382
Procurement, Navy	27.3	2,216
Total acquisition cost	\$5,698.4	

The Army cost estimate is about \$407 million less than an earlier production estimate provided in 1986. Major reasons for the difference are a reduced equipment cost due to using a different estimating technique, decreased cost of installation kits based on actual contractor proposals, and decreased estimate of warranty cost.

Through fiscal year 1988, the Congress had appropriated about \$551 million of the Army's total program cost; of this amount, \$154 million was for research and development. Based on the latest estimate, the Army's projected acquisition cost for a single SINGARS radio is about \$17,800.

According to program officials, in the last several years, reliability and other problems with SINGARS production resulted in a significant reduction in the Army's program budget. In fiscal year 1987, for example, the Congress deleted all but \$10 million of the \$209 million requested for SINGARS because of problems and delays. Fiscal year 1986 funds—about \$85 million—are now the major source of the program's procurement funds, and the Army will spend \$52 million of this amount to begin the second source production effort.

Army program officials stated that, once in full-rate production, the program will need substantial amounts of production funds. In the long term, these officials believe that sufficient funds have been programmed to purchase the needed quantity of radios.

Recent Reports

Battlefield Automation: Army Command and Control Systems Acquisition Cost and Schedule Changes (GAO/NSIAD-88-42FS, Dec. 9, 1987).

**Appendix I
Army Programs**

Battlefield Automation: Status of the Army Command and Control System Program (GAO/NSIAD-86-184FS, Aug. 26, 1986).

Separate Army and Air Force Airborne SINGARS Programs May Be Uneconomical (GAO/NSIAD-85-60, Jan. 31, 1985).

Navy Programs

SSN-21 Seawolf Submarine

The Seawolf (SSN-21) nuclear-powered attack submarine is the Navy's proposed successor to the Los Angeles (SSN-688) class, which has been in production since 1970. One of the primary missions of the SSN-21 submarine is to track and destroy or disable Soviet submarines. The Seawolf program is in full-scale development, and in June 1988 the Navy plans to seek approval from the Office of the Secretary of Defense to award the lead ship construction contract in November 1988. According to a program official, the Navy plans to have 29 SSN-21 submarines authorized by fiscal year 1999 with 13 delivered. The Navy estimates that these 29 submarines will cost about \$41.5 billion (escalated dollars) to develop and construct. The Navy established a procurement cost cap¹ of \$1.6 billion for the lead ship and \$1 billion for the fifth and follow-on ships (in fiscal year 1985 dollars). Cost caps were not established for ships 2 through 4. These caps exclude development costs and costs incurred after delivery.

The Navy has stated that the SSN-21 program is the only solution to its requirement for a submarine capable of countering the projected capabilities of the Soviet submarines in the 1990s and beyond. It believes that it will need at least 29 SSN-21s to meet its minimum force-level goal of 100 attack submarines and to maintain "submarine superiority," a keystone of its maritime strategy.

Although minor funding cuts have caused some work deferrals or revisions to the scope of work to be performed, program officials believe that the SSN-21 development and construction schedule can be met. A program official said that any increase in program costs resulting from the revision of work would be minor; however, it is too early to know for sure. Tight Defense budgets and high development and construction costs for the SSN-21 and its combat system (AN/BSY-2) may make it difficult for the Navy to achieve its SSN-21 force-level goal.

Background

The SSN-21 will be about 30 percent larger than the SSN-688. (An artist's conception is shown in fig. II.1.)

¹A cost cap is a tool used by the Navy to focus management attention on design and procurement issues to help ensure cost control. It is not a legislated ceiling, but to exceed the cap requires specific management review and actions.

Figure II.1: Artist's Conception of the SSN-21 Submarine



The SSN-21 is being designed to be quieter, deeper diving, tactically faster, more heavily armed, and equipped with more advanced sensors than the SSN-688. The SSN-21 will be used in forward ocean areas to seek out and destroy enemy submarines and surface ships and to attack land targets. Many of these new features represent dramatic improvements over earlier submarines, and the Navy expects the SSN-21 class to have three times the mission effectiveness of the improved SSN-688 class submarine. However, for the SSN-21 to achieve its full mission capability it must have a fully capable AN/BSY-2 combat system. The combat system will detect, classify, track, and launch weapons towards enemy targets. The Navy is developing the AN/BSY-2 under a separate acquisition program. This program is discussed on p. 92.

The Newport News Shipbuilding Division of Tenneco is the lead design yard with specific responsibility for the detailed design of the entire ship's pressure hull and those internal compartments contained in the front half (forward of the nuclear reactor compartment) of the ship, i.e., the torpedo room and the combat system area. The Electric Boat Division of General Dynamics is responsible for the detailed design of the

internal compartments of the back half of the ship to include the nuclear reactor compartment, the propulsion plant, the stern, and the wide aperture arrays. As a subcontractor to Newport News Shipyard, Electric Boat also has responsibility for the engineering of selected nonnuclear systems and integration of all nonnuclear systems in the engine room and reactor compartment. Bettis/Westinghouse, which has responsibility for the design of the nuclear propulsion system, has a subcontract with Electric Boat to integrate the nuclear reactor into the ship's propulsion plant.

Design work began in January 1987 under an interim contract, and in April 1987 the contract was finalized. It is an 8-year cost-plus-fixed-fee contract. The schedule calls for 8 years of detailed design efforts, with the majority of the lead ship design occurring in the first 4 years and continuous design services for the lead and following ships occurring in the remaining 4 years. The Navy expects the design contractors to have enough design work completed by May 1988 to enable it to solicit construction bids. The Navy's goal is to have 70 to 80 percent of the detailed design configuration drawings completed by the time the construction begins in November 1989, but information obtained in meetings with the design agent indicates that this goal may be optimistic.

Requirements

The Soviet Union has improved its submarines, making them quieter, faster and more survivable. Their more modern submarines, such as the SIERRA, OSCAR, AKULA, and ALFA classes, present a formidable threat to the U.S. Navy. The primary missions of attack submarines are antisubmarine and anti-surface ship warfare. However, they also will be used for land-strike warfare, surveillance, and mine warfare.

The requirement for an advanced technology submarine began to be developed in July 1982 when a Navy study group was established to assess future threats and capability needs. In December 1982, the Chief of Naval Operations directed that studies be undertaken to evaluate the feasibility of developing and exploiting new technologies, and in December 1983, the Secretaries of the Navy and Defense approved the award of preliminary design contracts.

The Navy stated that it needs the SSN-21 to counter anticipated increases in Soviet submarine capabilities in the mid-1990s and beyond. The Navy stated that, although the SSN-688 submarines have been improved, it cannot adequately meet the increased mission demands posed by the improved Soviet submarines. The Navy said that the

SSN-21 is the only option currently available to ensure technological advantages over Soviet submarines.

Schedule

Funding cuts in fiscal years 1985, 1986, and 1987 affected the accomplishment of some development tasks, but SSN-21 program officials said that these cuts were minor and that the planned development and construction milestones shown in table II.1 will be met. This schedule has not changed during the past 2 years.

Table II.1: SSN-21 Program Milestones

Event	12/31/87 schedule
Detailed Design Phase approved	Oct. 1986
Lead ship contract award	Nov. 1988
Lead ship construction start	Nov. 1989
Full-scale production approved	Mar. 1990
Follow-on ship contract award	Nov. 1990
Follow-on ship construction start	Nov. 1991
Initial Operational Capability	Nov. 1994
Developmental testing completed	June 1995
Operational testing completed	June 1995

The SSN-21 schedule reflects a 3-year period between detailed design and the start of lead ship construction to allow sufficient time for detail design to progress to support modular construction. Navy officials stated that a 2-year period exists between the lead ship's and the second ship's construction to ensure that all problem solutions and changes made to the first ship are incorporated into the detailed design to support follow-on ship construction. The Navy believes that the scheduled concurrence of development and production is of medium risk. Successful deployment of an operationally effective SSN-21 is dependent upon the AN/BSY-2 combat system's meeting its development and production schedule and operational requirements. As indicated on pp. 94-95, the AN/BSY-2 schedule appears to be somewhat optimistic.

SSN-21 developmental testing is under way and will continue into fiscal year 1995. According to a program official, operational testing will be conducted from April 1995 through June 1995. While testing of the lead ship is being conducted, seven additional SSN-21s will be under construction, and numerous subsystems, components, and hardware items will have been ordered.

According to a program official, the Navy plans to have 29 SSN-21 ships authorized by fiscal year 1999 with 13 delivered and the remaining 16 in various stages of construction. These ship construction plans are based on the assumption that the Congress will fully fund the SSN-21 construction program at a rate of about three submarines a year. The Navy expects the lead SSN-21 to be built in 60 months, with the following ships to be built in 50 months each. By comparison, SSN-688 attack submarines are taking an average of 66 months to build. The Navy believes that the use of modular construction techniques will enable the contractor to build the SSN-21 faster than previous submarines have been built. While modular construction may shorten the time for building SSN-21s, this is the Navy's first attempt at designing a submarine for modular construction, and the shorter construction time has not yet been proven.

Performance

According to program officials, current development efforts indicate that the Seawolf's components will probably achieve planned silencing capabilities. Most of the SSN-21 technology has been tried and tested, and Navy officials are confident that it will achieve capability levels. They said, however, that sea tests of the lead ship will be needed to verify whether components will achieve planned silencing thresholds. Currently, both nuclear and nonnuclear subcomponents are primarily being tested separately. The Navy has not planned multi-component tests at sea until the early to mid-1990s.

Navy officials said that, due to minor funding cuts, the Navy has had to reduce or reschedule certain SSN-21 performance validation efforts but that the program will not be adversely affected. These changes concerned (1) the silencing of certain components, (2) the shock-testing efforts, and (3) the procurement of long-lead time material for technical prototype propulsion units and ship service turbine generators. In our opinion, it is too soon to know whether these changes will adversely affect the SSN-21 program.

Cost

The Navy estimates that by the year 2000 it will need about \$41.5 billion (escalated dollars) for the development and procurement of 29 SSN-21s. This estimate excludes development costs for the AN/BSY-2 but includes AN/BSY-2 procurement costs. Table II.2 shows the details of this estimate.

**Table II.2: The SSN-21'S Development
and Procurement Costs**
(Fiscal Years 1983-99)

Dollars in billions	
Item	Cost
Research, development, test, and evaluation	\$2.7
Shipbuilding and conversion, Navy	38.8
Total	\$41.5

Through fiscal year 1988, the Congress has appropriated about \$1.9 billion for research and development, acquisition of nuclear components, lead ship electronics, and contractor-furnished equipment. The fiscal year 1989 shipbuilding budget estimate for the SSN-21 is about \$1.5 billion.

The Navy set a procurement cap of \$1.6 billion for the lead ship and \$1 billion for the fifth and follow-on ships (in fiscal year 1985 dollars). These caps exclude costs directly related to research and development and costs incurred after the ship is delivered to the Navy.

The Congress appropriated \$375 million in fiscal year 1987 and \$275.6 million in fiscal year 1988 in advance procurement funds for the first SSN-21 submarine. The Navy is requesting authorization and appropriation of \$1,488 million in procurement funds for fiscal year 1989. According to program officials, this figure includes full funding for the first SSN-21 and \$393 million in advance funds for two SSN-21s expected to be authorized in fiscal year 1991. An additional \$239 million is being requested for development.

Recent GAO Report

Status of the Navy's New Seawolf Attack Submarine and Its New Combat System (Testimony before the Subcommittee on Projection Forces and Regional Defense and the Subcommittee on Conventional Forces and Alliance Defense, Committee on Armed Services, U.S. Senate, Mar. 24, 1987).

AN/BSY-2 Submarine Combat System

The AN/BSY-2 submarine combat system, which is being developed specifically for the SSN-21, is being designed to detect, classify, track, and launch weapons toward enemy subsurface, surface, and land targets. In March 1988, DOD approved full-scale engineering development and limited production. The Navy expects development and procurement of 28 tactical combat systems and associated equipment for the program to cost about \$9.1 billion (escalated dollars).

According to the Navy, it needs the AN/BSY-2 combat system to address shortfalls in existing combat systems and to counter the Soviet's significant gains in submarine quieting and acoustic sensors. To be delivered on time for construction of the first SSN-21 submarine, the AN/BSY-2 will begin production before its development is complete. Because of the system's size, complexity, and new software requirements, there are risks associated with the Navy's plans to concurrently develop, produce, test, integrate, and deliver systems on time, with full capabilities, and within the program's current cost estimate. According to the Navy's independent test group, although the system has the potential for improved effectiveness over prior systems, the Navy cannot demonstrate this because the system is not yet operational. Program officials stated that the Navy considers the AN/BSY-2 program a high priority and intends to fully fund it in the future.

Background

The AN/BSY-2 combat system evolved from the Submarine Advanced Combat System program the Navy had initiated in 1980. Because of technical problems, the Navy restructured the original program into two combat systems—the AN/BSY-1 system for the improved SSN-688 class submarine and the AN/BSY-2 system for the SSN-21 class submarines. The AN/BSY-2 combat system is planned to be more automated and more capable than the AN/BSY-1 combat system. The Secretary of Defense approved the AN/BSY-2 program's development in May 1985.

The AN/BSY-2 combat system is a computer-aided target detection, classification, and tracking system that consists of two major subsystems—acoustic sensors and combat control (fire control and weapons launch). The AN/BSY-2 combat system is critical to the success of the SSN-21 in achieving its mission requirement of countering advanced Soviet submarines. While the combat system and the submarine are managed as separate programs, it is essential that they meet program milestones so that the AN/BSY-2 is ready when needed to meet the ship construction schedule.

Two firms competed for prime contractor responsibility during the program's full-scale engineering development and limited production phase (for three combat systems). The Navy selected General Electric Company as the leader, or prime contractor. On March 31, 1988, the Navy awarded General Electric a fixed-price-incentive-fee contract worth an estimated \$1.8 billion (escalated dollars). The follower contractor, the International Business Machines Corporation, will perform at least 15 percent of the work under a subcontracting arrangement with General Electric. In addition, General Electric is to develop and qualify International Business Machines as a second production source. The two contractors will then compete for the larger share of future production contracts.

Requirements

Program requirements stem from the need to address shortfalls in existing submarine combat systems and the Soviets' significant gains in submarine quieting and acoustic sensors. The Navy recognized the need for a new combat system in 1980 when it began the Submarine Advanced Combat System Program and reaffirmed the need in 1985.

According to the Navy, the AN/BSY-2 combat system will be able to meet the projected Soviet submarine threat because of significant operational improvements over other combat systems. It is intended to take advantage of significant noise reductions required of the SSN-21 submarines. Consequently, if the SSN-21 does not meet its noise quieting requirements, the AN/BSY-2 will be less effective. The system's new and larger acoustic sensors are to significantly improve detection performance over the AN/BSY-1 system, and its new wide aperture array is to locate targets significantly faster and provide more accurate target range and motion data.

The AN/BSY-2 is also being designed to significantly improve data processing and management capabilities. For example, certain tasks, such as searching for, detecting, and tracking targets and setting the firing order of various weapons, are currently performed manually or with limited computer assistance. To reduce the time operators need to perform these tasks, the AN/BSY-2 system will include new and larger computers and new customized workstations, data displays, and additional algorithms.² These improvements will allow system operators to perform multiple tasks, address multiple targets concurrently, and process

²An algorithm is a computational or logical procedure to be used in a computer simulation to implement a mathematical model.

additional tactical data faster and more accurately than the AN/BSY-1 combat system is capable of. Collectively, these capabilities are to reduce the response time between initially detecting a target and launching a weapon. According to the Navy, other combat systems cannot offer this capability.

Schedule

In March 1988, the Navy began full-scale development of the AN/BSY-2. Table II.3 shows the AN/BSY-2 schedule.

Table II.3: AN/BSY-2 Combat System Schedule

Event	Date
Full-scale development/initial production decision	Mar. 1988
Follow-on production decision	Jan. 1992
First production combat system delivered	Nov. 1993
First SSN-21 submarine delivered	Nov. 1994
At-sea operational evaluation of first combat system	Nov. 1995
Full-rate production decision	Nov. 1995

Although the full-scale development decision was made 6 months later than planned, program officials believe that the delay will not affect the program because they awarded an interim contract to ensure that necessary development work would continue.

To meet the submarine's delivery schedule, the Navy must concurrently develop and produce the combat system. For instance, the Navy must deliver the first production AN/BSY-2 in November 1993. The at-sea operational evaluation of that combat system will not be completed until 2 years later. However, by the time the operational evaluation is completed, four more combat systems, several trainers, two engineering development models, and one land-based engineering system are scheduled to have been delivered to the Navy. This schedule involves risk to the extent that problems identified during at-sea operational evaluations will require modifications to delivered systems as well as systems in production.

We believe that the schedule is high risk and slippages may occur, primarily because of the magnitude of effort to develop the AN/BSY-2 system. Although the Navy has 14 months longer to develop, produce, and deliver the AN/BSY-2 combat system with full capabilities than it had for the AN/BSY-1 system, the AN/BSY-2 is much larger, more complex,

and requires much more new software. Historically, software development and integration have proven to be the most difficult aspects of delivering a combat system on schedule and with full system capabilities.

Program officials, however, believe that developing and delivering the AN/BSY-2 combat system is a moderate schedule risk and that the schedule will be met. They believe that the primary factor in assigning this level of risk (versus low risk) is the magnitude of the development effort. The Navy also has taken measures to reduce risks, such as dividing software into manageable segments, establishing firm performance and interface requirements, and allocating 2 years to design the system.

Performance

An October 1987 assessment by the Navy's independent test group indicated that the AN/BSY-2 combat system has the potential for improved effectiveness over prior systems. The group based its assessment on a review of system design requirements and observations of developmental testing. However, because a system had not been developed for operational testing, the independent test group could not determine the system's potential effectiveness and suitability against the projected threat.

Program officials believe that meeting system performance requirements is low risk, primarily because the Navy established firm program requirements during the first 2 years of the program and the prime contractor's proposal included no new or radical technology. However, the tight development schedule allows little time to resolve problems, which could result in the initial combat system's being delivered to the shipyard for installation in the SSN-21 without full performance capabilities. Furthermore, program documentation shows that, because of budget cuts in fiscal year 1986, a system may be delivered to the submarine that has some operability improvements that the Navy did not first validate at sea. The AN/BSY-2 deputy program manager stated that these operability improvements, such as algorithms, might not be fully tested at sea prior to delivering the initial combat system to the shipyard and would require further development and modification to optimize performance.

The AN/BSY-2 combat system will also require more new software development and software integration than any previous submarine combat system. For example, the AN/BSY-1 combat system development program originally required 1.4 million lines of new software. Based on

the prime contractor's accepted proposal, the AN/BSY-2 combat system will require about 3.3 million lines of new or modified software (2.5 million lines of tactical software and 0.8 million lines of support software). Although the Navy has taken measures (e.g., partitioning development into manageable segments) to mitigate software development risks, based on the Navy's experience with other combat systems including the AN/BSY-1 development program, the AN/BSY-2 system could experience software development and integration problems.

Cost

Estimated program costs have not increased since the last estimate in 1986. Table II.4 shows the estimated costs to develop and procure 28 AN/BSY-2 combat systems and associated equipment. In preparation for the March 1988 full-scale development decision, the DOD Cost Analysis Improvement Group and the Naval Center for Cost Analysis independently reviewed the AN/BSY-2 cost estimate and found it reasonable. The accuracy of the estimated costs will depend on whether performance and schedule expectations are met.

Table II.4: AN/BSY-2 Estimated Acquisition Costs (In Escalated Dollars)

Dollars in millions		
Cost	May 1986 estimate	Dec. 1987 estimate
Development ^a	\$1,821	\$1,815
Procurement	7,513 ^b	7,300 ^b
Total	\$9,334	\$9,115

^aIncludes \$9.3 million to develop wide aperture arrays for nine SSN-688 class submarines authorized in fiscal year 1989 and beyond.

^bThese costs are included in the SSN-21 program's costs

In December 1987, the Navy reduced estimated development and procurement costs by \$219 million. According to the AN/BSY-2 deputy program manager, the Navy reduced procurement costs because it had eliminated one shore location where the SSN-21 will be deployed. As a result, the Navy deleted some AN/BSY-2 system training equipment and other related equipment that would have been housed at this location.

The Congress has cut the AN/BSY-2 combat system program funding several times. While the cuts have caused some rescheduling of tasks and funding shifts, Navy officials do not believe the changes will delay the program. According to program officials, the Navy considers the AN/BSY-2 program a high priority and intends to fully fund it in future years. Although we believe that the program will likely experience some

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cost growth, program officials disagree and contend that it will meet its cost goals.

Recent GAO Reports

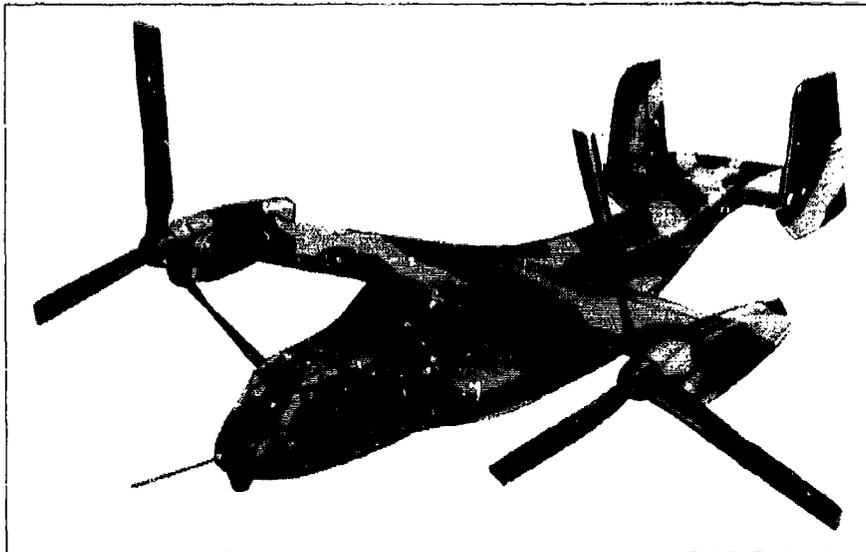
Status of the Navy's New Seawolf Attack Submarine and Its New Combat System (Testimony before the Subcommittee on Projection Forces and Regional Defense and the Subcommittee on Conventional Forces and Alliance Defense, Committee on Armed Services, U.S. Senate, Mar. 24, 1987).

Defense Acquisition Programs: Status of Selected Systems (GAO/NSIAD-87-128, Apr. 2, 1987).

V-22 Osprey Vertical Lift Aircraft

The V-22 OSPREY is a tiltrotor aircraft designed to take off and land vertically like a helicopter and to fly like an airplane by tilting its wing-mounted rotors to function as propellers. The V-22 is being developed to perform various combat missions including transporting troops and cargo during an amphibious assault (for the Marine Corps), combat search and rescue (for the Navy), and long-range special operations (for the Air Force). The V-22 is intended to replace the CH-46 Sea Knight helicopter in the Marine Corps and the HH-3A Sea King helicopter in the Navy and to supplement existing aircraft in the Air Force. The program is currently in full-scale development with an initial low-rate production decision scheduled for December 1989. The V-22 is estimated to cost \$23.0 billion (escalated dollars) for the development and production of 663 aircraft. Figure II.2 is an artist's conception of the V-22 OSPREY.

Figure II.2: The V-22 Osprey Tiltrotor Aircraft



The V-22 program is progressing through the early stages of engineering development with only a minor slippage anticipated in the originally planned first flight of the aircraft. DOD has not encountered any technical problems that could significantly affect program schedule and costs so far, although many critical tests remain before the first flight. However, the empty weight of the aircraft is estimated to exceed the production weight targets established by the Navy. If not resolved, this problem will reduce the aircraft's operational performance. Recently, the aircraft's program unit cost has increased by about \$2 million to an

estimated \$34.2 million (escalated dollars) due to the Army's decision not to buy the aircraft and the Air Force's decision to reduce the quantity of aircraft bought. The Army's decision was based on budget constraints, and the Air Force's on a review of its mission requirements. While concerned about program cost, DOD and the services agree that the V-22 is the most effective system to meet their operational requirements. In an effort to reduce the fiscal year 1989 and 1990 budgets, the Navy recommended delaying V-22 development and production by 1 year. DOD disapproved the recommendation, however, but may reconsider it during planning for the fiscal year 1990 budget. If approved, the delay would significantly increase total program costs.

Background

The V-22 aircraft, by combining advanced tiltrotor technology and the extensive use of composite materials, offers a unique capability to the military services. The Navy is developing the aircraft under a fixed-price incentive contract with the contractor team of Bell Helicopter Textron and Boeing Helicopter Company. The contract requires the team to coproduce six aircraft for flight testing and three for ground testing. The contract also includes an option for an initial low-rate production buy of 12 aircraft. Under its acquisition strategy, the Navy plans to have Bell and Boeing compete annually for the larger share of the production lots, after this initial production buy. For the engine development, the Navy awarded a firm fixed price contract to the Allison Gas Turbine Division of General Motors.

Requirements

Need for the program is based on the services' requirements to replace or supplement the aging and less capable aircraft now performing the medium lift/assault missions. A service-sponsored joint technology assessment group concluded in May 1982 that the application of tiltrotor technology offered the best potential for a common multiservice aircraft. From this assessment, the services developed a set of joint operational requirements, which suggested as the best alternative a tiltrotor aircraft with a worldwide self-deployment capability, that is, an aircraft that would not depend on other transportation means for its relocation from one area to another.

Prior to the April 1986 full-scale development decision, the Navy studied the cost-effectiveness of the V-22 aircraft in performing the Marine Corps, Navy, and Air Force missions. The studies concluded that the V-22 is the most operationally effective candidate in comparison to other available and potential helicopter alternatives. The V-22's greater

effectiveness is due largely to its greater speed and range. Accordingly, the studies show that, as mission distances increase, the V-22's operational effectiveness increases in comparison to other helicopter alternatives. As mission distances decrease, however, the V-22's effectiveness is similar to that of the alternatives. With respect to cost, the studies point out that the V-22 is more costly and that the cost difference essentially represents the price of the V-22's greater operational capabilities of speed and range. DOD and the services have decided that these capabilities are worth the V-22's increased cost.

The Navy has suspended completion of a study of the cost-effectiveness of using a V-22 variant aircraft to perform the antisubmarine warfare mission now performed by the S-3 Viking fixed-wing aircraft because of affordability. DOD has placed a hold on spending additional fiscal year 1988 funds for this purpose and excluded such funds from the fiscal year 1989 budget.

Schedule

The V-22 program has experienced only a minor schedule slippage since entering the full-scale development phase in April 1986, as shown in table II.5.

Table II.5: V-22 Osprey Program
Schedule Changes Since Full-Scale
Development Decision

Event	1986 program	Current program
Full-scale development decision	Apr. 1986	Apr. 1986
First flight	June 1988	Oct. 1988
Development testing start	Jan. 1989	Jan. 1989
Operational testing start	Aug. 1989	Aug. 1989
Initial limited production	Dec. 1989	Dec. 1989
Limited production	Dec. 1990	Dec. 1990
Full production	Dec. 1991	Dec. 1991
Initial operating capability	May 1992	May 1992

According to Navy officials, optimistic contractor schedules compounded by vendor part shortages have caused the first flight to slip 4 months. The initial flight testing of the aircraft is a critical event upon which the production schedule depends. Conducting the first flight on schedule is contingent upon the successful and timely completion of numerous system and structural tests yet to be completed. If these tests disclose safety-of-flight deficiencies, the first flight could slip further because the test schedule is very compressed with no time allowed to resolve major technical problems.

The schedule may also be subject to change due to affordability. In an effort to reduce its fiscal years 1989 and 1990 budgets, the Navy recommended to DOD that the production of the V-22 aircraft be delayed 1 year. Under this proposal, the Navy budget request for \$335.3 million in advance procurement funding would slip from March 1989 to March 1990. Also, the initial low-rate production decision, involving about \$2 billion in procurement funding, would be delayed until December 1990. DOD initially approved this proposal but in late January 1988 reversed its decision and retained the program's original schedule, because it believed that the program was experiencing no significant technical problems or schedule slippages. However, according to an OSD official, DOD may again consider delaying the program 1 year during early planning for the fiscal year 1990 budget. If approved, this action would delay the operational deployment of the aircraft, increase total program costs, and defer the need for the \$335.3 million in fiscal year 1989 advanced procurement funds and the \$2 billion in fiscal year 1990 procurement funds.

Performance

The Joint Services Operational Requirement for the V-22 aircraft established the following performance requirements:

- unrefueled range of 2,100 nautical miles,
- continuous cruise speed of 250 knots,
- dash speed of 275 knots,
- troop capacity of 24, and
- external cargo lift capability of 10,000 pounds.

Additional requirements were set forth in the areas of (1) readiness, reliability, and maintainability, (2) survivability and crashworthiness, (3) shipboard compatibility, and (4) adverse weather operations. The requirements also specified an aircraft empty weight guarantee, which the contractor must demonstrate based on the average weight of the first four production aircraft.

Until flight testing begins in October 1988, it is too early to assess how effective the V-22 will be in meeting its performance requirements. However, system and subsystem tests conducted so far have not identified problems with the technologies underlying the aircraft's development, according to Navy and contractor officials. Navy officials currently assess the overall program risk as medium.

Appendix II
Navy Programs

As of February 1988, the aircraft's empty weight was the only requirement that did not comply with Navy specifications. However, meeting the specification will require a major contractor effort. The development aircraft is currently about 260 pounds over the Marine Corps production weight target of 32,090 pounds. Navy officials stated that, based on historical experience, they expect aircraft weight to increase by about another 1,500 pounds during engineering development. They estimated, therefore, that without weight reduction measures, at the time of initial production, the V-22 development aircraft will exceed the weight target by about 1,760 pounds. With this extra weight, the aircraft would still be able to carry out its combat missions with a minor reduction in payload and/or range, according to Navy officials. The contractors have created a weight reduction team and believe that they can eliminate the excess weight.

The V-22's engines are currently about 44 pounds overweight, run about 40 degrees too hot, and are burning fuel 3 percent faster than specified. Although these factors will affect the performance of the engineering development aircraft, Navy officials are confident that the engine problems will be resolved prior to operational testing.

Cost

Since December 1986, program acquisition costs have decreased by about \$6.7 billion, primarily because the number of aircraft to be produced has decreased. While the number of aircraft to be produced during development has remained at 6, the total number to be produced has decreased from 913 to 657. Consequently, unit costs have increased by about \$2.1 million. Table II.6 compares V-22 acquisition costs as of December 1986 with those as of December 1987, as adjusted for the quantity reduction.

**Appendix II
Navy Programs**

Table II.6: V-22 Acquisition Costs

Dollars in millions		
Item	December 1986	December 1987
Research and development		
1986 dollars	\$ 2,443.7	\$ 2,471.4
Escalated dollars	\$ 2,625.2	\$ 2,663.1
Procurement ^a		
1986 dollars	20,629.3	15,574.1
Escalated dollars	27,037.1	20,337.3
Total acquisition ^a		
1986 dollars	\$23,073.0	\$18,045.5
Escalated dollars	\$29,662.3	\$23,000.4
Program acquisition unit cost		
1986 dollars	\$ 25.1	\$ 27.2
Escalated dollars	\$ 32.3	\$ 34.7

^aIncludes estimate for construction costs.

DOD reduced aircraft procurement quantities as a result of the Army's decision to cancel its planned buy of 231 aircraft and the Air Force's decision to lower its planned buy from 80 to 55. Budget constraints prompted the Army's decision, whereas the Air Force's decision was based on a review of its special operations mission requirements. The Navy has revised the V-22 procurement cost estimate to reflect the quantity reductions. However, the Navy has not adjusted the estimate for any efficiency loss caused by producing fewer aircraft, which would further increase the aircraft's unit cost.

Program acquisition costs will continue to change unless the procurement quantities stabilize. For example, the Navy may yet decide to acquire modified V-22 aircraft to perform an antisubmarine warfare mission, which would substantially increase total program costs. As discussed previously, costs could also increase to the extent that schedule delays occur.

The Marine Corps considers the V-22 program its highest priority program and has remained firm in its commitment to buy the required numbers of aircraft. According to program officials, before the fiscal year 1989 budget request, the program was adequately funded with only minor reductions made as a result of Navy reprogramming actions. Recently, however, funding constraints caused the Army to withdraw from the program and the Navy to propose delaying it.

Recent GAO Report

DOD Acquisition: Case Study of the Navy V-22 OSPREY Joint Vertical
Lift Aircraft Program (GAO/NSIAD-86-458-7, July 31, 1986).

MK-50 Torpedo

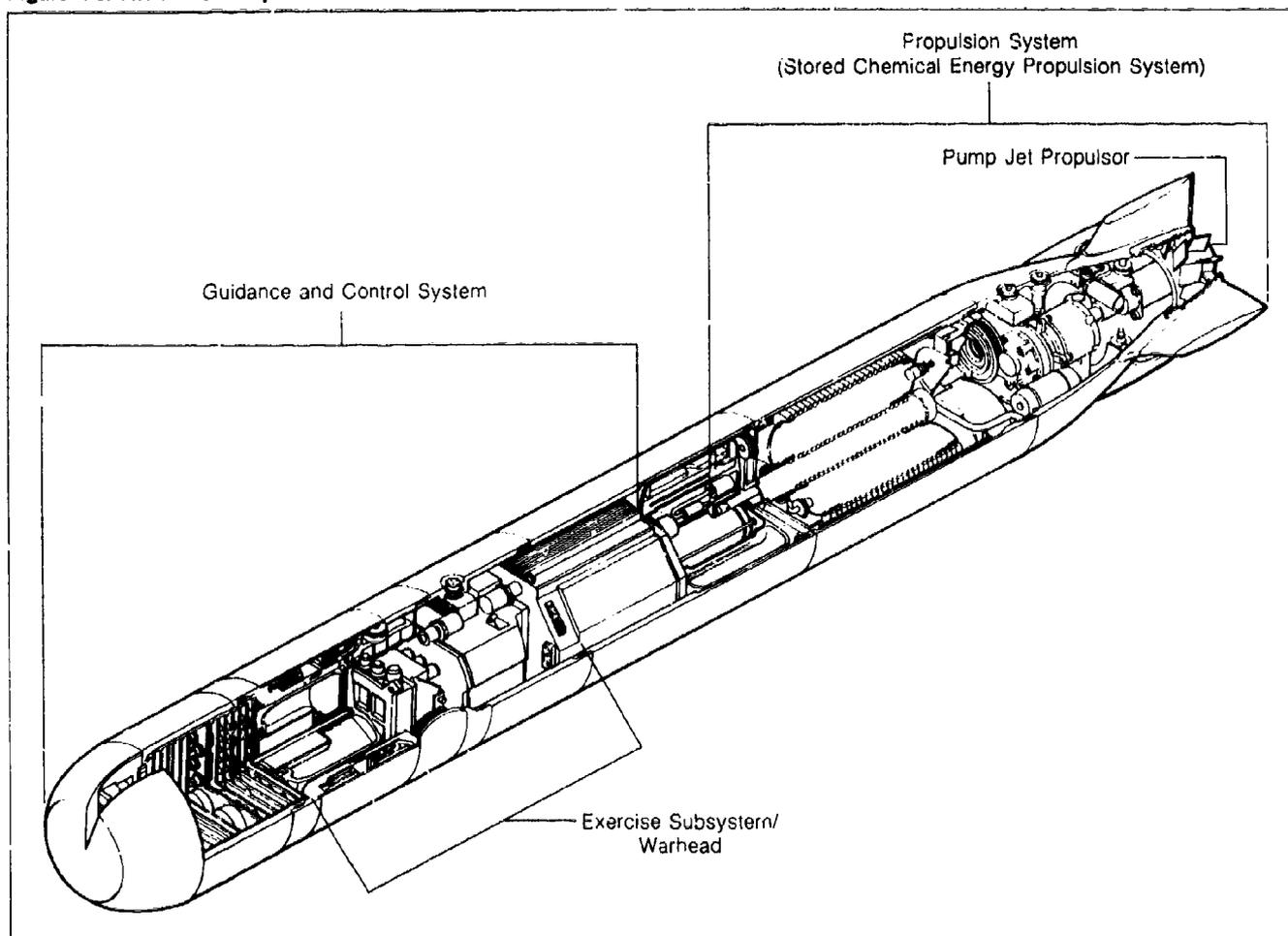
The MK-50 is an advanced lightweight torpedo intended to counter Soviet submarine threats through the year 2000. It will be launched from submarines, ships, and aircraft and will provide the fleet with enhanced performance and lethality. The MK-50 program is in full-scale development, with an initial production decision scheduled for February 1989. Total development, procurement, and military construction costs are estimated at about \$6.6 billion (escalated dollars).

According to the Navy, it needs the MK-50 to replace the MK-46 torpedo due to improvements in Soviet submarine capabilities. There are no North Atlantic Treaty Organization (NATO) alternatives being developed to meet this requirement. The MK-50 has demonstrated several of its technical performance thresholds in water but has not performed well in initial operational testing. The Navy restructured the full-scale development program during 1987 due to cost, schedule, and performance problems, and DOD approved the new program on February 16, 1988. Deliveries of hardware and software, while a problem earlier in the program, are now on schedule. According to a program official, cost estimates will be independently validated later this year. Overall, both DOD and the Congress have demonstrated funding support for the program.

Background

The MK-50 system consists of a torpedo and its automatic test equipment. Figure II.3 shows the torpedo and its major subsystems.

Figure II.3: The MK-50 Torpedo



The torpedo includes a command and control system for guidance and speed control, a stored chemical energy propulsion system unit for power (electrical and thrust), and either a warhead or exercise section as well as a sonar for target search and acquisition. The exercise section includes recording instrumentation and a buoyancy system to facilitate recovery after in-water exercises. The torpedo also includes air-launch accessories, such as a parachute.

The MK-50 is designed to be launched from ships, antisubmarine warfare fixed- and rotary-wing aircraft, and submarines equipped with the

Sea Lance antisubmarine warfare standoff weapon. The MK-50 is a fire-and-forget weapon—once launched, it independently searches, locates, and attacks its target.

Concept development began in 1975. In 1979, DOD approved advanced development of the torpedo, and in 1984, it entered full-scale development. The MK-50 full-scale development contract with Honeywell, Incorporated, which the Navy recently converted to a cost-plus-incentive-fee contract, is structured to reduce cost risk to the government through the use of cost sharing and a firm cost ceiling. Production will be competitive and will use the leader/follower strategy with the Westinghouse Corporation as the follower contractor.

Requirements

Soviet improvements in countermeasure capability and in submarine design and performance (speed, hull strength, maneuverability, depth, smaller acoustic target size, and lower radiated noise) necessitate having an advanced antisubmarine warfare torpedo. According to the Navy, the MK-50 is the only conventional air- and surface-launched antisubmarine warfare weapon capable of countering the newer generation of Soviet submarines. DOD anticipates that the MK-50 will meet or surpass NATO requirements for a lightweight torpedo for the 1990 to 2000 time frame.

In April 1974, the Navy established an operational requirement for an advanced lightweight acoustic homing torpedo capable of defeating the post-1985 Soviet submarine threat. In 1984, DOD revalidated the MK-50 requirement when it authorized full-scale development. The Defense Intelligence Agency validated the August 1987 System Threat Assessment Report on Antisubmarine Warfare Weapons Systems, including the MK-50, for use in threat analysis supporting Defense Acquisition Board milestone decisions.

Schedule

Full-scale development, originally envisioned to last 60 months, is now scheduled to take 89 months. The Navy extended the schedule due to minor technical difficulties; early hardware and software development problems; initial operational test failures; an underestimation of system complexity and the scope of work required; a poorly defined statement of work for the prime contractor; weak management by the prime contractor in managing a major subcontractor; and, to a lesser extent, minor funding reductions brought about by Gramm-Rudman-Hollings deficit reduction legislation. The Navy also extended the schedule to allow time

to conduct more development testing to ensure a reliable design before entering production.

Table II.7 compares the December 31, 1985, schedule with the December 31, 1987, approved program schedule.

Table II.7: Recent MK-50 Program Schedule Changes

Event	12/31/85 schedule	12/31/87 schedule
Demonstration and validation	July 1979	July 1979
Full-scale development	Jan. 1984	Jan. 1984
Full-scale development contract award	Sept. 1983	Sept. 1983
Critical design review	June 1986	May 1988
Initial operational test completed	Sept. 1986	Sept. 1988
Initial production	Dec. 1986	Feb. 1989
Operational evaluation completed	July 1988	July 1990
Full rate production	Oct. 1988	Jan. 1991

The MK-50 program manager assesses schedule risk as medium for the re-baselined program, based on limited data currently available from re-baselined cost performance reports. According to the MK-50 Acquisition Plan, the cost-sharing provisions of the renegotiated contract provide an incentive for Honeywell to meet the current schedule. The tactical software and MK-644 systems test equipment are the two most critical items in maintaining this schedule.

According to Navy officials, unlike the program schedule of the past 2 years, the new baseline program does not appear to be overly success-oriented. Concurrence between full-scale development and initial production is moderate and exists primarily to achieve the earliest possible fleet deliveries. However, moderate slack time exists prior to both initial and full-rate production, which will allow for some unexpected problems to occur without extending the schedule.

According to the Navy, the acquisition strategy controls the risks of concurrence through selected management reviews and decision points before entering both initial and full-rate production. Controls include a critical design review, use of prototype torpedoes, initial operational test and evaluation, and operational evaluation. The Navy also believes that competition between the leader and follower contractors—Honeywell and Westinghouse—will reduce the risk of concurrence.

Performance

The program office currently estimates that the MK-50 torpedo will achieve all technical and operational performance characteristics thresholds. The torpedo warhead, propulsion system, and tactical logic are considered to be significant technical advances or new applications of existing technology. For example, the torpedo employs a unique advanced stored chemical energy propulsion system with an extremely high-energy density. A pump jet propulsor drives the torpedo through the water. This design (1) enables the torpedo to achieve high speeds regardless of depth, (2) is quieter than an open-cycle engine, and (3) produces little wake. Technical risk is considered low because most critical technical challenges have been proven on advanced development torpedoes and on prototype torpedoes.

The first successful in-water run of a full-scale development prototype torpedo occurred on July 30, 1986. Between July 1987 and January 1988, 15 of 17 in-water full-scale development torpedo tests ran as planned.

However, the Navy terminated initial operational test and evaluation planned from October 1986 through April 1987, as part of combined developmental and operational testing, due to repeated in-water operational test failures. For example, in four out of five in-water test run attempts, the MK-50 either failed to start, or propulsive power was quickly terminated. In the one in-water run in which torpedo tactical logic software had an opportunity to perform, the MK-50 chased false targets. The Navy rescheduled these tests to run from June to September 1988. Results of this testing will be provided to support a decision to begin initial production.

Cost

The MK-50 has experienced significant development cost growth over the last 2 years, but procurement costs have not increased. (See table II.8.)

Table II.8: MK-50 Acquisition Costs (In Constant Fiscal Year 1984 Dollars)

Dollars in millions		
Item	12/31/85 estimate	12/31/87 estimate
Development	\$1,180.6	\$1,422.6
Procurement	3,736.8	3,672.5
Military construction	9.1	11.9
Total	\$4,926.5	\$5,107.0

Increases in the procurement cost estimates due to learning curve adjustments and production stretch-outs have been offset by estimated decreases due to competition and a reduction in initial spares requirements. Procurement quantities are unchanged, but actual numbers are classified.

The Navy converted the full-scale development prime torpedo contract in July 1987 from cost-plus-award fee to cost-plus-incentive fee. The new contract is structured to reduce cost risk to the government through the use of cost sharing and a firm cost ceiling. The government and the contractor will share all costs in the new contract between the target price of \$646 million and the assumption price of \$698 million on a 60/40 share line. The contractor will bear all costs beyond the \$698 million assumption price up to the firm ceiling price of \$703.2 million.

Both DOD and the Congress have adjusted MK-50 funding over the past 2 years, but, according to program officials, overall it has received adequate funding support. They stated that procurement funding in fiscal years 1987, 1988, and 1989 was reduced primarily because of premature plans to begin production, and development funding was increased in all 3 years because of increased requirements in the full-scale development program.

Recent GAO Reports

Test Resources: Early Testing of Major Antisubmarine Warfare Weapons Can Be Enhanced by Increased Focus on Test Resources (GAO/C-NSIAD-86-19, June 25, 1986).

Observations on the Advanced Lightweight Torpedo MK-50 Program (GAO/C-NSIAD-84-28, Aug. 30, 1984).

Surface Antisubmarine Warfare Improvement Program

The major objective of the Navy's Surface Antisubmarine Warfare (ASW) Improvement Program (previously called the Improved AN/SQQ-89) is to develop a new ASW sonar system that will improve the capability of surface ships in a carrier battle group to detect, identify, locate, and track threat submarines.

The program is in the early stages of development with a full-scale engineering development decision planned for early fiscal year 1990. The Navy estimates the research and development cost at about \$1 billion (escalated dollars). The Navy has not yet established procurement, installation, and operation cost estimates, as it does not yet know the number of systems it will procure and the components that will comprise the new system.

According to the Navy, it needs the Surface ASW Improvement Program to keep pace with threat submarine improvements. The program's operational requirements are consistent with the threat described in the Navy's current threat document. Until the contractors complete design work and propose technological solutions, the Navy cannot assess cost, schedule, and performance risks or determine whether it can afford the program. Some elements of the improvement program will probably involve high technological risks. Some funding reductions occurred in 1987 as a result of congressional direction, but because the Office of the Secretary of Defense initiated the program, the Navy expects adequate funding support within DOD.

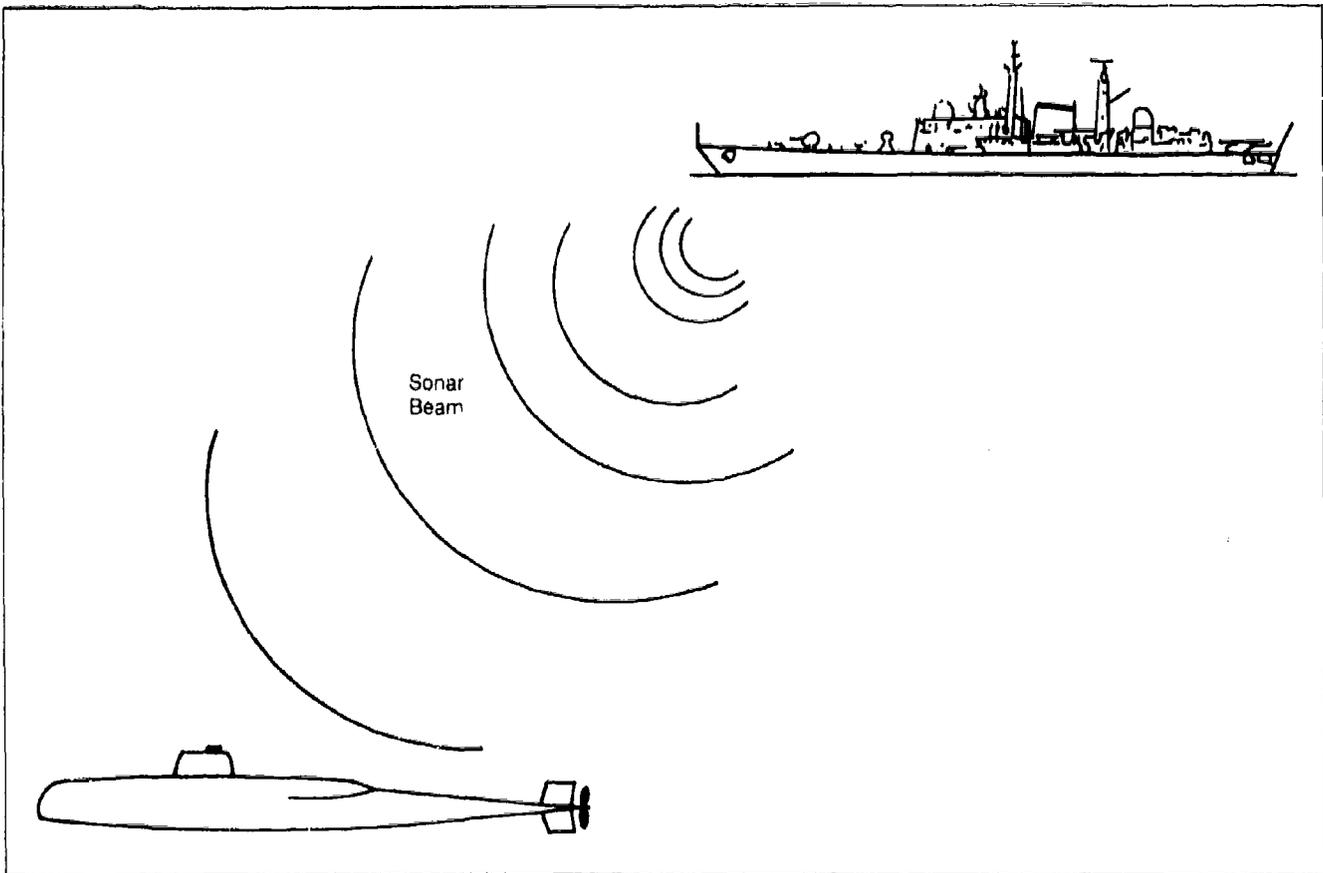
Background

The program has been in the design definition phase since 1986. At that time, the Navy was pursuing a full-scale development program to improve the existing AN/SQQ-89 ASW system, used on surface ships to protect carrier battle groups. The Improved AN/SQQ-89 program was relying on the outcome of high risk technology being developed at the same time under the Surface ASW Improvement Program. The Congress expressed concern over the high risk concurrence of the two projects, and in the fiscal year 1987 DOD Appropriation Act, the Congress required the Navy to postpone spending funds for surface ASW systems improvements until the Secretary of Defense certified that the AN/SQQ-89 Improvement Program had been approved to enter full-scale development. Because the program will not be ready for full-scale development until fiscal year 1989, the Secretary of Defense would not make the certification. Consequently, fiscal year 1987 funds were deferred.

The Navy, in response, combined the two projects into the "Surface ASW Improvement Program" and structured it into three phases, or blocks. Block 1 represents primarily a software update to make better use of the AN/SQQ-89 system. Block 2 will provide some ASW capability not now available to the FFG-7 class ships. The FFG-7, however, is not intended to provide carrier battle group protection. Block 3 will provide a new ASW system with the required capability for the surface ships that escort the carrier battle groups.

The Navy has awarded two fixed-price contracts to competing contractors for design definition of the new ASW system (blocks 1, 2, and 3). This design work will not be complete until the end of fiscal year 1989; therefore, the Navy does not know what components the system will use. The program office believes that proposed systems will be composed of a ship-mounted acoustic transducer array (a transmitter and receiver of sonar signals), a towed (passive) acoustic array (an underwater listening device), an integrating acoustic processor (a computer subsystem that processes the sonar signals), and a control subsystem. Figure II.4 shows an artist's conception of the ASW system's function.

Figure II.4: Artist's Conception of the Surface ASW System Concept



Requirements

The Office of the Secretary of Defense established the need for the Surface ASW Improvement Program through a program budget decision in December 1984. That decision specified certain performance criteria for improvements in the Navy's surface ASW capabilities. DOD validated the decision based on a threat analysis, highlighting the need to counter certain improvements in the Soviet submarine force.

Since the late 1970s, the Soviets have introduced improvements into their anti-ship attack submarines, demonstrating steadily advancing

technologies designed to make them more capable of threatening opposing surface ships. These improvements have been characterized by significant noise reduction, new weapons, new sensors, and increased speed. The Soviet incorporation of advanced technologies is narrowing the technological lead that the Western navies have held.

The current AN/SQQ-89, according to the Navy, has limited capability against the newer threat submarines. In classified documents, the Navy has noted and described specific deficiencies in U.S. forces in countering more modern Soviet submarines. The deployment of Soviet submarines with significantly reduced noise levels has degraded the effectiveness of current versions of the AN/SQQ-89, making it difficult to detect the submarines with passive acoustic sensors.

In addition, the Soviets are equipping their more modern submarines with cruise missiles with increased ranges. The AN/SQQ-89, which has detection ranges in line with the older threat, may not be able to adequately perform its mission of protecting the fleet against such submarines. Because of the increased Soviet cruise missile range, the currently assigned complement of escort ships to the carrier battle group, many equipped with the AN/SQQ-89, now need to defend a larger patrol area against the newer Soviet submarines, which will constitute the greatest part of the threat in the 1990s and early 2000s.

Schedule

The schedule for the Surface ASW Improvement Program as of January 1988 is shown in table II.9.

Table II.9: Surface ASW Improvement Program Schedule as of January 1988

Event	Date
Full-scale development decision	1st quarter, fiscal year 1990
Block 1 (Software) Production decision	4th quarter, fiscal year 1993
Block 2 (FFG-7) Full-rate production decision First production delivery	Middle of fiscal year 1994 Middle of calendar year 1997
Block 3 (Full System) Initial production decision Full-rate production decision First production delivery	4th quarter, fiscal year 1994 4th quarter, fiscal year 1995 Middle of calendar year 1998

The Navy awarded the competitive design definition contracts in February and May 1987, incorporating the block 1, 2, and 3 program structure

and expecting that fiscal year 1987 funding would be approved. However, the Secretary of Defense did not certify the program as ready to enter full-scale development, and the fiscal year 1987 funds were deferred. The Navy, however, retained the original dates for evaluation, selection, and full-scale development review. Thus, the contracts' time has been shortened by approximately 6 months.

According to the program office, the restructured three-block design philosophy reflects the Navy's attempt to reduce the appearance of dependence on high risk developments, as well as to address the need to reduce the concurrence of advanced development and engineering development. The current schedule represents a slip from the Improved AN/SQQ-89 schedule that preceded the combined program. Under the Improved AN/SQQ-89 schedule, first production deliveries for the fully capable system were to begin in August 1995, 3 years before first deliveries are anticipated under the current schedule. According to the program office, the fiscal year 1987 funding deferral and the three-block development approach, instituted to reduce risk, contributed to the slippage.

Performance

The Navy has not yet tested the new ASW system or its components. However, the Navy has assigned risk assessments to each of the three phases, or blocks, of the program. It believes that block 1, being principally a software update to existing equipment, is a low risk activity posing no serious technical problems. The Navy believes that block 2 will involve only the repackaging of known components and technical capabilities into a form compatible with smaller-sized vessels. The program office sees this as a moderately risky activity, involving some few, easily overcome engineering challenges. The block 3 system requires developing new technology and conducting a considerable amount of research to meet the needed degree of performance. The program office believes it involves fairly high risk technological advances.

Cost

In December 1987, Navy documents estimated research and development costs for the Surface ASW Improvement Program (referred to as the Improved AN/SQQ-89 in those documents) at \$958.1 million (escalated dollars). The project manager confirmed these costs in January 1988 to be about \$1 billion. The Navy has not yet estimated the costs for the procurement, installation, and operation of the systems. However, the current design work contracts require the contractors to provide such

cost estimates. Unknowns at this point include the total numbers of systems to be procured and the costs of the system selected.

While the Navy pursues the Surface ASW Improvement Program, with production of the units for the Battle Group Escorts to begin in 1998, it continues to acquire AN/SQQ-89 units. The Navy plans to procure AN/SQQ-89 systems under the Other Procurement, Navy account (not including the costs of units for new ships under construction) between fiscal years 1988 and 1994 at an estimated cost of \$1.633 billion. The Navy also plans to continue funding other improvements to AN/SQQ-89s deployed in the fleet. The December 31, 1987, AN/SQQ-89 Selected Acquisition Report estimated that the Navy would spend \$111.7 million in fiscal years 1988 through 1992 on AN/SQQ-89 research and development. These costs are in addition to costs for the Surface ASW Improvement Program.

The Surface ASW Improvement Program received a funding cut in fiscal year 1987, when the Secretary of Defense did not certify to the Congress that the program was ready to enter full-scale development. According to the program office, the program has been adequately funded since then, and the Navy expects DOD to provide adequate funds in the future, since the Office of the Secretary of Defense initiated the program.

Recent GAO Report

Navy Acquisition: Cost and Performance of Various Antisubmarine Warfare Systems (GAO/NSIAD-87-119, May 8, 1987).

Airborne Self-Protection Jammer

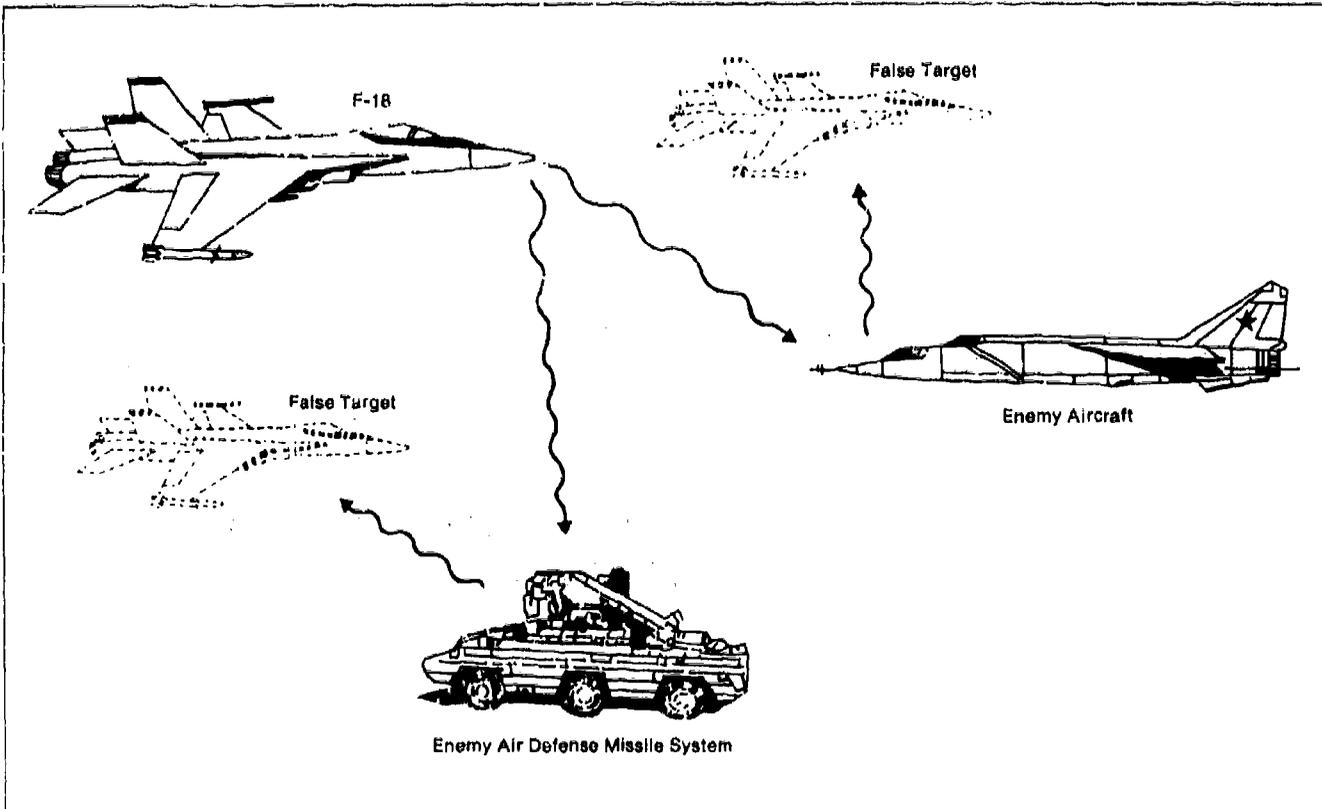
The Airborne Self-Protection Jammer (ASPJ) program is a joint Navy and Air Force development program to provide a common defensive electronic countermeasures system for tactical aircraft. The ASPJ is intended to increase the combat survivability of these aircraft against modern, diversified, radar-controlled weapons. The program is currently in full-scale development, and an initial production decision is scheduled for February or March 1989. The development and production of 2,369 ASPJ systems—894 for the Navy and 1,475 for the Air Force—is estimated to cost \$4.8 billion (escalated dollars).

The need for an effective system to jam enemy radars has been demonstrated by the successes of hostile air defenses in Vietnam and the Middle East. Although DOD believes that the ASPJ will meet this need, the jammer will not be fully effective against recent threat developments which will represent a significant portion of enemy air defense weapons in the 1990s. According to program officials, the jammer can be improved to increase its effectiveness against the updated threat, but such an improvement effort is not yet in the ASPJ program. Technical performance problems have extended the full-scale development phase by 5 years. Program officials believe that they have corrected these problems. The ASPJ must successfully complete development and initial operational testing before the initial production decision. Because of test limitations, however, these tests may not provide an adequate demonstration of the ASPJ's capabilities. Despite the delays, costs have not increased significantly, partly because the contractors have absorbed some of the additional costs. The program has not experienced significant budget cuts in the past 2 years. Future procurement costs will be funded from the aircraft programs that will use the ASPJ.

Background

The ASPJ is intended to increase aircraft survivability by deceiving enemy radar as to the true location of the aircraft, as illustrated in figure II.5.

Figure II.5: How the ASPJ Works



The ASPJ will be used on over 2,000 F/A-18, F-16, F-14, A-6E, and AV-8B aircraft. These tactical aircraft have different missions and operate in different environments. It is designed to automatically engage multiple threats simultaneously and overcome the threats it considers most dangerous by selecting the most appropriate defensive response from a variety of preprogrammed noise and deception jamming techniques. The ASPJ will be used with other systems aboard the aircraft, such as the radar warning receiver, which warns the pilot that he is under observation by hostile radars, and expendable systems, such as thin strips of metallic chaff and infrared flares, which can be ejected from the aircraft and act as decoys against hostile missiles.

The ASPJ is controlled by a reprogrammable computer and is compact, modular in design, and flexible in configuration. It can be installed

inside the aircraft on specially-designed racks or mounted in an external pod. The basic system will be installed on the F/A-18 and consists of five separate boxes that weigh about 250 pounds and occupy 2.3 cubic feet. Four of the boxes are high- and low-band transmitters and receivers; the fifth box is the computer. To provide additional jamming capability for the F-16, F-14, and A-6E aircraft, up to eight boxes will be installed internally on specially-designed racks. Because of limited internal space, the ASPJ for the AV-8B will be located in an external pod. All of the boxes are to be interchangeable; that is, they will be able to be used in any of the five aircraft.

The ASPJ program began as separate Navy and Air Force development programs involving four separate industrial teams. In 1976, DOD directed the two services to jointly develop an advanced, standardized system that could be used on a number of tactical aircraft and designated the Navy as the lead service. Following competition, the full-scale development contract was awarded in 1981 to a contractor team made up of International Telephone and Telegraph (ITT) and Westinghouse Electric Corporation. The acquisition strategy is to qualify both contractors to build ASPJ systems. Initially, each contractor will build only a portion of ASPJ. Subsequently, each contractor will be qualified to build the entire system, and the bulk of the remaining production systems will be opened to annual competition between the two contractors. The fiscal year 1987 budget contained procurement funds to buy six production verification units to ensure that the contractors can produce the ASPJ. The fiscal year 1988 budget contains funds for 14 more production verification units.

Requirements

The Navy and the Air Force formally approved their need for the ASPJ before full-scale development, and the Navy verified its need for the ASPJ in 1987. Both services cited the need to increase their capabilities in conducting tactical air operations in a hostile air defense environment. Their need is supported by the fact that hostile defense capabilities, including radar-controlled surface-to-air missiles, aircraft, and anti-aircraft artillery, are continually being improved through the steady deployment of new threat air defense systems.

Program officials advised us that the ASPJ, when fielded, will be the most advanced self-protection jammer in the U.S. inventory. The ASPJ has been designed to defeat the threat that was postulated during the 1980s and updated through calendar year 1986. The ASPJ, as initially

procured, will not be fully effective against a certain class of threat systems, which will represent a significant portion of enemy air defenses in the 1990s. Because the ASPJ is reprogrammable, program officials believe that it can be modified to accommodate minor changes in threat capabilities. However, to substantially improve the ASPJ's performance against the projected threats of the 1990s, product improvements to both its software and hardware would be required, and these improvements are not yet included in the program.

The Naval Intelligence Support Center, assisted by a number of other intelligence agencies, prepared a threat assessment specifically for the ASPJ. The assessment was considered valid until February 1987, and program officials stated that the assessment would be updated for the November 1988 initial production decision.

The Navy prepared a cost and operational effectiveness analysis, which concluded that the ASPJ would be an effective system for its aircraft. Although the Navy computer simulation for this analysis was based on data from actual test flights, the threat simulators the Navy used in the test did not fully represent the capabilities of the threat air defense systems, a limitation that may prevent an accurate assessment of the ASPJ's capabilities. The Air Force has performed no study similar to the Navy analysis but has looked at the characteristics of internal versus external systems and concluded that the ASPJ, which will be carried internally on the Air Force's F-16, should be an improvement over the current external pods carried by that aircraft. However, the Air Force has not addressed the fundamental question of the ASPJ's effectiveness in increasing the combat survivability of the F-16 when performing its assigned missions.

Schedule

The ASPJ program is about 5 years behind schedule since it entered full-scale development in 1981. The delays can be attributed primarily to technical performance problems. Table II.10 highlights the schedule changes.

Table II.10: ASPJ Schedule Changes

Event	Jan. 1981 schedule	May 1988 schedule
Full-scale development contract award	May 1981	Aug. 1981
Developmental testing completed	—	May/June 1988
Decision to buy 14 production verification units	—	Aug./Sept. 1988
Limited rate production decision	—	Feb./Mar. 1989
Operational evaluation completed	July 1984	Nov. 1989
Full-rate production decision	Jan. 1984	Jan. 1990

According to program officials, the technical performance problems involved power supplies and the dissipation of heat away from the ASPJ, especially for those aircraft in which the ASPJ will be mounted internally. They stated that these problems have been overcome and that they expect developmental testing to be completed as scheduled. The successful completion of developmental testing is important for the program if it is to meet the current schedule. The pending decision on whether to exercise the full-scale development contract option for 14 additional production verification models is dependent on the successful completion of developmental testing and a 12-flight operational assessment.

The schedule calls for making decisions to buy additional production verification units and to begin initial production before operational test results are evaluated. Program officials stated that the schedule for making the decisions will likely be met and that the risks are acceptable because the quantities involved (14 and 186) represent less than 10 percent of the total program.

Performance

As of May 1988, the ASPJ was undergoing developmental flight testing to correct a major system performance deficiency found in late March by the Air Force testers. These tests are being made at the Air Force's Eglin Air Force Base and the Navy's China Lake facility. Operational testing will begin shortly after the development tests end. The ASPJ has experienced significant technical problems in the past, but results from the current tests are not yet available. However, the development and operational tests, as currently designed, have limitations that may hamper an accurate assessment of the ASPJ's performance. These limitations include the following:

- The version of the ASPJ being tested is an earlier development model, not the current production verification model, which is an updated design.

The first production verification units will not be available until after testing is completed.

- The aircraft being used to test the ASPJ are not the models in which it will be installed. F/A-18 and F-16 "A" models are being used in testing, because "C" models will not be delivered from the aircraft producers and made available for ASPJ testing until at least October 1988. As a result, there may be some integration problems when the "C" models become available because the "C" and "A" models are equipped differently.
- Although the simulators used to represent threat systems are currently the best available at the test ranges, the simulators are neither in full conformity with the latest threat capabilities nor as numerous as would typically be employed.

Program officials believe that their testing program is adequate and that the above limitations will be overcome as the testing program continues. GAO is currently examining these efforts as part of another review.

Cost

DoD estimates \$577 million in development costs and \$4,215 million in procurement costs for the 2,369 jammers, for a total estimated program cost of \$4.8 billion (escalated dollars). These figures compute to a unit program cost of about \$2 million each. The estimated production unit cost when the ASPJ is in full production (1992-1994) is expected to be \$1 million. Despite the schedule delays and technical problems, ASPJ costs have not increased significantly in the past 2 years. Part of the reason the development cost estimate has not increased is that the contractor team has absorbed some of the additional costs caused by the delays.

The \$1 million unit cost figure represents the basic five-box configuration to be used in the F/A-18 and the AV-8B pod. The much larger buys for the F-14 and F-16 aircraft require seven boxes, while the smaller A-6 buy will be augmented with an eighth box. Not included are the integration, checkout, and labor costs for the mounting racks, cables, antennas, and pods.

The cost estimates are based upon many assumptions that are subject to considerable change: that the annual production rates and quantities will remain as estimated, that there will be no major modifications, that there will be adequate integration with whatever radar warning receivers are procured in the 1990s, that the majority of the nonrecurring costs will be completed from 1987 to 1989, and that the adjustments for competition are correct.

**Appendix II
Navy Programs**

According to program officials, the ASPJ program has not suffered significant budget cuts in the past 2 years. Support for future procurement funds within DOD will depend on the willingness and ability of the five aircraft programs to set aside funds for the ASPJ.

Recent GAO Reports

Electronic Warfare: Multiple Developments of Costly Threat Simulators (GAO/NSIAD-88-93, Feb. 1, 1988).

Electronic Warfare: Navy/Air Force Still Developing Separate, Costly Radar Warning Receivers (GAO/NSIAD-87-167, July 1 1987).

Radar Jammers: Department of Defense Efforts to Incorporate Electronic Countermeasures (GAO/C-NSIAD-86-21BR, June 1986).

An Opportunity to Reduce Proliferation and Improved Acquisition Strategy for Electronic Combat Jammers (GAO/C-NSIAD-86-1, Oct. 8, 1985).

Air Force Programs

C-17 Aircraft

The Air Force is developing the C-17 aircraft to meet a reported shortfall in long-range airlift capability. The aircraft is expected to modernize the airlift fleet and improve U.S. capability to rapidly project, reinforce, and sustain combat forces worldwide. The C-17's ability to airlift the full range of military cargo directly into small, austere airfields distinguishes it from other aircraft in the airlift force and is key to its cost-effectiveness over the alternative C-5.

The C-17 program is currently in full-scale development, with an initial production decision scheduled for October 1988. The Air Force plans to acquire 210 aircraft at an estimated cost of \$35.7 billion (escalated dollars), a 5 percent increase (excluding inflation) since full-scale development began in fiscal year 1985. The Air Force believes that the C-17 is a low risk technical program because it relies heavily on demonstrated technologies.

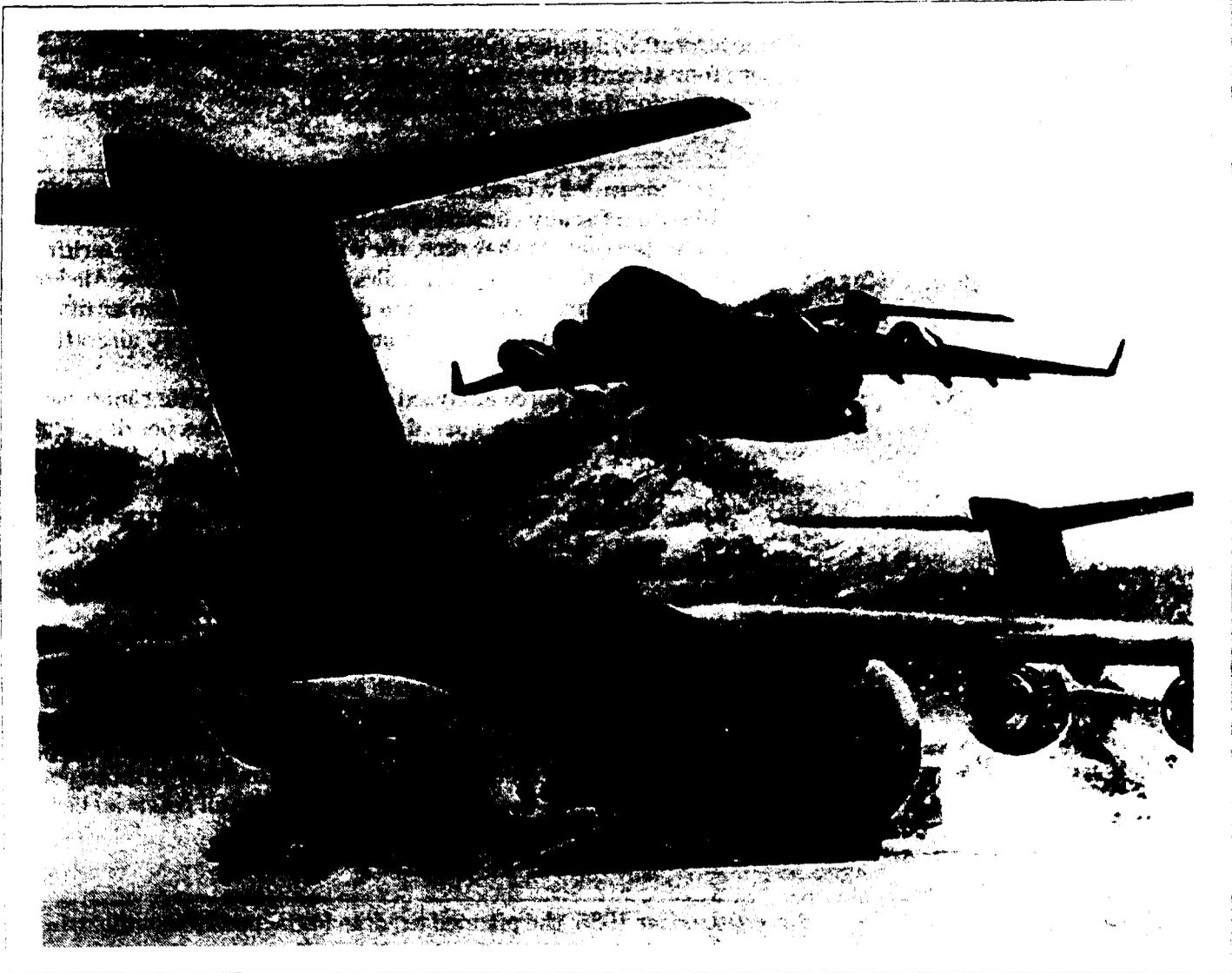
According to the program office, the adequacy and stability of funding are the most significant program concerns. Funding reductions in fiscal years 1986 and 1987 forced the restructure of the prime contract, resulting in a \$110 million cost increase and a 5-month slip in Initial Operational Capability (IOC). The program office believes that current funding levels are inadequate to support a September 1992 IOC.

In March 1987, GAO reported that to reach the airlift goal established by DOD, the Air Force will likely need to acquire more than the currently planned procurement of 210 aircraft.

Background

The C-17 will be a four-engine, wide-body aircraft designed to airlift substantial payloads over intercontinental ranges without refueling. It is intended to deliver oversized combat equipment and cargo to small, austere airfields in moderate threat environments. (See fig. III.1.)

Figure III.1: Artist's Conception of the C-17 Aircraft



Full-scale development of the C-17, which began in fiscal year 1985 under a fixed-price incentive contract with Douglas Aircraft Company, McDonnell Douglas Corporation, provides for the fabrication of one test aircraft and two full-scale test units. As of March 1988, the price of the full-scale development portion of the prime contract, including initial production tooling, amounted to \$4.2 billion. The prime contract also includes two options for the purchase of production aircraft. The Air

Force exercised the first production option for two aircraft in January 1988 for \$604 million and plans to exercise the second option for three to nine aircraft in January 1989. The Air Force currently plans to acquire four aircraft under the second option and provided long-lead time funding for this number in January 1988.

Requirements

In 1981, DOD identified a need for additional long-range airlift capability and established a fiscally-constrained goal of being able to airlift 66 million ton-miles per day. At that time, the Air Force's long-range airlift capability was about 29 million ton-miles per day. In 1983, the Air Force took a number of intermediate steps to increase its near-term airlift capability, including buying 50 additional C-5 and 44 KC-10 aircraft.

Also, in 1983, the Air Force analyzed alternatives to further increase airlift capability to reach the goal of 66 million ton-miles per day. The alternatives involved buying either additional C-5s or the C-17 aircraft. The Air Force concluded that the C-17 was the more cost-effective alternative. It based its decision on the life-cycle costs of the alternatives, as well as on how well each alternative met mission requirements and affected manpower levels, force stabilization, and force modernization.

The C-17 offers the potential to provide greater military utility than the C-5. While the C-5 is a capable aircraft, it cannot match the C-17's expected capability to land and operate on a wider range of airfields closer to the battle area. This flexibility could reduce the time it takes to position forces to meet wartime needs. The Air Force says that it will routinely use the C-17 for direct deliveries, including deliveries to potentially hostile areas. This use is key to achieving the full potential benefits from the C-17.

Schedule

Since December 1985, the planned IOC date has slipped 5 months, while other milestones have slipped more, compressing key events against the IOC. Table III.1 compares the Air Force's December 1985 schedule with its current program schedule for upcoming major events.

Appendix III
Air Force Programs

Table III.1: Recent C-17 Program
Schedule Changes

Event	Dec. 1985 estimate	Feb. 1988 estimate
Initial production decision	Sept. 1986	Oct. 1988
First flight	Feb. 1990	Aug. 1990
Full-rate production decision	Aug. 1991	Oct. 1992
IOC (delivery of 12th aircraft)	Apr. 1992	Sept. 1992

According to the C-17 program office, reduced program funding in fiscal years 1986 and 1987 forced a restructuring of the prime contract in 1987. Consequently, the program incurred a 9-month delay in the start of fabrication and assembly, a 6-month delay in first flight, and a 5-month delay in the IOC. The current schedule does not reflect the potential impact of fiscal year 1988 funding reductions.

The Air Force delayed the initial and full-rate production decisions to obtain additional program performance information. It delayed the initial production decision until October 1988, after completion of the critical design review, and the full-rate production decision until October 1990, after initial operational test and evaluation.

Several events are scheduled to be completed prior to the initial production decision planned for October 1988. These include a critical design review, an independent cost analysis, the Test and Evaluation Master Plan update, and a third production readiness review.

Performance

The Air Force considers the C-17 to be a low risk technical program because it relies on demonstrated technologies and proven design features. For example, the aircraft's engine will be a modified version of the Pratt and Whitney 2040, which has been certified by the Federal Aviation Administration and is currently in commercial use.

According to program office representatives, the C-17's current design will meet approved program requirements for payload, range, takeoff and landing distances, and cruise speed. In addition, the Army, a principal user, believes that the C-17's current design will meet or exceed its requirements. However, Air Force and contractor officials agree that the program faces technical performance-related challenges. These include (1) maintaining the aircraft's operating weight at 268,000 pounds and (2) integrating the avionics software and the redesigned flight control system into the aircraft in a timely manner.

Development testing and evaluation are under way with reported successful results. According to the program office, wind tunnel testing has been successfully completed, and structural testing on major components is about 85 percent complete, resulting in reportedly minor design revisions.

The Air Force plans to conduct a comprehensive flight test program to support the full-rate production decision scheduled for October 1992, with the first flight scheduled for August 1990. Development and initial operational tests and evaluations will be combined to the maximum extent possible during the flight test program. Development tests will verify system and air vehicle specifications, safety of flight, and correction of hazardous conditions.

Cost

The Air Force currently estimates that acquisition costs for 210 production aircraft will total \$35.7 billion (escalated dollars). The program has experienced a 5-percent cost growth, based on constant fiscal year 1981 dollars, over the last 2 years. Table III.2 compares program costs projected in December 1985 and in December 1987 (in constant fiscal year 1981 dollars).

Table III.2: C-17 Cost Estimates
(In Fiscal Year 1981 Dollars)

Dollars in millions			
Item	Dec. 1985 estimate	Dec. 1987 estimate	Change
Research and development	\$2,879.8	\$3,519.0	\$639.2
Procurement	16,684.2	17,022.0	337.8
Construction	112.5	92.2	(20.3)
Total	\$19,676.5	\$20,633.2	\$956.7

A major portion of the net increase in the research and development cost was due to a shift in production tooling costs from procurement. In addition, procurement costs increased due to the Air Force's redefinition of initial spares. Program officials do not consider the latter increase real program growth since the cost was previously accounted for as an element of operations and support costs rather than procurement costs.

The balance of the increase in program costs was due primarily to estimating changes made by the program office for support requirements, flyaway costs, and schedule revisions resulting from budget cuts and other funding constraints.

The construction cost estimates do not include funding requirements for improvements, such as support and repair facilities and engine inspection and repair shops, planned at four airfields where Air Force Reserve and Air National Guard C-17 squadrons will be based. The program office currently estimates these costs at \$82.7 million (excluding inflation).

In addition, although space, weight, and power provisions for defensive systems are included in the C-17's design, defensive systems are not currently funded. The Air Force has completed a study of defensive systems options and their associated costs. The study report recommended an initial defensive systems option costing an estimated \$616.8 million for the fleet. Follow-on options included in the study would cost, at least, an additional \$450 million.

Finally, GAO reported in March 1987 that to reach the goal of 66 million ton-miles per day, the life-cycle cost of the C-17 will likely exceed the Air Force's estimates. This is due to optimistic assumptions concerning the wartime utilization rates for the C-17 and other aircraft. The Air Force may need to buy an additional 29 C-17 aircraft to reach the established goal.

The C-17 program sustained congressional research and development funding cuts of approximately \$81 million in fiscal year 1986 and \$65 million in fiscal year 1987. As a result of these cuts, the Air Force restructured the prime contract at an additional cost of \$110 million.

In fiscal year 1988, the Congress reduced the C-17's research and development funding by \$100 million and procurement funding by \$56.4 million. Program officials, while stating that it is too early to assess the long-term implications of this cut, believe that current funding levels are inadequate to support a September 1992 IOC. According to the program office, to meet the current IOC, \$193 million in research and development funds projected for fiscal year 1993 must be reallocated to fiscal years 1990 through 1992, and additional funds must be provided.

While the Congress has not appropriated funds for fiscal year 1989, DOD's amended budget reduced the research and development request for the C-17 by \$20.9 million and increased the procurement request by \$14 million. According to program officials, these requests support the procurement of four aircraft, maintain the test program intact, and preclude another contract restructure at this time.

Recent GAO Reports

Military Airlift: C-17 Wing Competition Fair, but Savings Lower Than Air Force Estimates (GAO/NSIAD-88-3, Nov. 13, 1987).

Military Airlift: Air Force Analysis Supports Acquisition of C-17 Aircraft (GAO/NSIAD-87-97, Mar. 20, 1987).

Small Intercontinental Ballistic Missile

The Air Force initiated the Small Intercontinental Ballistic Missile (ICBM) development program to partially meet the need to deploy more accurate and survivable missiles to complement existing U.S. nuclear forces. The program is intended to help counter the increased accuracy of Soviet missiles, as well as the deployment of mobile ICBMs. The Air Force's planning baseline is a force of 500 missiles transported on mobile launchers, hardened to a limited degree against the effects of a nuclear explosion, at a program cost currently estimated at \$36.4 billion (escalated dollars). The program is currently in the second year of a 5-year full-scale development effort. Testing and analysis of Small ICBM components to date have been successful.

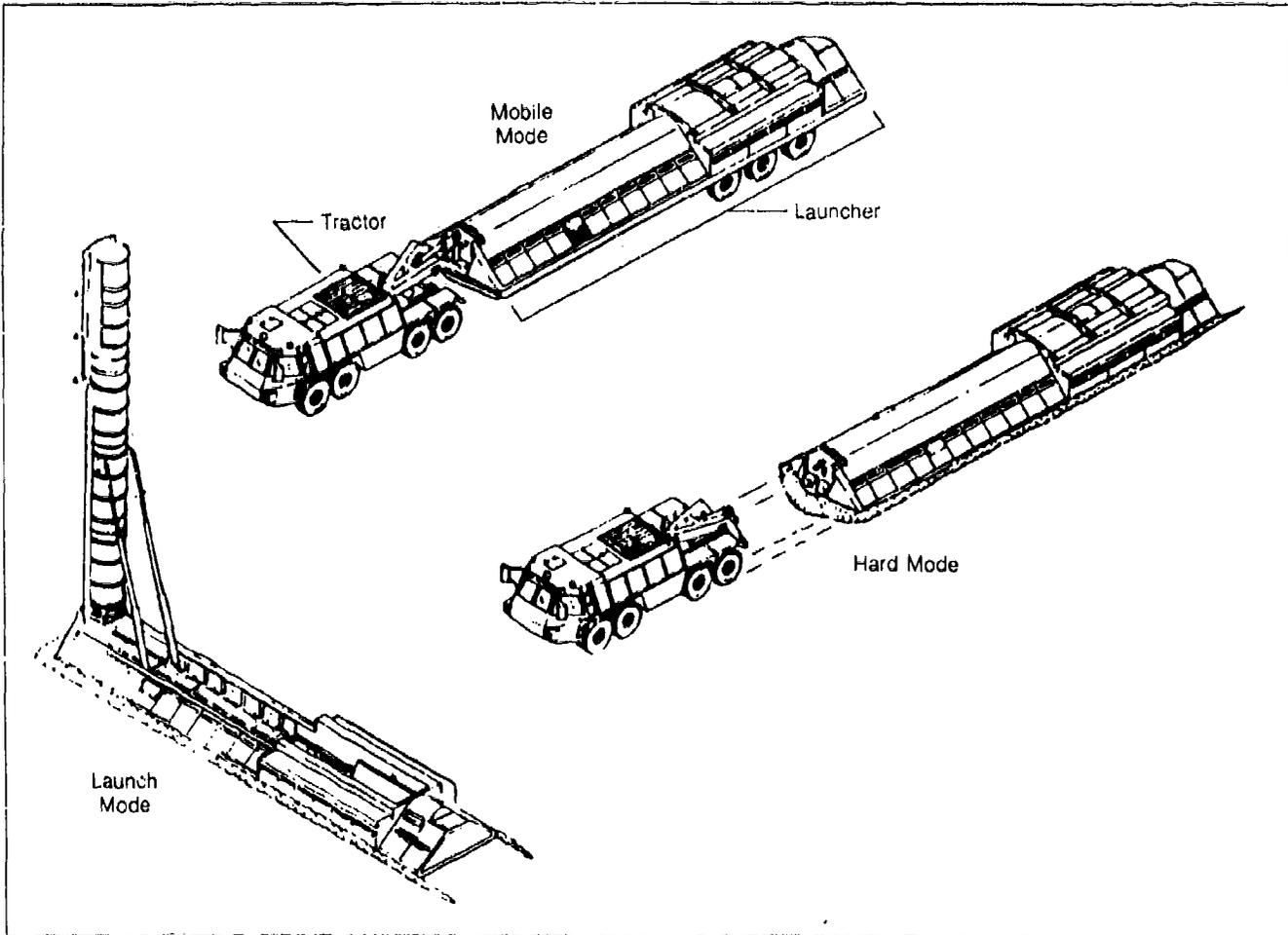
The high cost to acquire and maintain a Small ICBM force has been an issue since the program's inception. However, its development was accepted, and full funding support was provided through fiscal year 1987. In fiscal year 1988, concerns about the affordability of a 500 Small ICBM program led to a significant reduction in funding. In the revised fiscal year 1989 budget, the Secretary of Defense recommended terminating the Small ICBM program. The reason given was that the program would not be cost-effective because the cost per deployed warhead, including the missile and hard mobile launcher that each system requires, is well above that of other new survivable strategic systems. The Secretary of Defense said that deployment of the Peacekeeper, a 10-warhead ICBM, in a rail garrison mode fully meets the requirement for a survivable and stabilizing land-based system. For a variety of reasons, including arms control negotiations and alternative congressional views regarding the merits of the Small ICBM, DOD plans to continue a development program using \$700 million appropriated in fiscal year 1988 and \$200 million requested for fiscal year 1989. The purpose of this action is to provide a basis for the next administration to continue the Small ICBM program, if desired.

Background

The Small ICBM is a three-stage, solid propellant, single reentry vehicle missile that will be 53 feet long and 46 inches in diameter and weigh approximately 37,000 pounds. The operational concept calls for basing the Small ICBM missiles on hard mobile launchers deployed at Minuteman launch facilities. The original plan to deploy the system in a random movement mode is, according to the Air Force, still an option. When at Minuteman facilities, the systems will be ready to disperse off the Minuteman sites upon tactical warning, that is, notification that missiles have been launched against the United States. Under the concept, the

mobile Small ICBM would be more survivable than current silo-based systems and could better provide a post-attack capability. The Small ICBM weapon system is depicted in figure III.2.

Figure III.2: The Small ICBM Weapon System Modes



Requirements

In 1983, the President appointed a Commission on Strategic Forces to provide advice on ICBM basing options and alternatives to the Peacekeeper. Among the Commission's recommendations was the development of a new, single-warhead Small ICBM. The underlying logic for this recommendation was that a Small ICBM, possessing the capability to

place Soviet hard targets at risk, could allow flexible basing and would be more survivable than current silo-based systems.

The Air Force's validated Statement of Operational Need for the Small ICBM describes the need generally as follows. Single reentry vehicle ICBMs are essential to satisfying targeting requirements. The flexibility of the single reentry vehicle would permit a more efficient application than a multiple reentry vehicle ICBM. The single-warhead Small ICBM system must have the capability to attack fixed targets, relocatable targets, and time-urgent targets throughout the spectrum of conflict.

Schedule

The Small ICBM development had been on schedule through fiscal year 1987. Pre-full-scale development and the first year of a planned 6-year full-scale development effort have been completed. The first missile flight test is tentatively scheduled for early 1989 pending DOD concurrence. The first system flight test using both the hard mobile launcher and the Small ICBM was scheduled for the second quarter of 1990. As a result of congressional action, which reduced DOD's fiscal year 1988 request from \$1.7 billion to \$700 million, the program office had to restructure its activities in order to continue both the missile and basing portions of the program. A major assumption in the program office's revised plan was that approximately \$1 billion would be received in fiscal year 1989. Under this restructuring, the Air Force planned to retain the 1992 initial operational capability date.

As a result of DOD's decision to terminate the program and request only \$200 million for fiscal year 1989, the program office is restructuring program activities a second time. It is attempting to protect missile development, including the first test flight, but substantially reduce the basing efforts.

Performance

In 1983, an assessment of the need for the Small ICBM and the risks involved in its development identified three subsystems as the program's key technological challenges—guidance and control, propulsion, and a hard mobile launcher. The primary technological challenge was keeping the weapon system weight to a minimum to promote mobility.

Subsystem development testing has been conducted, and all the major tests planned to date have been successfully completed, except for cold weather mobility testing. This testing could not be completed due to mild winter weather conditions at Malmstrom Air Force Base, Montana. The

1988 winter weather has been more severe, and according to the program office, facilitated needed testing. Some of the other major tests conducted included missile cold launch tests, propulsion stage firings, flight tests of alternate inertial navigation systems, and land navigation tests using the baseline Advance Inertial Reference Sphere inertial measurement unit. Initial land navigation testing showed that the baseline inertial measurement unit could navigate successfully in a land-mobile environment and maintain sufficient accuracy. Further testing will be required to validate this capability.

In addition, the alternate inertial navigation system competition was completed. The program office has decided to continue only the baseline inertial measurement unit development; no alternate inertial navigation system will continue into full-scale development or compete for later production contracts. The alternate inertial navigation system development effort started in 1984 with three competing contractors and was later narrowed to two contractors and eventually to one in December 1987. At that point, the remaining contractor submitted a bid for a full-scale development contract that included fixed-price options for production. After evaluation of that bid, the program office, in February 1988, decided not to pursue development of alternate inertial systems based on both technical and return-on-investment considerations.

Cost

As reported in DOD's Small ICBM Selected Acquisition Report, dated June 30, 1987, the estimated program acquisition cost for a force of 500 deployed Small ICBMs was \$33.7 billion in 1984 base-year dollars, or \$44.7 billion escalated dollars. The report also stated that revisions to the estimated cost were being made by the program office to reflect changes from a 30,000- to a 37,000-pound missile and lower estimates for development.

The program office's current cost estimate for 500 deployed systems is about \$27.1 billion in 1984 base-year dollars, or \$36.4 billion escalated dollars. According to program officials, the \$6.6 billion difference in the base-year estimates is attributable to factors such as decreases in risk funding, savings resulting from competitive contracting, and the decision to use the baseline inertial measurement unit rather than introduce a new system.

Table III.3 depicts the program office's current Small ICBM acquisition cost estimate by cost category in escalated dollars.

Table III.3: Small ICBM Acquisition Costs
(In Escalated Dollars)

Dollars in billions	
Item	Cost
Research and development	\$8.7
Procurement	25.2
Construction	2.5
Total Acquisition	\$36.4

The program office recognized that a force of 500 single-warhead small ICBMs is expensive. They stated, however, that alternatives do exist that could make the Small ICBM program more cost-attractive while still maintaining a viable deterrent capability, and these alternatives are in the early stages of discussion with higher commands. One such alternative is to deploy a force of 350 rather than 500 Small ICBMs at Minuteman sites. According to the program office, the cost of this alternative would be \$30.5 billion (escalated dollars).

According to program officials, funding for the Small ICBM was relatively stable until fiscal year 1988. DOD's combined fiscal year 1988 and 1989 budget request contained about \$2.2 billion in both 1988 and 1989 to continue full-scale development. The \$2.2 billion requested for 1988 was later reduced to \$1.7 billion by the Air Force and subsequently reduced by the Congress to \$700 million. In preparing its amended fiscal year 1989 request, the program office reduced its fiscal year 1989 funding needs to about \$1.8 billion. In its amended fiscal year 1989 budget request, DOD proposes to terminate the program but, to reflect congressional concerns, requested \$200 million to carry the program through until the next administration can make a decision on it.

In January 1988, the Chairmen of the Senate and House Armed Services Committees and the Senate Armed Services Committee's Ranking Minority Member, in correspondence to the Secretary of Defense regarding continued funding for the Small ICBM, stated that sufficient funding should be provided in 1988 and 1989 to sustain the total weapon system development program (including the hard mobile launcher and command and control systems) in order to keep together the teams working on the essential parts of the program. The objective, they stated, should be to ensure that all parts of the program are maintained and moved forward in such a way that it presents a credible option for the next President in making decisions prioritizing the ICBM modernization program.

In response, the Secretary stated that DOD cannot afford to develop and acquire the Small ICBM within the funding levels that will be available in the near future. He also said that he has serious doubt that the program is cost-effective at budget levels higher than can be reasonably foreseen. However, he stated that DOD will ensure that there is a basis for continuing the program if the new administration decides to do so in early 1989. He said that the details for accomplishing this goal are now being worked out and that funds would be included in the budget request. According to the program office, the \$200 million in the fiscal year 1989 request is not sufficient funding to maintain the Small ICBM contractor team. The program office said that major suppliers, subcontractors, and vendors will be terminated in late fiscal year 1988 due to inadequate funding in fiscal year 1989.

Recent GAO Reports

Procurement: Delivery Problems With Inertial Measurement Units
(GAO/NSIAD-87-74BR, Dec. 18, 1987).

ICBM Modernization: Status, Survivable Basing Issues, and Need to Reestablish a National Consensus (GAO/NSIAD-86-200, Sept. 19, 1986).

DOD Acquisition: Case Study of the Air Force Small Intercontinental Ballistic Missile (GAO/NSIAD-86-45S-16, July 31, 1986).

Status of the Intercontinental Ballistic Missile Modernization Program
(GAO/NSIAD-85-78, July 8, 1985).

Peacekeeper Rail Garrison

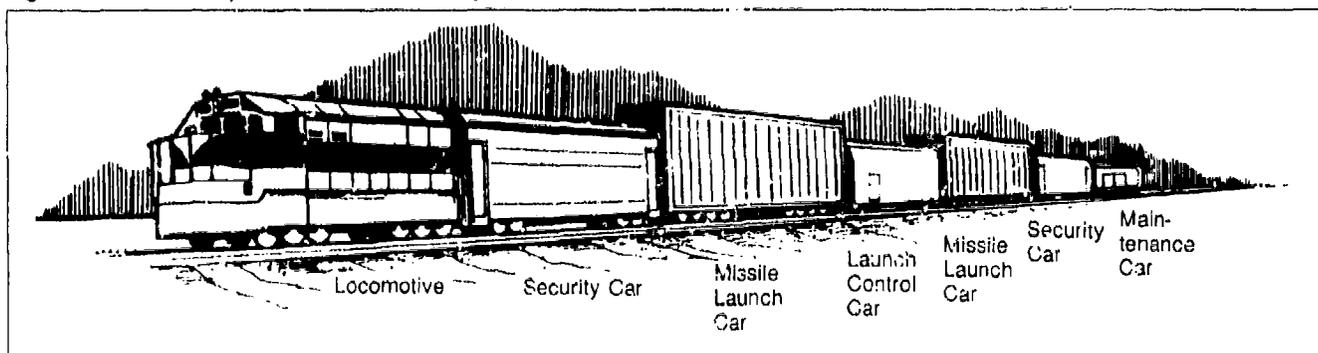
The Peacekeeper Rail Garrison concept has recently emerged as DOD's highest priority basing mode for Intercontinental Ballistic Missiles (ICBM) for fully meeting the requirements for a survivable and stabilizing land-based system. The rail garrison concept consists of 25 trains, each carrying two Peacekeeper missiles deployed on existing military installations. The Air Force estimates that rail basing will cost about \$7.4 billion (escalated dollars), exclusive of operational missile costs of about \$3.2 billion.

The program is still in the early design and development stage. The Air Force is confident that it can achieve a successful system by integrating existing missile and railroad technology, but system performance remains to be demonstrated as the system progresses through development.

Background

The Peacekeeper Rail Garrison basing system will consist of a train with two locomotives and six rail cars—two missile launch cars; one launch control car; two security, personnel, and support cars; and a missile maintenance car. (See fig. III.3.) The Air Force may add more rail cars as required for operations.

Figure III.3: Peacekeeper Rail Garrison Concept



The trains will be deployed in secure garrisons at the main operating base at F.E. Warren Air Force Base, Wyoming, and at existing Air Force bases throughout the continental United States. Each garrison will include train alert shelters to house the train and a maintenance area or facility to provide the capability to remove or replace the missile guidance and control set and the reentry system. All Peacekeeper missiles will be on continuous alert and will move onto the nation's railways only

in the event of a national need. If necessary, the missiles can be rapidly launched from within the train alert shelters while in the garrisons.

The rail garrison concept represents a significant departure from previous planning assumptions for ICBM survivability. Previously proposed mobile basing modes have been dependent only on tactical warning to ensure survivability. Tactical warning indicates that missiles have already been launched in the direction of the United States and survivability is dependent upon dispersal measured in minutes. Survivability of the rail garrison system is dependent upon strategic warning. Strategic warning is a notification that enemy-initiated hostilities may be imminent. This notification may be received from hours to days, or longer, prior to the initiation of hostilities.

Requirements

On December 19, 1986, the President instructed DOD to begin developing a rail garrison basing system for the Peacekeeper missile and directed that it achieve initial operational capability by December 1991. The Congress had previously limited Peacekeeper missile deployment in Minuteman silos to 50 missiles and instructed DOD and the Air Force to develop more survivable concepts for the missile's basing. The rail garrison concept enables the Air Force to deploy 50 Peacekeeper missiles on rail cars and accomplish survivability by moving them onto the commercial railroad network upon national need.

Air Force officials stated that the Peacekeeper mission is primarily one of prompt retaliatory response whether based in a silo or on a train. According to the Air Force, the rail garrison basing mode will deter attackers and provide an acceptable level of survivability because the enemy faces an extremely difficult targeting problem when the trains move onto the commercial railroad. The Office of the Secretary of Defense and the Air Force agree that rail garrison appears to meet the requirements for additional warheads in a survivable basing mode. The Strategic Air Command's formal Statement of Operational Requirements Document was validated by Air Force Headquarters in March 1988.

The Secretary of Defense recently stated that DOD's primary near-term objective in modernizing land-based ICBM forces is to counter Soviet advantages in hardened target¹ capability by deploying more accurate missiles with increased capability to hold very hard Soviet targets at

¹A hardened target is defined as a location that provides protection against the effects of nuclear explosions, such as a hardened missile silo.

risk. To this end, the Air Force is deploying 50 Peacekeeper missiles in refurbished Minuteman silos at F.E. Warren Air Force Base, Wyoming. The Secretary of Defense has stated that his long-term objective is to deploy Peacekeepers in a basing mode that is more survivable. To do this, the Air Force is developing rail garrison basing for the Peacekeeper force. DOD's long-term goal is to deploy 100 Peacekeepers in rail garrisons, including the 50 missiles initially deployed in silos.

Schedule

During 1985 and 1986, the Air Force evaluated and identified more survivable basing modes for the Peacekeeper missile. The rail garrison basing concept developed from these follow-on basing concept studies. In late 1986, the Secretary of Defense recommended, and the President directed, that DOD develop this concept. The Air Force proceeded into the development phase, bypassing demonstration and validation. The Defense Acquisition Board recommended that the program proceed into full-scale development on May 10, 1988. An initial production decision for the rail garrison is currently scheduled for April 1990.

Selected major program milestone dates, as approved by the program office in February 1988, are listed in table III.4.

Table III.4: Selected Major Program Milestones for the Rail Garrison

Milestone	Date
Begin full-scale development	May 1988
System design reviews	Aug. 1988
Preliminary design reviews	Feb. - May 1989
Critical design reviews	Dec. 1989 - Mar. 1990
Initial production decision	Apr. 1990
Basing mode verification tests	June 1991 - May 1992
Initial operational capability	Dec. 1991
Full-rate production decision	Mar. 1992

In September 1987, the Air Force awarded the Boeing Aerospace Company a Basing Test and System Support contract. Under this contract, Boeing is to provide comprehensive, validated system requirements and specifications to support production and deployment of the rail garrison system. Contracts for the missile launch car and launch control system are scheduled for award in May 1988 after full-scale development approval.

The primary driver of the overall Peacekeeper Rail Garrison program schedule is the presidentially-directed December 1991 initial operational capability—defined as one train on alert with two missiles, plus one spare train, available to the Strategic Air Command. Cost, performance requirements, and contract delivery schedules have all been developed around this date, and any trade-offs necessary in the future will be made with the primary objective of maintaining it without degrading mission objectives. The program office believes that the schedule is challenging, yet achievable. We view the schedule to be success-oriented with little margin for error should unforeseen problems occur.

Performance

The rail garrison concept is in the latter stages of system definition, and any assessment of its technical performance must await the results of testing planned during full-scale development. However, program office representatives believe that there are no major technical risks involved and that the development program is principally an engineering integration effort. In addition to demonstrating technical performance, the Air Force needs to resolve (during full-scale development) issues such as (1) interoperability with the railroads, (2) garrison site basing selection, and (3) security and safety. According to the program office, preliminary efforts to address these issues are proceeding well.

Cost

In January 1988, the program office estimated that the Peacekeeper Rail Garrison basing program would cost about \$7.4 billion (escalated dollars), exclusive of operational missile costs.² An Air Force Independent Cost Analysis team reviewed the estimate and found it to be reasonable. Table III.5 depicts the program office's acquisition cost estimate by cost category.

Table III.5: Peacekeeper Rail Garrison Acquisition Costs (In Escalated Dollars)

Dollars in millions	
Item	Cost
Research and development	\$2,871
Procurement	3,594
Construction	921
Total Acquisition	\$7,386

²Program office documentation shows that 50 additional deployed missiles and 12 operational test and evaluation missiles will cost about \$3.2 billion.

The Congress reduced DOD's fiscal year 1988 rail garrison funding request from \$591 million to \$350 million. As a result of decreases in estimated acquisition costs due to better program definition, the Air Force reduced its fiscal year 1989 request from \$1.2 billion to \$793 million. Given these funding levels and provided that the Congress appropriates currently estimated out-year funds, the Air Force expects to meet its December 1991 initial operational capability date.

In November 1987, the Congress stated that its authorization of research and development funds for the proposed rail-mobile basing mode did not constitute a commitment or express an intent by the Congress to provide funds to deploy any Peacekeeper missiles in a rail-mobile basing mode. The December 1987 Conference Committee report on DOD fiscal year 1988 appropriations stated that \$350 million was being provided for the rail garrison program in order to maintain the 1991 initial operational capability date.

Recent GAO Reports

Procurement: Delivery Problems With Inertial Measurement Units (GAO/NSIAD-87-74BR, Dec. 18, 1987).

ICBM Modernization: Status, Survivable Basing Issues, and Need to Reestablish a National Consensus (GAO/NSIAD-86-200, Sept. 19, 1986).

Status of the Intercontinental Ballistic Missile Modernization Program (GAO/NSIAD-85-78, July 8, 1985).

Short Range Attack Missile II

The Air Force's Short Range Attack Missile (SRAM) II is to be an improved nuclear air-to-surface missile capable of penetrating advanced defensive threats and striking targets from stand-off ranges. The SRAM II is to have greater range, speed, lethality, and accuracy than the existing SRAM A. The Air Force Strategic Air Command will incorporate the SRAM II into the strategic aerospace offensive forces, with the B-1B³ and advanced bombers as the primary carrier aircraft. Originally called the Advanced Air-to-Surface Missile, the SRAM II is to replace the SRAM A currently in the inventory. The program is in full-scale development, and an initial production decision is scheduled for July 1991. The Air Force estimates acquisition costs at \$2.4 billion (escalated dollars) for 1,633 missiles.

DOD has concluded that it must replace the SRAM A and that the SRAM II is the only way to meet its requirements. The schedule was delayed about 1 year because of changes during contractor source selection, difficulties with warhead requirements, and a decision by the Office of the Secretary of Defense to reduce concurrence in the schedule. The missile's performance will be demonstrated when the first live launch occurs in September 1990, and the Air Force considers technical risks to be low because existing propulsion, guidance, and airframe technology are to be used. Cost estimates have not increased in the past 2 years. The Air Force considers the program a high priority, and Air Force officials believe that the program will be adequately funded. The SRAM II program was not cut in the amended fiscal year 1989 budget request.

Background

The Air Force initiated the SRAM II program after an unsuccessful attempt to establish a new production source to replace the existing SRAM A rocket motor. The original contractor had gone out of business, and the Air Force was concerned about the potential effects of aging on the motor and about the declining SRAM A inventory. The Office of the Secretary of Defense approved the SRAM II program as a new start in fiscal year 1985.

The Air Force competitively selected three contractors in February 1985 to perform system definition studies and to conduct component risk reduction testing. The Air Force used these studies and test results to select two key SRAM II missile characteristics—size and propulsion type—and to develop specifications for the subsequent development

³In order for the B-1B to carry the SRAM II, modifications to the aircraft will be required. The Air Force currently estimates that the modification kits will total about \$450 million.

contract. In April 1986, the Air Force issued a request for proposal for pre-full-scale development, full-scale development, initial production (of 100 units), and the first lot (of 300 units) of full-rate production. Two of the three contractors submitted proposals. The Air Force awarded the pre-full-scale development contract to Boeing Aerospace on April 29, 1987.

The missile is comprised of three major sections: the forebody, which contains the warhead; the centerbody, which contains the avionics and the dual-pulse solid propellant rocket motor; and the boattail, which contains the control surfaces and control actuators. Figure III.4 shows an artist's conception of the SRAM II.

Requirements

The Air Force believes that, even with modifications, the SRAM A--which achieved an initial operational capability in August 1972--will not continue to meet strategic penetrating bomber needs. Therefore, it plans to develop and procure the SRAM II as a replacement missile with improved capabilities. Compared to SRAM A, the SRAM II is to have increased range, greater speed, greater lethality, and better accuracy and is to use a new warhead that meets current criteria for nuclear safety. Also, the SRAM II is to have improved reliability, availability, and maintainability. The Air Force justifies replacing the SRAM A on the basis that

- the SRAM A inventory has declined and will continue to do so as missiles are expended in testing,
- the effects of aging could further reduce inventory and degrade effectiveness and safety,
- SRAM A's warhead does not meet current criteria for nuclear safety design, and
- a more capable missile is needed because enemy defenses have improved and target characteristics have changed since SRAM A became operational.

The SRAM II program has generated substantial congressional concern over whether the Air Force adequately considered potential alternatives, such as modifying the existing SRAM A. At the request of the Congress, DOD submitted a report in April 1987, which compared SRAM II with two SRAM A modification options. DOD stated that modifying SRAM A would cost less than SRAM II but that a sufficient number of missiles to meet long-term requirements could only be provided by a new missile production line. DOD also concluded that only the SRAM II meets stated requirements, that problems would be encountered if SRAM A were re-

Figure III.4: Artist's Conception of the SRAM II Missile



motored, and that the SRAM A warhead does not meet current criteria for nuclear safety design.

In our December 1987 report, we agreed with DOD's conclusion that no single SRAM A modification or combination of modifications could overcome the basic limitations imposed by the declining inventory of an out-of-production missile.¹ We also stated that the inventory issues, safety concerns, effects of aging, logistics support problems, and the apparent

¹Strategic Forces: Justification for the Short Range Attack Missile II (GAO/C-NSIAD-88-10BR, Dec. 31, 1987).

need for improved missile capabilities were legitimate concerns, which supported replacement of the SRAM A.

Schedule

The Air Force chose an accelerated acquisition approach for SRAM II because it needed an operational system in the early 1990s and because it considered the development program to be low risk. Under this approach, the Air Force bypassed the demonstration/validation phase and proceeded to full-scale development.

Table III.6 compares the SRAM II's schedule as approved in 1985 to the currently estimated schedule.

Table III.6: SRAM II Approved and Current Schedules

Event	Approved schedule	Current schedule
System concept paper	Feb. 1985	Feb. 1985
Full-scale development decision	June 1987	Aug. 1987
Preliminary design review	July 1987	Nov. 1987
Critical design review	June 1988	May 1989
First live launch	Oct. 1989	Sept. 1990
Initial production decision	Apr. 1990	July 1991
Full-rate production decision	Sept. 1991	Oct. 1992
Initial operational capability (50 missiles)	Mar. 1992	Apr. 1993

The schedule changes resulted from adjustments made during the contractor source selection process and from difficulty in reaching agreement on warhead requirements. Also, in 1986 DOD delayed production funding from fiscal year 1989 to fiscal year 1990 because of concern regarding the degree of concurrence in the schedule. Production funding for 1,633 missiles is scheduled to begin in fiscal year 1990 and extend through fiscal year 1996, with missile deliveries scheduled from fiscal years 1991 through 1997.

Performance

Because the first SRAM II live launch is not scheduled until September 1990, no performance assessment using test results is possible at this time. The Air Force considers technical risks to be low since existing propulsion, guidance, and airframe technology are to be used.

Cost

The SRAM II cost estimate, as reflected in the December 31, 1987, Selected Acquisition Report, is \$2,393.4 million (escalated dollars),

including \$1,082.9 million for research, development, test, and evaluation and \$1,310.5 million for procurement of 1,633 missiles. Warhead costs are not included in the estimate. In fiscal year 1987, \$65.5 million was provided for development; in fiscal year 1988, \$174.2 million is planned; and in the fiscal year 1989 budget submitted in February 1988, \$231.5 million is proposed to continue development. Estimated costs have not increased in the past 2 years.

The Air Force considers the SRAM II a high priority program. Air Force officials said that they expect continued funding support for the SRAM II program. For example, the original request for \$231.5 million in fiscal year 1989 was not cut in the amended fiscal year 1989 budget request.

Recent GAO Reports

Strategic Forces: Justification for the Short Range Attack Missile II
(GAO/C-NSIAD-88-10BR, Dec. 31, 1987).

Strategic Forces: Justification for the Short Range Attack Missile II
(GAO/NSIAD-88-81BR, Dec. 31, 1987).

DOD Acquisition Programs: Status of Selected Systems (GAO/NSIAD-87-128,
Apr. 2, 1987).

Titan IV Expendable Launch Vehicle

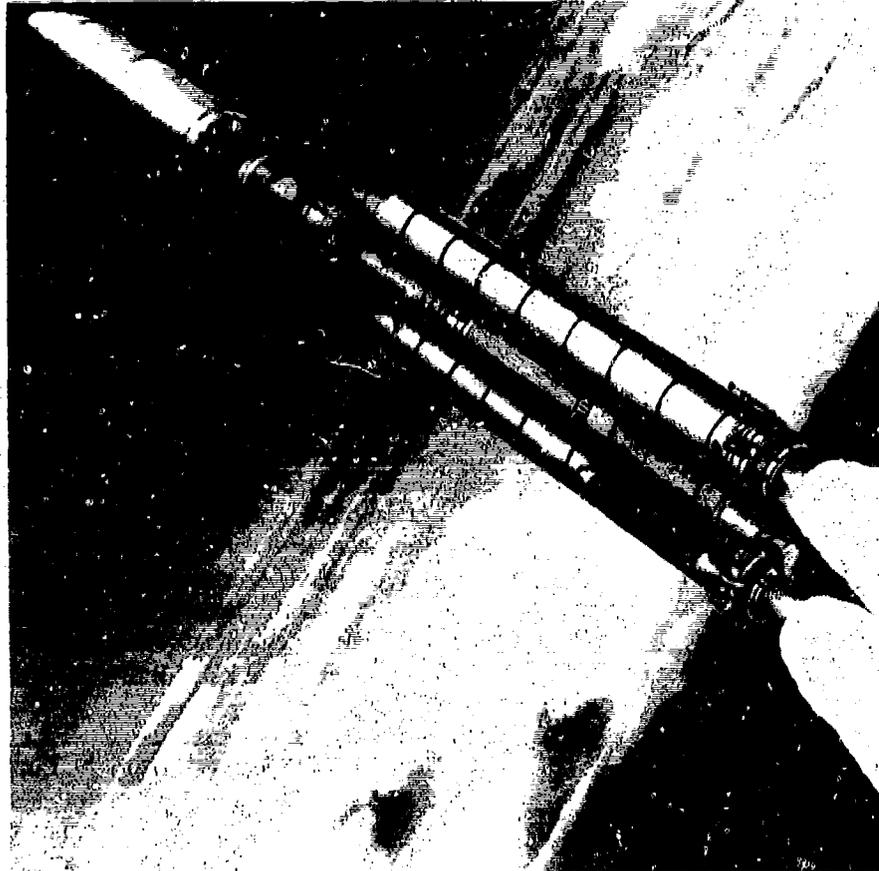
The Titan IV is an expendable launch vehicle intended to launch the nation's highest priority space systems. The vehicle has five configurations, dependent upon the payload to be carried and the desired orbit. The program is in its third concurrent development and production year, and the initial launch capability for the first of five Titan IV configurations is scheduled for October 1988. Initial launch capability dates for two configurations have slipped, and the Titan IV/Inertial Upper Stage (IUS) configuration falls short of its performance requirement. According to the December 1987 Selected Acquisition Report, the estimated cost for the 23 vehicles under contract is \$5.1 billion (escalated dollars), an 18 percent increase since last year. However, the program office estimates that the 23 vehicles will cost \$6.6 billion (escalated dollars). According to the program officials, the Congress recently approved the Air Force's request to increase the program quantity to 48 vehicles, bringing total costs estimated by the program office to \$12.7 billion (escalated dollars). Costs have increased in the past year, and the program office estimate does not include \$175 million of launch pad cost increases and funds from other programs. Although the program could have some funding shortfalls in fiscal year 1989, program officials stated that the fiscal year 1989 amended budget contains sufficient funding for the program and that the program is a high enough priority to receive sufficient funding in future years.

Background

The Titan IV evolved from the family of Titan launch systems, which DOD and the National Aeronautics and Space Administration (NASA) have used for over 25 years. It consists of five major components—a 119-foot, two-stage, liquid propellant core; a pair of seven-segment solid rocket motors; three liquid rocket engines; a Centaur upper stage;⁶ and payload fairings of four different lengths. There are five Titan IV configurations designed to lift a variety of payloads into several different orbits: the Titan IV/IUS to launch 5,000-pound class payloads to geosynchronous orbit; the Titan IV/Centaur to launch 10,000-pound class payloads to geostationary orbit; and three versions of the Titan IV/No Upper Stage (NUS) to launch 30,000-pound class payloads to low earth orbit. Figure III.5 shows the Titan IV/Centaur.

⁶An upper stage is used to provide additional propulsion to carry payloads from a lower orbit to a higher orbit.

Figure III.5: The Titan IV/Centaur
Expendable Launch Vehicle



In February 1985, the Air Force contracted with Martin Marietta Corporation for 10 Complementary Expendable Launch Vehicles, now called Titan IVs, all planned for a Cape Canaveral, Florida, launch. After the loss of the space shuttle Challenger and two Titan 34D (an earlier Titan model) failures, the Air Force contracted with Martin Marietta for 13 more Titan IVs (including the Titan IV/IUS and one Titan IV/NUS configuration), for a total of 23 vehicles, and one modified launch pad at Vandenberg Air Force Base, California. The Air Force also plans to contract separately for a new launch pad at Vandenberg to support the 23-vehicle program. According to program officials, in December 1987, the Congress approved the Air Force's request for 25 additional Titan IVs (including two more Titan IV/NUS configurations) and a second modified

Cape Canaveral launch pad. This will bring the total program to 46 vehicles and 4 launch pads. Program officials said that they need the additional Titan IV vehicles because NASA delayed the shuttle's return-to-service flight and reduced the shuttle flight rate from 16 to 14 per year. The Air Force has a fixed-price incentive contract for 23 vehicles, and program officials expect to contract for the additional 25 vehicles in early fiscal year 1989.

Requirements

DOD initiated the program as a result of its 1984 Space Launch Strategy, which stated that total reliance upon the shuttle for sole access to space, in view of the shuttle's technical and operational uncertainties, represented an unacceptable national security risk. DOD saw the need for a complementary system to provide the United States with high confidence of access to space, particularly given that the shuttle was envisioned as the only launch vehicle for all U.S. space users at that time. The strategy called on the Air Force to acquire a commercial, unmanned, expendable launch vehicle to complement the shuttle, which the Air Force is implementing with the Titan IV. There are no other U.S. expendable launch vehicles that can meet the requirements.

Schedule

The Titan IV's overall schedule risk is moderate, according to the program manager. However, two initial launch capability dates for the three original Titan IV configurations have slipped, as shown in table III.7.

Table III.7: Comparison of Titan IV Initial Launch Capability Dates

Configuration	Launch site	Apr. 1987 schedule	Mar. 1988 schedule	Slippage (in months)
Titan IV/IUS	Canaveral	Oct. 1988	Oct. 1988	0
Titan IV/Centaur	Canaveral	Feb. 1990	May 1990	2
Titan IV/NUS	Vandenberg	Apr. 1989	Feb. 1990	10
Titan IV/NUS	Vandenberg	--	Oct. 1990	*
Titan IV/NUS	Canaveral	--	Jan. 1989	*

According to the program manager, the Air Force can make the Titan IV/IUS date, but the schedule will be very tight. In fact, the Air Force plans to begin assembling the first Titan IV/IUS on the launch pad prior to an important core vehicle test at the plant. The program manager said that the Air Force will have to take the vehicle off the pad and delay the initial launch if the test reveals significant problems.

According to a program official, the 2-month Titan IV/Centaur delay occurred because the start of Centaur development was delayed due to inadequate funding for fiscal years 1985 and 1986. The 10-month Titan IV/NUS delay occurred because its initial launch follows a Titan 34D launch from the same Vandenberg launch pad, and this launch was delayed. According to the program manager, because the Air Force plans the initial Titan IV/IUS and one of the Titan/NUS launches from the same launch pad, a Titan IV/IUS launch slip could cause an equivalent Titan IV/NUS launch slip.

The Air Force needs the core vehicle, current solid rocket motors, liquid rocket engines, and a 56-foot payload fairing for the October 1988 Titan IV/IUS launch. The Air Force plans six core vehicle tests starting in June 1988 and ending in September 1988. A program official said that the Air Force had successfully completed the only two tests planned on the current solid rocket motors. However, a problem surfaced with the cone at the bottom of one of the motors. The official said that he will not be able to estimate motor development completion until he knows the cause of the problem and a solution. According to program officials, the Air Force successfully test-fired the liquid rocket engines to be used on the October 1988 initial launch for the full 445-second flight duration, but for all subsequent tests the Air Force plans to test-fire the engines for 20 seconds. A program official stated that the Air Force successfully completed one major test on the 56-foot payload fairing and plans to complete the remaining two major tests by June 1988. The Air Force plans to begin testing an 86-foot fairing in June 1988 and complete testing in May 1989. The Air Force plans to evaluate 66- and 76-foot fairings using computer models rather than actual tests.

The Air Force plans to conduct the two major Centaur tests both beginning in November 1988 and ending by July 1989 and to complete Centaur development by December 1989. Because the Centaur's performance requirement has increased, the test program will change, but an official said that he will not know how the program will change until June 1988.

Beginning in fiscal year 1989, the Air Force plans to incrementally increase production from 5 to 10 Titan IVs per year, achieving the 10-per-year rate by fiscal year 1991, according to a program official. For fiscal years 1989 through 1993, the Air Force plans a total of 30 launches, but only 22 of the 23 vehicles under contract are to be delivered by that time. A program official stated that some of the 25 vehicles

yet to be placed under contract will be used to cover the 8-vehicle shortfall.

Starting in 1991, the Air Force plans to replace the current solid rocket motor with an upgraded motor to increase reliability and performance. According to a program official, the upgrade is a major development effort, while another program official stated that the upgrade requires concurrent, problem-free development and production to meet the 1991 date.

Performance

Each of the five Titan IV configurations has its own performance requirements. The program office uses computer model simulations, done on a continual basis, to estimate the capability of the vehicles to meet their requirements. The Titan/IUS has three primary requirements. The first requirement is to deliver a 38,784-pound IUS and satellite to an 80 nautical mile by 95 nautical mile, 28.6 degree inclination orbit. As of December 1987, the program office estimated that the Titan IV/IUS will exceed the requirement by 177 pounds. The second requirement is for the IUS to lift a 5,250-pound payload, plus or minus 90 pounds, to a geosynchronous orbit (the 90-pound range is to allow for variations in the payload's weight). As of February 1988, the program office estimated that the vehicle had a 5,261-pound capability, 11 pounds over the 5,250 pounds but 79 pounds short of the 5,340-pound upper end. The third requirement is for the IUS to lift from 5,050 pounds to 5,250 pounds to a geosynchronous orbit. As of February 1988, the program office estimated that the vehicle had a 5,208-pound capability, 42 pounds short of the 5,250-pound upper end. The program office estimates that the Titan IV/Centaur and the Titan IV/NUS configurations will meet all of their requirements.

Starting in 1991, all Titan IVs are to use the solid rocket motor upgrade to increase solid rocket motor (1) lift capability, primarily by increasing the casing's diameter and replacing the steel motor casings with lighter filament-wound casings, and (2) reliability. According to a program official, no U.S. launch vehicle has ever used a filament-wound casing of this diameter, but another program official stated that an adequate test program will reduce the casing's risks.

A program official said that the Air Force is concerned about the current motor's reliability because of the failures of the Challenger and the Titan 34D, both of which use solid rocket motors. However, the upgrade

will only increase reliability from 0.9975 to 0.9986. The 0.0011 increase would save one Titan IV failure about every 909 launches.

The motor upgrade is also intended to provide the additional lift capability required by one payload. The Titan IV/NUS's lift requirement for a Vandenberg launch with the new motor is 40,000 pounds, compared to 32,000 pounds with the existing motor. The Titan IV/Centaur's requirement has increased from 10,000 to 12,700 pounds to geosynchronous orbit. Program officials have not yet assessed vehicle performance against these requirements. According to a program official, meeting the increased requirements may require changes to the Centaur.

Cost

The December 1987 Selected Acquisition Report estimates the 23 vehicles under contract at \$5,133.5 million, compared to last year's \$4,334.6 million estimate—an 18-percent increase. The program office estimate differs from the Selected Acquisition Report, showing estimated costs for the 23 vehicles, without the solid rocket motor upgrade, at \$6,596.4 million (escalated dollars).¹⁰ The latest program office estimate does not include a \$126.1 million cost increase to provide the new Vandenberg launch pad or \$48.9 million to be obtained from another program. The program office estimates that the additional 25 vehicles will cost \$6,075.0 million. However, included in the cost are \$610 million for rocket motor upgrades on 13 of the first 23 vehicles, which should be allocated to the cost estimate for the 23 vehicles. The program office estimates the 48-vehicle program costs at \$12,671.4 million. The Selected Acquisition Report does not include a cost estimate for 48 vehicles. Adding the \$126.1 million and \$48.9 million costs that were excluded would bring the estimate for 48 vehicles to \$12,846.4 million (escalated dollars). Satellite programs that will use the Titan IV will fund \$5,510 million of the total costs. A program official stated that an independent cost analysis of the Titan IV cost estimate should be completed by April 1988.

The program office estimate includes modifying a launch pad at Cape Canaveral for \$157 million and modifying one at Vandenberg for \$169 million. Since last year, the estimate for the Cape Canaveral pad has increased 20 percent, and the estimate for the Vandenberg pad has increased 109 percent. The new Vandenberg pad is estimated to cost

¹⁰One major difference between the program office estimate and the Selected Acquisition Report is that the program office estimate includes \$884 million in operations and maintenance costs that the Selected Acquisition Report does not include.

\$726 million, but no estimate was available from last year for comparison. The program estimate includes \$155 million to modify a second Cape Canaveral pad, which was recently added to the program with the additional 25 vehicles.

The 23-vehicle contract is for \$4,382.1 million (escalated dollars). As of January 1988, the contractor estimated a \$59 million overrun at contract completion, while the program office estimates a \$53 million overrun. The Air Force will be responsible for 90 percent of whatever overrun exists at contract completion up to the contract ceiling price. The program cost estimate for the 25 additional Titan IVs includes \$758.0 million to increase production from 5 to 10 Titan IVs per year and to increase the launch rate. It also includes \$2,219 million for the solid rocket motor upgrade, which will be offset somewhat by \$1,258 million that will not have to be paid to the current solid rocket motor contractor, for a net solid rocket motor upgrade cost of \$961 million.

The Air Force plans to indefinitely produce and launch 10 Titan IVs per year. Beyond the 48-vehicle program, the program office estimates that producing 20 more Titan IVs will cost \$3,084 million.

The Congress reduced Titan IV funds by \$75 million in fiscal year 1987. Although the program office anticipated at least a 3-month schedule slip if the funds were not restored that same year, no slip occurred. The funding was restored, but program officials said that they had not received all of it until fiscal year 1988. The program office estimates a \$385.8 million shortfall in fiscal year 1988. To fund the shortfall, according to a program official, the program office received \$80 million and expects another \$107 million from a satellite program that will use the Titan IV and anticipates receiving an additional \$198.8 million from DOD. If the program office does not receive the additional funds for fiscal year 1988, a program official said that some efforts, including development of the solid rocket motor upgrade, the Centaur, and production enhancements (related to increasing the production rate), would be discontinued. According to the program office, the amended fiscal year 1989 budget contains the \$1,824 million the program will need. Despite potential funding problems for fiscal year 1988, program officials believe that the program has a high enough priority within the Congress and the executive branch to obtain the funding needed to successfully complete the program.

**Appendix III
Air Force Programs**

Recent GAO Report

DOD Acquisition Programs: Status of Selected Systems (GAO/NSIAD-87-128,
Apr. 2, 1987).

Advanced Medium Range Air-to-Air Missile

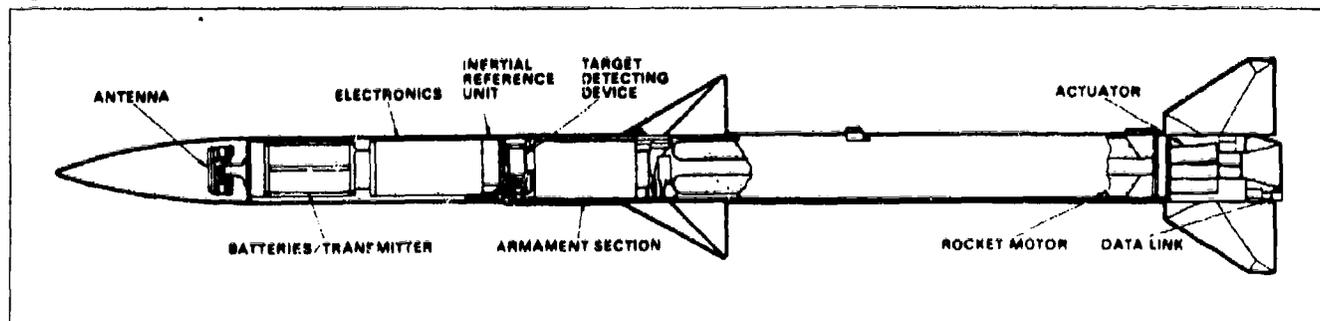
The Advanced Medium Range Air-to-Air Missile (AMRAAM) is being developed jointly by the Air Force and the Navy to meet their medium-range air-to-air missile requirements through the year 2005. The program is nearing the end of its full-scale development phase and has already begun initial production. The full-rate production decision is scheduled for March 1989. Program acquisition costs are estimated at \$8.7 billion in 1984 dollars (\$11.2 billion when inflation is considered). This estimate includes \$1.2 billion for research and development and \$7.5 billion for procurement of 24,320 missiles.

According to DOD, AMRAAM is the best alternative for providing improved medium-range air-to-air missile capabilities. However, some schedule, performance, and cost risks still exist in the program. Testing has fallen behind schedule, and additional schedule slippage appears likely because of the large number of tests still to be completed. DOD cannot make an accurate assessment of AMRAAM's performance capabilities until the design is complete and has been tested. Almost all of the tests conducted to date have been with interim design missiles. The validity of the current cost estimate depends primarily on whether assumptions about cost savings from planned future design changes and competitive procurements materialize. DOD considers the AMRAAM a high priority program, but it has sustained some funding cuts by the Congress in recent years.

Background

The AMRAAM is to replace the Sparrow air-to-air missile and is to be compatible with the services' latest fighter aircraft—the F-14, the F-15, the F-16, and the F/A-18—as well as future aircraft such as the Advanced Tactical Fighter. The AMRAAM has a built-in radar tracking capability that allows the launching aircraft either to turn away from the target once the missile is launched or to engage additional targets, a feature the Sparrow does not have. The AMRAAM, which is about 12 feet long and weighs about 335 pounds, is smaller and lighter than the Sparrow. (See fig. III.6.)

Figure III.6: The AMRAAM



The AMRAAM program experienced substantial cost growth and schedule delays between 1978 and 1985. DOD restructured the program and adopted revised cost and schedule estimates in 1985. In 1986, the Secretary of Defense certified to the Congress that the missile met certain cost, design, testing, and performance requirements.

Requirements

A 1976 joint Air Force and Navy tactical study of air-to-air weapons requirements for 1985 and beyond identified the need for an AMRAAM. The study group, composed primarily of combat-experienced Air Force, Navy, and Marine Corps air crew members, determined that existing air-to-air missile systems had a number of operational limitations. These shortcomings formed the basis for the AMRAAM's Joint Service Operational Requirement, which was approved on September 15, 1976. The joint requirement called for a missile with advanced capabilities to succeed the Sparrow and defined a total of 33 specific requirements that the missile had to satisfy. These requirements include higher speed, greater range, increased maneuverability, the ability to engage targets from any approach angle, and better resistance to electronic countermeasures.

DOD reaffirmed the need for AMRAAM in 1985. At that time, the Secretary of Defense directed the Assistant Secretary of the Air Force for Research, Development and Logistics to conduct a comprehensive review of the AMRAAM program and alternatives for meeting the requirements. The Air Force examined about 20 program alternatives during the review, including variants of an improved Sparrow missile. The review reaffirmed the AMRAAM requirement and concluded that all of the alternatives were unacceptable either because they did not meet the

requirements or because they were projected to take longer to develop and to cost more than AMRAAM.

Schedule

DOD revised the program schedule in 1985 when it restructured the AMRAAM program. Since then, the completion of some tasks has slipped, but the decision point for full-rate production has not changed. Table III.8 compares the AMRAAM's schedule in 1985 with the current schedule as of December 1987.

Table III.8: AMRAAM Schedule

Event	1985 schedule	Current schedule
Functional configuration audit	Nov. 1986	Dec. 1987
Initial production decision	Apr. 1987	June 1987
Development and operational testing complete	July 1988	Oct. 1988
Initial production of full-capability missiles	late 1988	late 1988
Full-rate production decision	Mar. 1989	Mar. 1989
Initial operational capability	Oct. 1989	Oct. 1989
Initial delivery of fully capable missiles	late 1989	late 1989
Follow-on test and evaluation	Jan. 1990	Jan. 1990

As the table indicates, the final stages of the AMRAAM development program run concurrently with initial production. Moreover, DOD will achieve initial operational capability with initial production missiles that have not been designed to meet all performance requirements. The Secretary of Defense plans to review the program in May 1988, before the Air Force finalizes contracts for the production of missiles that have the more advanced design capable of meeting all performance requirements.

The Air Force plans to complete AMRAAM development and initial operational tests, including flight tests of 15 full-capability development missiles, before the March 1989 decision on full-rate production. However, the follow-on operational test and evaluation phase, which is to determine whether the full-capability production missiles actually meet the system requirements, is not scheduled to begin until January 1990—10 months after the decision on full-rate production. Production missiles with the full AMRAAM capabilities would not be available for testing until after the March 1989 decision point.

The schedule for completing some tasks has slipped since the program was revised in 1985. For example, the functional configuration audit, a

review intended to ensure that the design is complete, did not start until December 1987. The flight test program has also proven to be optimistic. Through December 1987, AMRAAM had completed 26 fewer guided flight tests than the Air Force originally scheduled for completion by that time. Some significant tests that have slipped are the first live-warhead test (which slipped 14 months to February 1988), a test to simultaneously engage four targets (which slipped 14 months to June 1988), and the first test of a fully capable development missile (which slipped 7 months to February 1988).

To cover the slippage in the flight test schedule, the Air Force recently negotiated a contract option to extend the contractor flight test support by 3 months to October 1988. However, a further slip in completion of flight testing appears likely because of the large number of tests still to be completed. To complete development flight testing within the 3-month extension, the Air Force would have to launch an average of about four missiles a month from January through October 1988. Since a third test site became fully operational in March 1987, however, the Air Force has fired an average of only about three missiles each month. Also, the Air Force was not able to launch any of the three missiles planned for January 1988. If the average test rate does not increase, testing may not be completed until about the time of the March 1989 full-rate production decision. If the Air Force encounters additional delays, it may not complete testing by that time.

Performance

DOD cannot accurately assess AMRAAM's ability to meet its performance requirements until the design is complete and tested. Tests completed as of January 1, 1988, have demonstrated the missile's ability to meet many performance requirements, but these tests used an interim configuration missile. The Air Force cannot conduct the most demanding development tests and many of the more realistic operational tests until missiles designed to meet all performance requirements are available. The Air Force completed the first development flight test of a fully capable missile in February 1988 and has scored the test as successful.

The Air Force plans to conduct 89 guided flight tests of AMRAAM—64 of which are classified as development and 25 as operational. As of January 1, 1988, AMRAAM had completed 51 guided flight tests, including 45 development tests and 6 operational tests. Of the 51 completed flight tests, the Air Force scored 40 as successful and 8 as unsuccessful; 3 tests were not scored. These tests have demonstrated a number of AMRAAM performance capabilities, but they have also identified some areas that

will require additional testing. For example, AMRAAM was not always successful when fired at targets simultaneously employing more than one countermeasure. The Air Force plans another test in this environment but not until after the May 1988 program review, which is to approve funding for the second production year.

The Air Force Operational Test and Evaluation Center currently rates the missile's operational performance as marginal but improving. The Center based this assessment on firing the first six missiles during AMRAAM's initial operational tests. Four of the six missiles were successful, including the last two missiles fired.

DOD did not require the Air Force to demonstrate all AMRAAM performance requirements before beginning low-rate production. For example, DOD did not require that the missile demonstrate full electronic countermeasure performance or the minimum requirement for multiple simultaneous engagements before the decision to begin initial production. To gain approval for the second year of low-rate production, AMRAAM will have to demonstrate capabilities beyond those demonstrated for the initial low-rate production decision but will not have to demonstrate all required capabilities. For example, DOD requires that tests using live warheads and tests against higher altitude, higher speed targets be conducted before it grants approval to begin the second production year.

Cost

The Air Force currently estimates that AMRAAM acquisition costs will total \$8.7 billion (1984 dollars), including \$1.2 billion for research and development and \$7.5 billion for procurement. The estimate for research and development should remain stable, although the Air Force may require an increase to extend the full-scale development contract and to settle a contractor claim. Achieving the \$7.5 billion procurement estimate will depend primarily on the extent to which assumed savings from planned future design changes and competitive procurements materialize.

The principal component of the research and development estimate is \$567.6 million for the full-scale development contract with Hughes Aircraft Corporation. The contract is at its fixed-ceiling price and therefore should not increase substantially unless the government increases the scope of work. The Air Force recently negotiated a \$1.8 million option to extend the development contract with Hughes by 3 months to continue needed test support. Another factor that could affect the estimate is a \$60 million Hughes claim against the government for costs exceeding the

fixed ceiling price of the contract. If the claim is upheld, the development estimate will increase because it does not include reserves to cover the claim.

The National Defense Authorization Act for fiscal year 1987 provides that AMRAAM's procurement cost may not exceed \$7 billion (1984 dollars) for 24,000 missiles. However, the act provides that the \$7 billion cap may be adjusted for the effects of congressional funding reductions. According to the Air Force, the production program will stretch out and the ceiling will increase to \$7.6 billion as a result of congressional funding reductions in fiscal years 1987 and 1988.

The current procurement cost estimate is based on a detailed analysis of material and labor costs, including the negotiated costs of contracts for the first production year. Underlying the estimate, however, are a number of uncertainties and assumptions that could change. For example, the estimate reflects \$1.9 billion (1984 dollars) in savings projected from a number of design changes to reduce production costs. Most of these are to be incorporated in the fourth production year (fiscal year 1990). The accuracy of the estimated savings will remain uncertain until the Air Force negotiates contracts for missiles with the advanced design.

Another major uncertainty is the amount of savings anticipated from contractor competition. The estimate assumes that DOD can save \$1.1 billion (1984 dollars) by having two contractors compete for the larger share of each year's production quantities beginning in the third production year (fiscal year 1989). The estimate recognizes that the savings could increase or decrease depending on how aggressively the contractors compete.

AMRAAM priority is very high within the Air Force, the Navy, and DOD. However, congressional concerns over the program's development progress and the proposed schedule for increasing production rates have resulted in appropriations less than the amounts included in the budget requests for fiscal years 1987 and 1988. To avoid further program stretch-outs due to funding, the program office estimates that it will need about \$1 billion yearly for AMRAAM production from fiscal year 1989 through the late 1990s.

Recent Reports

Missile Development: Development Status of the Advanced Medium Range Air-to-Air Missile (GAO/NSIAD-87-168, Aug. 14, 1987).

Missile Procurement: Advanced Medium Range Air-to-Air Missile
Preproduction Test Results (GAO/NSIAD-87-165FS, June 2, 1987).

DOD Acquisition Programs: Status of Selected Systems (GAO/NSIAD-87-128,
Apr. 2, 1987).

Missile Procurement: AMRAAM Cost Growth and Schedule Delays
(GAO/NSIAD-87-78, Mar. 10, 1987).

Missile Development: Advanced Medium Range Air-to-Air Missile
(AMRAAM) Certification Issues (GAO/NSIAD-86-124BI, July 8, 1986).

Missile Development: Advanced Medium Range Air-to-Air Missile Legal
Views and Program Status (GAO/NSIAD-86-88BR, Mar. 28, 1986).

Missile Development: Status of Advanced Medium Range Air-to-Air Mis-
sile (AMRAAM) Certification (GAO/NSIAD-86-60BR, Feb. 18, 1986).

Sensor Fuzed Weapon

The Air Force Sensor Fuzed Weapon (SFW) is a target-seeking munition to be delivered by fixed-wing aircraft. The Air Force is developing the SFW for use against formations of enemy armored vehicles held in reserve behind the battle lines. The program is in full-scale development, and the initial production decision is scheduled for August 1989. The Air Force plans to request the first production funds in fiscal year 1990. As of February 1988, the program office estimated total development and production costs for 19,978 munitions at \$3.2 billion (escalated dollars).

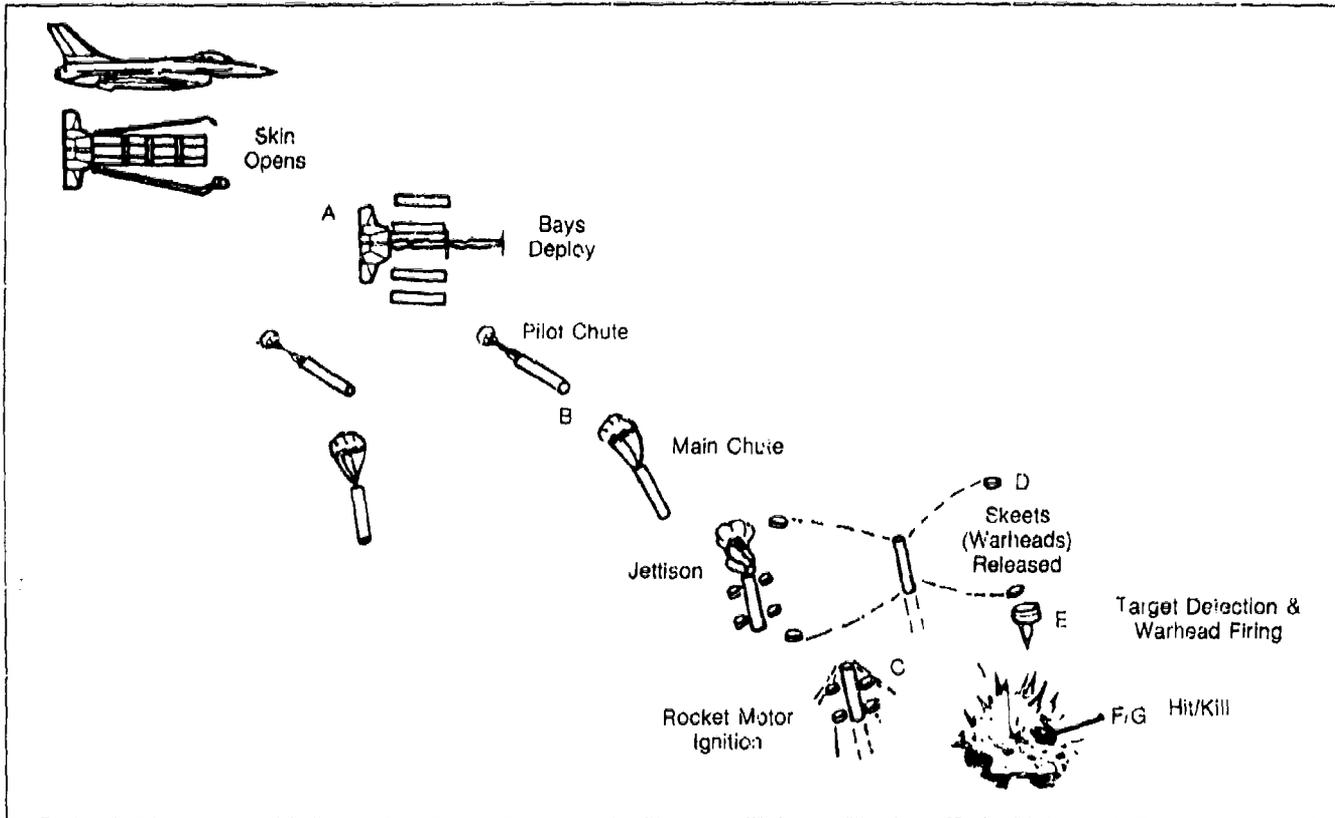
According to the Air Force, the SFW should significantly enhance U.S. anti-armor capabilities and help reduce aircraft losses. Although the SFW has proven to be more complex than originally thought, the SFW program manager rates the system's performance risk as low to medium because the weapon does not depend on high-risk technical advances. However, until development and initial operational tests are completed, any assessment of the weapon's capabilities and utility should be considered preliminary. The program manager rates the program's schedule risk as medium to high, primarily because the contractor's test plan is considered optimistic. The program manager also rates the program's cost risk as medium to high. The SFW has only a medium priority when competing for resources, but the program has received adequate funding in the past.

Background

The SFW will consist of a tactical munitions dispenser containing 10 submunitions. Each submunition will contain four individual warheads, or "skeets."

The delivery aircraft will launch the dispenser upon reaching the target area. At a preset time or altitude, the dispenser will release the submunition launchers. Parachutes will deploy from the submunition launchers to stabilize their descent. At a predetermined distance from the ground, rocket motors will fire to elevate and spin the submunition to dispense the skeets. Once released, an infrared sensor in each of the skeets will scan the target area. When the sensor detects a vehicle, the skeet will fire an armor-piercing penetrator into it. Figure III.7 is an illustration of the SFW and its operational sequence.

Figure III.7: Sensor Fuzed Weapon Deployment Events



The SFW is to be compatible with a number of aircraft, including the F-15E, F-16, F-4, A-7, A-10, B-52, F-111, and several allied nations' aircraft. It will not replace any existing weapon system.

In November 1985, the Air Force awarded a fixed-price-incentive-fee contract for full-scale development to Textron Defense Systems in Wilmington, Massachusetts. Because of prior cost and schedule problems, the Air Force restructured the SFW program in June 1986 and established cost and schedule baselines.

Requirements

The SFW is to provide delivery aircraft the capability to destroy multiple armored vehicles in a single pass over a target area, thus decreasing the time spent over enemy territory. The weapon is also to be capable of

operations during day, night, and all weather conditions. The Air Force established the requirement for such a weapon in the late 1970s. The requirement is included in a 1978 Air Force general operational requirement for wide area anti-armor munitions and a "U.S. Air Force Mission Element Need Statement" dated September 14, 1979.

In May 1987, the Air Force Center for Studies and Analyses prepared an analysis to determine whether the SFW is a cost-effective weapon for attacking second echelon enemy armored formations. The Center concluded that the SFW would be considerably more effective against enemy armor formations than other alternatives—the Maverick missile, Combined Effects Munition, and 30-mm gun.

Schedule

The schedule for completing some milestones has slipped up to 10 months since June 1986. Table III.9 shows changes in the SFW schedule. According to the program manager, there is a medium to high risk of even further program delays.

Table III.9: Sensor Fuzed Weapon Schedule Changes

Event	Approved program estimate (6/30/86)	Current program estimate (2/88)	Schedule delay (months)
Begin risk reduction	July 1984	July 1984	0
Full-scale development contract award	Nov. 1985	Nov. 1985	0
Critical design review	July 1987	Apr. 1988	9
Begin development and initial operational tests	Mar. 1988	Aug. 1988	5
Initial production decision	Nov. 1988	Aug. 1989	9
Production contract award	Dec. 1988	Oct. 1989	10
First delivery to inventory	July 1990	Apr. 1991	9

The schedule delays were caused by the need to correct a structural weakness in the submunition launcher body and anticipated delays in obtaining hardware for tests.

Performance

The SFW program manager rates the weapon's performance risk as low to medium. Although some technical challenges remain, the SFW is not dependent on high-risk advances in technology, according to the program manager. However, until development and initial operational tests

are conducted, any assessment of SFW's performance capabilities should be considered preliminary.

As of February 1, 1988, the contractor had conducted 79 of 117 planned subsystem and system qualification tests. These included tests of the submunition's ejection from the dispenser, warhead design, and parachute subsystem and live tests of the skeet's target detection and warhead firing performance. According to test officials, the testing has shown the SFW to be a more complex system than originally thought, and the system may face additional technical challenges before the critical design review is completed. For example, recent testing revealed a problem with the submunition altimeter, which caused the skeets to malfunction. Additional tests demonstrated that the problem had been resolved.

After a delay of about 9 months, the critical design review was completed in late April 1988. Following that review, the Air Force plans to conduct development and initial operational testing. This testing is to include 28 development test flights to verify that any design deficiencies identified in contractor tests have been corrected and that the system meets all performance requirements. The Air Force will also conduct 36 flight tests under simulated operational conditions to determine the weapon's suitability for use in combat. Together, the development and operational tests are to provide the information needed for the upcoming decision on whether to begin initial production of the system.

Cost

The SFW's estimated total acquisition cost has increased by \$806 million, since its baseline cost was established, primarily due to an increase of 5,894 units to be procured, from 14,084 to 19,978. On a per-unit basis, the estimated cost decreased from about \$171,000 to about \$161,000 per weapon. Table III.10 shows the changes in the cost estimate.

Table III.10: SFW Acquisition Costs
(In Escalated Dollars)

Dollars in millions		
Item	June 1986 estimate	Current estimate (2/88)
Development	\$128	\$154
Procurement	2,278	3,059
Total	\$2,406	\$3,213

The Air Force estimated development costs primarily from data on the actual costs of similar development programs. The production cost estimate was derived from a model that forecasts prices based on the statistical relationship between the technical characteristics of components of other weapons and their actual costs. The formulas used in the model were adjusted to account for differences between the complexity of the SFW's components and the complexity of those used in the model's data base. An independent cost estimate, developed by the Armament Division Comptroller, supports the current estimate. The program manager rates the program's cost risk as medium to high.

According to the program manager, the SFW is a medium-priority program in competing for Air Force resources. However, the program has received adequate funding in the past, and the program manager expressed confidence that it will receive sufficient funding in the future. DOD deleted SFW procurement funds from the amended fiscal year 1989 request because of the delay in the production decision, not because of higher budget priorities, according to the program manager.

Recent GAO Reports

None.

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