United States General Accounting Office

GAO

Report to the Honorable
Denny Smith, House of Representatives

July 1988

MISSILE DEVELOPMENT

AMRAAM's Combat Effectiveness at Production Not Fully Tested

GAO/NSIAD-88-186

GAO

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

National Security and
International Affairs Division

B-221734

July 7, 1988

The Honorable Denny Smith
House of Representatives

Dear Mr. Smith:

This report, prepared at your request, addresses developmental and operational testing of the Advanced Medium Range Air-to-Air Missile at the time of the Defense Acquisition Board's program review for the second low-rate production decision. As requested, we focused on testing to predict how well the missile will perform in combat.

As requested, we did not obtain formal agency comments on this report. However, we obtained the views of Air Force and Navy officials and considered their comments in preparing this report.

Unless you publicly announce the contents of this report earlier, we plan no further distribution until 5 days after its issue date. At that time, we will send copies to the Secretaries of Defense, the Air Force, and the Navy; the Director, Office of Management and Budget; and interested congressional committees.

Sincerely yours,

Frank C. Conahan
Assistant Comptroller General

Executive Summary

Purpose

Short of actual combat, test and evaluation is the primary means of assessing a weapon system's performance. The role of test and evaluation is to demonstrate that a system, before it is produced, can meet performance requirements and that it will be effective in combat. Insufficient testing increases performance uncertainty and the risk of costly redesign and modification after deployment.

Representative Denny Smith requested that GAO review the plans for and report on the status of Advanced Medium Range Air-to-Air Missile (AMRAAM) testing at the time of the Defense Acquisition Board's review for the second low-rate production. Specifically, GAO was asked to assess

- the adequacy of AMRAAM's test plan to ensure that performance requirements are demonstrated in an operationally realistic environment,
- the Air Force's implementation of the plan, and
- the test results.

Background

The Air Force and the Navy are jointly developing the AMRAAM to meet their medium range air-to-air missile requirements into the next century. The AMRAAM, which is to replace the Sparrow missile, is to be compatible with the services' latest fighter aircraft: the F-14, F-15, F-16, F/A-18, and the Advanced Tactical Fighter.

Performance improvements over the Sparrow are to include higher speed, greater range, increased maneuverability, and better resistance to electronic countermeasures. Also, the AMRAAM is to provide the pilot with the capability of simultaneously engaging several targets and then maneuvering to avoid counterattack.

In 1985, concern over rising costs and schedule delays led to a restructuring of the program. The restructured program extended the development schedule from 54 to 79 months and delayed the initial operational capability date from 1986 to 1989.

The Secretary of Defense approved the initial low-rate production of 180 interim design (less-than-full-capability) missiles in June 1987. In May 1988, the Defense Acquisition Board recommended that the Secretary of Defense approve the low-rate production of about 400 full-capability missiles. These missiles will be fielded for combat use and should perform better against enemy countermeasures designed to confuse AMRAAM. The Air Force and the Navy plan to procure more than 24,000

missiles over an 11-year period. The program's development and production cost is estimated at $8.7 billion in 1984 dollars.

Results in Brief

The AMRAAM test plan appears comprehensive. It addresses the system's performance requirements in simulations and flight tests. The Air Force command that represents tactical operational units assessed the planned operational flight tests and concluded that they were operationally realistic and tactically significant. Operational tests are intended to predict how the missile will perform in combat.

The Air Force had planned to complete 89 live-fire tests—64 developmental to demonstrate missile requirements and 25 operational—before the Defense Acquisition Board's review of the program in May 1988. However, it completed 48 developmental and 11 operational tests. Although tests had demonstrated some critical performance requirements, the more difficult and operationally realistic tests had not been conducted. For example, the Air Force had not conducted any operational tests of a full-capability prototype missile. Nonetheless, the tests that were conducted identified performance issues that the Air Force had not resolved. Also, the Air Force changed parameters on some tests, which improved the missile's probability of success. The test delays, problems, and parameter changes increased the risk that the missiles placed in operational inventory will not be effective or reliable in combat.

According to an official with the Office of the Secretary of Defense, the Air Force told the Defense Acquisition Board in May 1988 that good progress had been made toward meeting AMRAAM's tactical requirements and most of the missile's required capabilities had been met. The same official also said that, based on the Board's review, the Secretary is expected to approve the production of 400 full-capability missiles.

GAO's Analysis

Test Plan Will Demonstrate Key Requirements

The AMRAAM test plan addresses each of the system's performance requirements. It provides for a combination of live missile firings, other flight tests, and simulations to demonstrate required performance. The Air Force coordinated the plan within its own and the Navy's test communities and with the Director of Operational Test and Evaluation

within the Office of the Secretary of Defense. The Air Force's Tactical Air Command and the Department of Defense's Institute for Defense Analyses independently assessed the planned tests and concluded that they were realistic and tactically significant and that the plan was adequate to determine whether the system meets requirements.

Test Schedule Could Not Be Achieved

The AMRAAM test program has fallen behind its schedule. The schedule provided for completing all 89 live-fire tests before the Defense Acquisition Board's review of the program in May 1988. However, through April 1988, 59 of 89, or about 66 percent, of the tests had been completed. The causes for the delays can be linked to either the maturity of the missile or the availability of test resources.

Some of the more difficult and realistic tests had not yet been conducted at the time of the second low-rate production review. These included tests to demonstrate AMRAAM's performance against the sophisticated electronic countermeasures that an enemy would use to confuse the missile's guidance.

Completed Tests Have Identified Problems

Although tests conducted through April 1988 demonstrated many performance requirements such as maximum speed, range, and altitude and autonomous guidance, they also identified some problems that had not been fully resolved. For example, the missile was not successful against a very small target intended to demonstrate AMRAAM's capabilities against a cruise missile.

Test Parameters Changed Which Improved Success

The AMRAAM Program Office changed some test parameters prescribed in the plan, which increased the missiles' probability of success. Air Force officials made the changes after simulations showed that the tests had a low probability of success. The changes made the tests less comprehensive. Program officials said some of the original parameters will be included in later tests of missiles with more mature software.

Production Schedules Remain Unchanged

Although development tasks and test schedules have been delayed, the production schedule remained unchanged. For example, design audits to ensure that the missile functions properly and meets specifications will

probably not be completed until October 1988, 5 months after the second low-rate production review. Beginning production without sufficient testing increases the risk of costly redesign and modification after deployment.

Recommendations

GAO's report provides an analysis of AMRAAM testing at the time of the second low-rate production review; it contains no recommendations.

Agency Comments

The views of Air Force and Navy officials responsible for managing the AMRAAM program were obtained during the course of the work and were considered in preparing this report. As requested, GAO did not request formal agency comments on a draft of its report.

Contents

Abbreviations

AMRAAM Advanced Medium Range Air-to-Air Missile
GAO General Accounting Office

Introduction

The Air Force and the Navy are jointly developing the Advanced Medium Range Air-to-Air Missile (AMRAAM) to meet their medium range air-to-air missile requirements into the next century.[1] The primary objective of the AMRAAM program is to produce an all-weather medium range missile capable of simultaneously engaging multiple aircraft in combat. The missile is to destroy targets both within and beyond the pilot's visual range and be compatible with the services' latest fighter aircraft: the F-14, F-15, F-16, F/A-18, and the Advanced Tactical Fighter.

The AMRAAM is to replace the Sparrow missile and is intended to improve aircraft combat effectiveness. Improved performance features over the Sparrow are to include higher speed, greater range, increased maneuverability, better resistance to electronic countermeasures, and an active terminal seeker.[2] The missile's seeker and the launch aircraft's radar enable the pilot to simultaneously track multiple targets, launch multiple missiles, and maneuver to avoid counterattack. The missile is also intended to be more reliable and maintainable than the Sparrow.

The AMRAAM program is nearing the end of full-scale development under contract with Hughes Aircraft Company. Raytheon Company is also under contract to monitor the Hughes design effort and to produce 15 missiles. The purpose of this contract is to qualify Raytheon as a second-source producer. The contractors will share in each year's missile production. For example, in the first production year, Hughes and Raytheon are manufacturing 105 missiles and 75 missiles, respectively.

The Air Force estimates program acquisition cost at $8.7 billion in 1984 dollars. This estimate includes $1.2 billion for research and development and $7.5 billion for procurement of 24,320 missiles.

Program History

In a March 1987 report[3] (GAO/NSIAD-87-78), we stated that overly optimistic cost and schedule estimates had adversely affected the AMRAAM program. For example, the ambitious development schedule resulted in a greater use of older, larger, and more costly electronic circuitry technology. Because of cost increases and schedule slippage, the development and production phases were restructured.

[1]The Air Force is the lead procuring service. The primary office responsible for managing development and production is the Joint System Program Office located at Eglin Air Force Base, Florida.

[2]An active terminal seeker means that the missile's on-board radar can autonomously acquire and track a target.

[3]See appendix I for other GAO reports on AMRAAM.

After the June 1987 program review for initial production, we reported (GAO/NSIAD-87-168) that the unstable AMRAAM design and small number of completed tests increased production risk. The initial production decision was made 13 months before the scheduled completion of development.

Key Milestones and Events

The AMRAAM development program began in October 1975 when the Under Secretary of Defense for Research and Engineering established an Air Force and Navy tactical working group to study requirements for air-to-air weapons for 1985 and beyond. The Congress approved the missile's development in July 1976. In November 1978, the Secretary of Defense approved the program's transition to the validation phase. Two contractors—Hughes and Raytheon—began a 33-month validation phase competition in February 1979 to determine the primary design contractor for full-scale development. Hughes was awarded a 54-month full-scale development contract in December 1981.

In June 1987, the Air Force recommended and the Secretary of Defense approved the initial low-rate production of 180 interim design missiles referred to as the tape 3A configuration.[4] The Secretary's Defense Acquisition Board reviewed the program's status and test results in May 1988. According to an official with the Office of the Secretary of Defense, the Air Force told the Board that good progress had been made toward meeting AMRAAM's tactical requirements and most of the missile's required capabilities had been meet. The Air Force recommended that the Board approve the continued production of AMRAAM. The same official also told us that, based on the Board's review, the Secretary is expected to approve the production of 400 full-capability missiles, known as tape 4. Some of these missiles will be placed in inventory for combat use. Tape 4 missiles should perform better than the tape 3A missiles against enemy electronic countermeasures designed to confuse AMRAAM and degrade its performance.

The Board also considered a decision on the long-lead items for full-rate production. According to the official, the Board deferred that decision until October 1988 when more data should be available on operational testing for tape 4 missiles. A decision on full-rate production is scheduled for May 1989.

[4]AMRAAM software was developed in five incremental stages, referred to as tapes 1, 2, 3, 3A, and 4.

By 1992, the Air Force and the Navy plan to procure missiles at a rate of about 3,000 a year. The services plan to procure more than 24,000 missiles over an 11-year period—2 years of low-rate and 9 years of full-rate production.

Restructuring of the Program

The AMRAAM program experienced substantial schedule slippages and cost increases during development. In January 1985, the Secretary of Defense expressed concern over the program's schedule delays and escalating costs and ordered a complete program review to determine if and how program costs could be reduced. This review resulted in a restructuring of the AMRAAM program and the initiation of a producibility enhancement program to reduce production costs by redesigning several missile components.

Even with the producibility enhancements, the program's estimated development and production cost increased from $3.4 billion for 20,000 missiles to $8.2 billion for 24,335 missiles in 1984 dollars. The program's full-scale development phase was extended from 54 to 79 months, and the initial operational capability date changed from 1986 to 1989.

Congressional Requirements

The National Defense Authorization Act for Fiscal Year 1986 required the Secretary of Defense to certify to the House and Senate Committees on Armed Services by March 1, 1986, that the AMRAAM program would meet certain cost and performance requirements, or the program would be terminated. In the performance area, the Secretary was to certify that (1) the AMRAAM design was complete, (2) system performance had not been degraded from the original development specification, and (3) the missiles procured would perform in accordance with the development specification. The Secretary certified to these items on February 28, 1986.

The National Defense Authorization Act for Fiscal Year 1987 established a cost cap of $7.0 billion (1984 dollars) for procurement of 24,000 missiles. The cap does not apply to cost increases that result from congressional funding actions. Considering congressional funding actions for fiscal years 1987 and 1988, the Air Force believes the current cap should be $7.5 billion.

Objectives, Scope, and Methodology

Congressman Denny Smith asked us to review the plans for and the status of AMRAAM tests that were to demonstrate the system's effectiveness in combat and report on the status at the time of the Defense Acquisition Board's program review for the second low-rate production decision. Specifically, he asked us to assess whether

- the AMRAAM test plan is adequate to ensure that performance requirements are demonstrated in an operationally realistic environment,
- the tests are being done in accordance with the plan, and
- the results show that the missile will meet performance requirements.

We used our prior work on AMRAAM (see app. I) and obtained information from records and officials primarily within the AMRAAM Joint System Program Office located at Eglin Air Force Base, Florida. We discussed AMRAAM's status and testing issues with officials in the following organizations.

Department of Defense:

- Office of the Secretary of Defense, Director of Operational Test and Evaluation.
- Office of the Under Secretary of Defense for Acquisition.

Department of the Air Force:

- Systems Command, Armament Division.
- Operational Test and Evaluation Center.

Department of the Navy:

- Pacific Missile Test Center.

Contractors:

- Hughes Aircraft Company.
- Institute for Defense Analyses.

To assess the test plan, we reviewed pertinent regulations and controls intended to ensure that the plan provides for adequate demonstration of the missile's effectiveness for combat. We reviewed the test plan and subsequent changes, compared the planned tests to missile performance requirements, and discussed the plan and changes with test officials

responsible for ensuring its adequacy. We also reviewed an Institute for Defense Analyses study on the adequacy of the test plan.

In the test results area, we compared planned and actual test schedules and correlated the individual test results with the critical performance issues that were to be addressed. We witnessed selected guided flight tests, reviewed test reports, and discussed test results with Air Force, Navy, and Office of the Secretary of Defense officials responsible for conducting and monitoring the tests. We also reviewed the design status of missiles used in the test program and reviewed plans for resolving outstanding design questions.

The views of responsible agency officials were obtained during the course of our work and were considered in preparing this report.

Our review was conducted from November 1987 through May 1988 in accordance with generally accepted government auditing standards.

Test Plan Addresses Key Requirements

Test results, particularly for tests performed under realistic combat conditions, are a key factor in decisions to begin or continue production of a major weapon system. The AMRAAM test plan appears adequate to demonstrate the missile's performance requirements and effectiveness in combat. The plan is designed to demonstrate critical technical and operational performance capabilities through a combination of simulations and flight tests, including an extensive live-fire program. Many of the live-fire tests are designed to predict how well the missile will perform in combat.

Importance of Testing Before Production

Short of actual combat, test and evaluation is the primary means of assessing a weapon system's performance. The role of test and evaluation is to demonstrate that a system, before it is produced, can meet performance requirements and that it will be effective in combat. A key requirement for each major production decision is the successful accomplishment of test and evaluation objectives. When there is insufficient testing, performance uncertainty increases along with the risk of costly redesign and modification after deployment.

Two types of weapon system test and evaluation serve parallel, but distinctly different, purposes. Development testing, normally accomplished or managed by the agency responsible for developing the weapon system, is designed to assist the engineering design and development process and to verify that technical specifications are met.

In contrast, operational testing is designed to assess the system's operational effectiveness and suitability for combat. Operational testing, which is conducted by a military service agency separate and distinct from the developing agency, can provide essential data for the initial production decision of a major weapon system. Initial operational testing is conducted with prototypes and begins as early as possible in the system's development. Defense acquisition policy requires the completion of initial operational testing before a full-rate production decision.

The AMRAAM Test Plan

The AMRAAM test plan is comprehensive in that it addresses each of the system's performance requirements. The Joint Service Operational Requirements and Decision Coordinating Papers (agreed to by the Air Force and the Navy) identify specific performance parameters that the missile must demonstrate. Specific performance categories include various guidance modes, as well as specific speed, range, and maneuverability requirements.

In combat, AMRAAM must be capable of intercepting enemy aircraft as well as cruise missiles. The intercepts must occur when the enemy is employing electronic countermeasures and evasive maneuvers.

The AMRAAM test plan provides for a combination of live missile firings, captive flight tests, and simulations to demonstrate required performance. In the first category, missiles are fired from manned aircraft under planned launch conditions against remotely piloted target aircraft. Captive flight tests involve missile hardware attached to an aircraft, which is flown from a simulated launch point toward a target along a path similar to the one a missile in free flight would follow. Captive flights can be used to ensure that the missile's guidance is working properly before each live-fire or to obtain reliability data by carrying the missiles on routine training missions.

In simulations, the missile seeker is exposed to a target signal in a laboratory environment. Simulations are conducted before each live missile firing to predict how the missile will perform. Simulations are also used to examine other engagement possibilities too costly, and sometimes too dangerous to perform with manned aircraft. Data from the live tests are used to validate and refine the simulation models.

The live-fire test plan includes 89 missile launches. Of these 89, 64 are to assist the development process and demonstrate specific missile requirements such as range, speed, and safe separation from the delivery aircraft. The remaining 25 launches are operational tests to predict how the missile will perform under combat conditions. The Air Force's independent test organization—the Operational Test and Evaluation Center—controls the operational tests.

The AMRAAM test plan outlines a large number of flight tests that increase in difficulty as the missile design matures. For example, an early development test demonstrated that one missile could guide to a target at relatively short range. Tests much later in the program, however, involve multiple missile launches at multiple targets employing various tactics, maneuvers, and electronic countermeasures intended to confuse the missiles' guidance and to degrade their effectiveness. This building-block approach is common to test plans of complex defense systems.

Coordination and Reviews

The plan was initially developed with input from various organizations including those responsible for independently testing the weapon to

ensure that it will perform effectively and reliably as well as those who would use the weapon in combat. These initial planning efforts have been supplemented by ongoing reviews by the principal advisor to the Secretary of Defense for operational testing, the Air Force's and the Navy's independent test organizations, and the Tactical Air Command.

For example, the Office of the Director, Operational Test and Evaluation,[5] approved the continuation of operational testing in increments after several reviews. Specifically, in February 1987, based on a preliminary assessment of the AMRAAM test plan, the Director provided interim approval of the plan through the time of the initial low-rate production decision in June 1987. Additional reviews in June and December 1987 authorized the continuation of testing until the May 1988 review for the second low-rate production decision.

A study by the Institute for Defense Analyses[6] supported the Director's determination to continue implementation of the plan. The Institute's July 1987 report[7] concluded that the AMRAAM test plan addresses each of the AMRAAM operational requirements and that it would support a determination as to whether the system meets the operational requirements.

According to Navy test officials, they also contributed to the test plan and have monitored the AMRAAM testing very closely. These officials said the test plan will complement the Navy's specific test needs.

Realism of Operational Tests

The Air Force Tactical Air Command also assessed the test plan and concluded that planned AMRAAM tests were realistic. Within the Air Force, this command represents operational units that would use the weapons in combat.

In July 1987, the Tactical Air Command reviewed the initial operational test profiles at the request of the Director of Operational Test and Evaluation. The Director asked for a "fresh operator look" at the operational test profiles to verify the "operational realism and tactical significance"

[5]Public Law 98-94 (1983) established the Office of the Director for Operational Test and Evaluation, with the Director as the principal advisor to the Secretary of Defense on operational testing.

[6]The Institute is a Department of Defense sponsored federally funded research and development center that performs special studies for the Office of the Secretary of Defense, the Joint Chiefs of Staff, and Defense agencies.

[7]"Review of Operational Test and Evaluation of AMRAAM, Review of AMRAAM Test Plan," Memorandum Report M-340, July 13, 1987.

of each profile. As a result of this review, Tactical Air Command concluded that the test profiles were operationally realistic and tactically significant. According to the Tactical Fighter Weapons Center's AMRAAM project manager,[8] the review was conducted at a meeting attended by both Air Force and Navy officials. The participants concluded that the remaining test profiles were representative of actual combat conditions.

Conclusions

We found that the Departments of Defense and the Air Force exercised controls intended to ensure that the AMRAAM test plan is comprehensive and provides for adequate demonstration of the missile's effectiveness in combat conditions. Organizations responsible for independently testing the weapon and those who would use it in combat helped develop the plan. Those organizations as well as the principal advisor to the Secretary of Defense for operational testing have continued to review its progress. In addition, the Institute for Defense Analyses' independent review of the plan concluded that it would support a determination on whether AMRAAM meets operational requirements.

The test plan addresses each of the system's performance requirements. The detailed plan includes simulations, captive flight tests, and a large number of live-fire tests. The flight tests increase in difficulty as the missile design matures. Of the 89 live-fire tests, 25 are designated as operational and intended to predict how the missile will perform under combat conditions. These have been assessed as operationally realistic and tactically significant by the Air Force command that represents operational units.

[8]The Weapons Center is located at Nellis Air Force Base, Nevada.

Test Delays, Problems, and Parameter Changes Make AMRAAM Operational Effectiveness Uncertain

Although the test plan appears adequate to demonstrate AMRAAM's operational effectiveness, the Air Force could not implement the plan on schedule. At the time of the second low-rate production review, only about 66 percent of the planned live missile firings had been completed. Some of the more difficult and realistic tests had not yet been completed. Because no operational flight tests of the full-capability missile had been conducted, Air Force Operational Test officials recently described the missile's combat effectiveness as undetermined.

Completed tests have demonstrated that the missile can meet some of its critical performance requirements, but the tests also identified some performance and reliability issues that have not been resolved. Also, the AMRAAM Program Office changed the planned parameters or conditions before conducting some of the live-fire tests, which increased the missiles' probability of success.

As a result of the delays and changes, a number of uncertainties about AMRAAM's combat performance existed at the time of the second low-rate production review. These uncertainties increase the risk that the missiles for inventory may not be totally effective or reliable in combat.

AMRAAM Tests Behind Schedule

The AMRAAM test program has fallen behind its restructured schedule. The program schedule, approved in 1985, provided for completing all 89 live-fire tests before production of full-capability missiles. Through April 1988, only 59 of the 89 planned live-fire missiles, or about 66 percent, had been launched. The Air Force determined that 44 missiles successfully accomplished their test objectives, 12 others failed, and the remaining 3 were recorded as no-tests because external factors prevented the testing of the missiles. The Air Force's data reflect a 75-percent success rate when the three no-tests are not included in the count.

Table 3.1 shows planned and completed tests for the five versions of the missile that coincide with the software configurations. All but three of the tests conducted to date have been with the less-than-full-capability missiles.

Table 3.1: AMRAAM Live-Fire Tests Planned and Completed as of April 30, 1988

	Developmental		Operational		Total	
Missile/software	**Planned**	**Completed**	**Planned**	**Completed**	**Planned**	**Completed**
Early development (tapes 1, 2, and 3)	21	21	4	2	25	23
Interim capability (tape 3A)	35	24	14	9	49	33
Full capability (tape 4)	8	3	7	0	15	3
Total	**64**	**48**	**25**	**11**	**89**	**59**
Number behind schedule	16		14		30	

Although 66 percent of all planned live-fire tests had been completed, only 44 percent (11 of 25) of the planned operational tests had been completed. There have been no operational tests of a full-capability missile, which should perform better against enemy electronic countermeasures. Operational tests are used primarily to predict the missiles' effectiveness and suitability for use in combat.

Important Tests Not Completed

Many of the technically difficult and operationally realistic tests had not been completed. These more complex tests, which normally occur near the end of development, are intended to provide the best insight into AMRAAM's technical and operational performance capabilities and limitations.

Many of the remaining tests are to demonstrate AMRAAM's performance against sophisticated electronic countermeasures that an enemy would use to confuse the missiles' guidance and thereby degrade its effectiveness. Some of these tests are to demonstrate the missiles' capabilities when multiple targets simultaneously employ sophisticated countermeasures and maneuvers. Others are to show that the missiles will be reliable when exposed to the vibration, shock, and temperature changes characteristic of carriage on a fighter aircraft.

Test Delay Causes

Although there was no single overriding reason for delays in completing the flight tests, there were a number of causes that can be linked to either the maturity of the missile design or the availability of test resources. In the design area, for example, about one of every five missiles the contractor delivered to the test sites could not be launched because it did not pass prelaunch tests. These missiles were either returned to the factory for additional testing and repair or repaired at the site by contractor technicians.

For several weeks in 1987, flight tests were suspended to investigate the cause of successive flight test failures. Even though the causes of the failures were found, the test program was delayed during the period of investigation. At other times, delays occurred because the missile's software had to be revised before the test. For example, tests were delayed because the preflight tests showed the missile's software could not correctly process electronic countermeasure information and respond appropriately. Missile delivery delays also contributed to test program slippage. For example, tests of the full-capability missiles were delayed because the first missile was not delivered until February 1988—7 months later than planned.

Air Force officials responsible for conducting the guided flight tests told us that competition for test resources such as delivery aircraft, test ranges, and target aircraft also contributed to delays. For example, in 1985 the Air Force decided to establish an initial operational capability for the AMRAAM on the F-15, instead of the F-16. The only F-15 aircraft available had to be shared between the AMRAAM flight test program and the program to upgrade the aircraft's fire control system. Additional time was lost when targets crashed or were grounded to investigate problems.

Completed Tests Have Identified Performance and Reliability Uncertainties

Although tests conducted through April 1988 had demonstrated many critical performance requirements, they had also identified reliability and performance problems that had not been resolved. In addition, changes made to some planned test parameters made the tests less comprehensive.

Tests completed through April 1988 have demonstrated that AMRAAM can meet many of its critical performance requirements. For example, tests have shown that the missile can be very accurate; some test missiles made direct hits on the targets. Other tests have shown that the missile can operate successfully in an autonomous mode.[9] The tests have also demonstrated that AMRAAM can meet its maximum speed, altitude, and range requirements.

[9]In the autonomous mode, the missile's on-board radar provides the needed guidance information. The autonomous mode is critical to the pilot's ability to engage multiple targets or maneuver to avoid counterattack.

Live-Fire Tests

Some test missiles have identified performance problems that have not been resolved. For example, missiles failed to perform effectively when the targets used certain combinations of tactics and electronic countermeasures. In addition, the missile was not successful against a very small target intended to demonstrate AMRAAM's capabilities against a cruise missile. Also, two of the three full-capability missiles tested in developmental flights were unsuccessful.

During the past 12 months, there have been three air aborts and two instances in which the missile malfunctioned shortly after it was launched. An air abort occurs when the missile's internal logic detects a problem and prevents launch. Also, as discussed previously, about one in five missiles the contractor delivered to the test sites had to undergo repairs or additional tests.

Reliability Tests Delayed

The AMRAAM test plan includes evaluations of the missile's reliability when exposed to vibration, shock, temperature changes, and other elements that it will be exposed to in flight.

Several problems were identified during earlier reliability flight tests. For example, in several tests, the guidance section lost pressure, causing it to malfunction. In other tests, the missile's fins and fin-control mechanisms were damaged when the aircraft did certain maneuvers. Although missile design changes had been made to address these problems, the start of additional flight tests with the new components was delayed by about 10 months, from June 1987 to April 1988. At the time of the second low-rate production review, only about 1 of the 12 months of planned reliability testing had been completed.

Changes in Test Parameters

Because of considerable variations in enemy tactics such as how aircraft would be spaced against AMRAAM and the specific parameter settings of various electronic countermeasures, the test plan provided a series of tests to determine how well the missile performs across a range of likely values in these areas. The Program Office changed these parameters in some tests after simulations showed the missiles would have a low probability of intercepting the targets.

Computer simulations and captive flight tests are conducted before live-fire flights to predict how the missile will perform during the live tests. These tests investigate several specific values for various electronic parameters because threat documents only describe a range of likely

values. The preflight simulations often show that the missile's probability of success will be lower or higher depending on which specific values are used.

According to AMRAAM Program Office test officials, in some instances planned electronic countermeasures or target spacing were changed which improved the missile's probability of success. These officials told us that it was better to make the changes and have the opportunity to obtain test data relative to these and other test objectives rather than do a test that had a very low probability of success. Officials from the Air Force's independent operational test center did not always agree with the changes because collectively, the changes reduced the test data to a small segment of the range of likely values. AMRAAM program officials said some of the original parameters will be included in later tests of missiles with more mature software.

AMRAAM's Effectiveness Is Not Fully Tested

According to officials from the Air Force's independent test center, tests have not yet demonstrated AMRAAM's operational effectiveness in some important areas. The assessment of a system's test progress by the service's independent test organization is vital to decision makers at major program milestones.

The independent test officials discussed their preliminary assessment with us several weeks before the May 1988 program review. According to these officials, AMRAAM's effectiveness in certain performance areas is not yet determined. The officials described the reliability of the missile as undetermined because of delays in completing the reliability tests and recent reliability failures in the flight test program. They described AMRAAM's effectiveness as undetermined because planned operational flights of the full-capability missile had not been conducted. They pointed out that the missile's probability of destroying a target has decreased due to some recent test failures. According to the test officials, the tests have become more difficult over time, which may account for the downward trend.

Production Schedule Has Not Changed

AMRAAM's production schedule has not changed, although there have been significant delays in completing development tasks. For example, design audits to ensure that the missile functions properly and meets specifications will probably not be completed until October 1988, 5 months after the second low-rate production review. Moreover, flight tests to help ensure that the weapon will be reliable and effective in

combat may not be completed until about the time of the full-rate production decision. Table 3.2 shows the planned dates for these and other development and production milestones, the current milestone dates, and the slippage from the planned milestone dates.

Table 3.2: Planned and Current Development and Production Milestones as of April 30, 1988

Milestone	Planned date	Current date	Months slipped
Design audit (tape 3A)	November 1986	October 1988	23
Production decision (tape 3A)	June 1987	June 1987	0
Design audit (tape 4)	December 1987	October 1988	10
End of flight testing	April 1988	November 1988[a]	7
Production decision (tape 4)	May 1988	May 1988	0
Full-rate production decision (tape 4)	May 1989	May 1989	0

[a]If testing continues at the current rate, the ending date will be May 1989.

Conclusions

At the time of the second low-rate production review on AMRAAM, the Air Force had not completed the tests needed to make a full and accurate assessment of AMRAAM's performance. Tests that were completed identified performance and reliability uncertainties that had not yet been resolved. In addition, the audit to ensure that development is complete will not be finalized for several months after the review. Therefore, the combat performance of missiles to be produced for inventory is uncertain.

Related GAO Reports

Progress and Problems of the Advanced Medium Range Air-to-Air Missile Program (GAO/C-MASAD-81-6, February 23, 1981).

Effectiveness of Advanced Medium Range Air-to-Air Missile is Uncertain (GAO/C-MASAD-81-17, August 4, 1981).

The Advanced Medium Range Air-to-Air Missile: Resolve Uncertainties Before Production (GAO/NSIAD-84-18, May 7, 1984).

Missile Development, Status of Advanced Medium Range Air-to-Air Missile (AMRAAM) Certification (GAO/NSIAD-86-66BR, February 18, 1986).

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

Missile Development, Advanced Medium Range Air-to-Air Missile (AMRAAM) Certification Issues (GAO/NSIAD-86-124BR, July 9, 1986).

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

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

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

Requests for copies of GAO reports should be sent to:

U.S. General Accounting Office
Post Office Box 6015
Gaithersburg, Maryland 20877

Telephone 202-275-6241

The first five copies of each report are free. Additional copies are $2.00 each.

There is a 25% discount on orders for 100 or more copies mailed to a single address.

Orders must be prepaid by cash or by check or money order made out to the Superintendent of Documents.

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

Official Business
Penalty for Private Use $300

First-Class Mail
Postage & Fees Paid
GAO
Permit No. G100