United States General Accounting Office

GAO

Report to Congressional Requesters

August 1987

MISSILE DEVELOPMENT

Development Status of the Advanced Medium Range Air-to-Air Missile

GAO

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

National Security and
International Affairs Division

B-221734

August 14, 1987

The Honorable Charles E. Grassley
United States Senate

The Honorable Denny Smith
House of Representatives

This report, which was prepared at your request, addresses the status of the Advanced Medium Range Air-to-Air Missile at the low-rate production and full-rate production milestones. As you requested, we focused on design stability, test adequacy, and the accuracy of the $5.2 billion (1984 dollars) procurement estimate for 17,000 Air Force missiles.

The views of Air Force and Navy officials were obtained and incorporated, where appropriate. As requested, we did not obtain formal agency comments on 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 interested congressional committees; the Secretary of Defense; the Secretaries of the Air Force and the Navy; and the Director, Office of Management and Budget.

Frank C. Conahan
Assistant Comptroller General

Executive Summary

Purpose

Since its inception, the Advanced Medium Range Air-to-Air Missile (AMRAAM) program has experienced cost growth and schedule delays. The missile's estimated acquisition costs (both development and production) have increased, in 1984 constant dollars, from about $3.4 billion for 20,000 missiles to $8.2 billion for 24,335 missiles. The scheduled initial deployment date has slipped from 1986 to 1989.

In June 1987, the Air Force recommended the beginning of AMRAAM production. The Air Force program manager estimates that $7.123 billion (1984 dollars) will be needed to procure 24,335 missiles for the Air Force and the Navy.

Senator Charles Grassley and Representative Denny Smith requested that GAO review several aspects of the AMRAAM program that relate to production readiness. Specifically, GAO was asked to assess the AMRAAM program's

- design stability,
- test adequacy, and
- cost estimate for 17,000 Air Force missiles.

Background

The 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 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, and F/A-18.

Performance improvements over the Sparrow are to include higher missile speed, greater range, increased maneuverability, and better resistance to electronic countermeasures. Also, an active terminal seeker is to provide the pilot with the capability to simultaneously engage several targets and then maneuver to avoid counterattack.

In 1985, concern over rising costs and schedule delays led to a restructuring of the program. In 1986, the Secretary of Defense certified to the Congress that (1) AMRAAM's design was complete, (2) the missile would meet original performance specifications, and (3) 17,000 Air Force missiles could be procured for $5.2 billion in constant 1984 dollars. The 1987 Defense Authorization Act capped the missile procurement cost at $7.0 billion (constant 1984 dollars) for 24,000 missiles but allows for increases due to congressional funding actions, such as funding reductions that result in less efficient production rates. The 1987 Defense

Appropriations Act required a successful demonstration of AMRAAM's multiple-target engagement capability in an electronic countermeasure environment before low-rate production can begin. The Air Force considered the second flight test of April 29, 1987, successful in meeting the congressional requirement.

Results in Brief

As of July 1, 1987, the AMRAAM had completed 35 of 90 planned guided flight tests of which 23 were considered fully successful. These tests demonstrated a number of AMRAAM performance capabilities. However, at the time of the June 1987 AMRAAM low-rate production decision, there were a number of design, performance, and cost uncertainties. These uncertainties increase the risk that retrofit programs will be required to achieve the desired performance. At the time of the low-rate production decision, the contractor had only delivered missiles designed to meet interim performance requirements. This design is likely to change because many of the more demanding development and operational tests are yet to be completed. In addition, design changes will be made to reduce costs to stay within the total cost certified by the Secretary of Defense and capped by the Congress.

At the time of the May 1989 full-rate production decision, more will be known about AMRAAM design, performance, and cost. At that time development and initial operational tests are to have been completed.

GAO's Analysis

Low-Rate Production of Interim Design

In order to prevent additional delays in fielding the AMRAAM, the Air Force plans to begin low-rate production with 180 interim design missiles that do not have all the required electronic countermeasure capabilities. This interim design was undergoing engineering changes and software revisions at the time of the low-rate production decision.

Design, integration, and testing of the hardware and software will continue after low-rate production begins. The full-capability missile is to be available in the second year of low-rate production.

Testing of the Interim Design

Recognizing that the June 1987 low-rate production decision would be made 13 months before development and testing were completed, the Air Force lowered some performance criteria. Air Force officials believe that the lower criteria reflected sufficient progress toward satisfying the full requirements.

Tests to demonstrate the interim capabilities have been delayed because of missile problems and the unavailability of various test resources, such as delivery aircraft and targets. The test program is several months behind schedule, and most of the completed tests used earlier software designs. Air Force program officials believe that tests after the decision will demonstrate the full performance of the interim design. However, tests conducted on June 5 and June 12, 1987, were not fully successful.

Continued Cost Uncertainties

AMRAAM procurement costs remain uncertain; however, the current program office estimate shows costs will exceed the $5.2 billion estimate for Air Force missiles by $80 million and the $7.0 billion combined program estimate by $123 million. The program office attributes the higher cost to fiscal year 1987 congressional funding reductions that lowered the number of missiles to be purchased during the early production years when savings from competition are expected to be the greatest.

Major savings needed to achieve the cost estimate cannot be validated at this time. For example, the $7.0 billion estimate assumes that about $1.6 billion (1984 dollars) included in earlier estimates can be saved by redesigning certain components. Most of these redesigns, however, are not scheduled to be available until the third and fourth production years.

Lower Risk at the Time of the Full-Rate Decision

At the time of the full-rate production decision, the Air Force plans to have completed all development and initial operational testing, including tests of 15 full-capability development missiles. Additional operational tests using full-capability production missiles are to begin in January 1990—about 8 months after the full-rate decision.

At the time of the full-rate decision, only a few of the design changes needed to achieve the $7.0 billion congressional funding cap will have been incorporated into production. Redesign projects, which account for 43 percent of the $1.6 billion savings needed to achieve the cap, are not scheduled to be incorporated until the fourth production year—about 1 year after the full-rate decision.

Recommendations

This report provides GAO's analysis of AMRAAM design, test, and cost status at the time of the low-rate and full-rate production decisions; 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 have been incorporated in the report where appropriate. GAO did not request formal agency comments on this report.

Contents

Abbreviations

AMRAAM Advanced Medium Range Air-to-Air Missile

Introduction

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 into the next century.[1] The missile is to be compatible with the services' latest fighter aircraft: the F-14, F-15, F-16, and F/A-18. The missile is to operate both within and beyond the aircraft pilot's visual range.

As a follow-on to the Sparrow medium range air-to-air missile, AMRAAM is intended to improve interceptor combat effectiveness. Performance improvements over the Sparrow are to include higher speed, greater range, increased maneuverability, better resistance to electronic countermeasures, and an active terminal seeker. The active seeker and track-while-scan radar aboard the launch aircraft will provide the capability 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 development program includes the missile, rail launchers, aircraft interfaces, support equipment, and aircraft modifications for AMRAAM testing. It does not include modifications to operational aircraft and eject launchers that are to be developed and funded by the appropriate aircraft program offices.

The missile is in 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. These efforts are intended to qualify Raytheon as a second-source producer. In June 1987, the Air Force recommended beginning low-rate production of 180 AMRAAMs in the first year. A decision for the second year's low-rate production of 630 missiles is scheduled for May 1988. A decision to enter into full-rate production the third year is scheduled for May 1989. During full-rate production, 1,800 missiles are scheduled for the first year, 2,900 for the second year, 3,000 each year for the following 5 years, and 3,810 in the eighth year. The Air Force plans to produce the AMRAAM for 10 years—2 years of low-rate production and 8 years of full-rate production.

[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.

Program History

In a previous review of AMRAAM cost growth and schedule delays (GAO/NSIAD-87-78), we reported 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 slippages, the development and low-rate production phases have been restructured, and the Congress has imposed specific mandates.

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. In November 1978, the Secretary of Defense approved transition to the validation phase (milestone I). In February 1979 two contractors—Hughes and Raytheon—began a 33-month validation phase competition to determine the primary design contractor for full-scale development. In December 1981, Hughes was awarded a 54-month full-scale development contract with priced options for the first two production lots. In September 1982, the Secretary of Defense approved continued engineering development (milestone II).

The AMRAAM program has experienced schedule slippages and cost increases since the program was first approved. The system's contractor was not able to complete development on schedule, and the 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.

Restructuring of the Program

In January 1985, the Secretary of Defense, expressing concern over the program's schedule delays and escalating costs, 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 a producibility enhancement program to reduce production costs by redesigning several missile components. The program's full-scale development phase was extended from 54 to 79 months, and the initial operational capability date was advanced from 1986 to 1989. The restructured program included $1.2 billion for development and $7.0 billion for procurement.

Congressional Requirements

The Defense Authorization Act for fiscal year 1986 required the Secretary of Defense to certify, by March 1, 1986, that the AMRAAM program would meet certain cost and performance requirements or the program would be terminated. Specifically, the Secretary was to certify that (1) the AMRAAM design was complete, (2) system performance had not been degraded from the original development specification, (3) the maximum practical number of cost reduction design changes would be incorporated into the flight test program and qualified before production, (4) a fixed price contract not to exceed $556,580,480 had been entered into with the development contractor for research, development, test, and evaluation, (5) total production cost for a minimum of 17,000 missiles (the Air Force share) would not exceed $5.2 billion in fiscal year 1984 dollars, and (6) the missiles procured would perform in accordance with the development specification. On February 28, 1986, the Secretary of Defense certified to these items.

The fiscal year 1987 Defense Authorization Act established a procurement cost ceiling at $7.0 billion (1984 dollars) for 24,000 Air Force and Navy missiles. The act allows for upward adjustments to the ceiling resulting from congressional funding actions, such as funding reductions that result in a less efficient production rate and higher total program cost. The 1987 Defense Appropriations Act required that the missile successfully complete a multiple target engagement (two missiles against two targets) in an electronic countermeasure environment before funds for low-rate production are spent. This spending restriction did not apply to long-lead procurement.

Objectives, Scope, and Methodology

Senator Charles Grassley and Representative Denny Smith asked us to review AMRAAM's development status at the time of the low-rate and full-rate production decisions and assess whether

- the design was complete and stable, including changes needed to reduce costs;
- required performance had been demonstrated and enough realistic testing had been done to identify any operational deficiencies; and
- the $5.2 billion procurement cost ceiling for 17,000 Air Force missiles certified by the Secretary of Defense would be met.

We focused our assessment on the June 1987 low-rate production decision because the full-rate production decision is not scheduled until May 1989. We did, however, assess AMRAAM's projected status at the time of the full-rate production decision.

We used our prior work on AMRAAM and obtained information from records and officials primarily within the AMRAAM Joint System Program Office located at Eglin Air Force Base, Florida. We also visited or contacted the following organizations to discuss AMRAAM's status and production issues.

Department of Defense:

- Office of the Secretary of Defense, Directorate of Program Analysis and Evaluation
- Directorate of Operational Test and Evaluation
- Office of the Under Secretary of Defense for Research and Engineering

Department of the Air Force:

- Systems Command, Armament Division and Laboratory
- Tactical Air Command, Tactical Air Warfare Center
- Operational Test and Evaluation Center

Department of the Navy:

- Pacific Missile Test Center

Contractors:

- Hughes Aircraft Company
- Institute for Defense Analysis
- The Analytical Sciences Corporation

To assess design stability, we reviewed pertinent regulations and the results of key activities intended to determine design progress. These included design reviews, production readiness reviews, component qualification tests, engineering change proposals, and the schedule for the functional configuration audit.

In the test area, we reviewed test plans and correlated the individual tests with the critical performance issues that were to be addressed. We examined the results of captive flight tests, various ground tests, and live air-to-air missile firings. We witnessed a guided flight test 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 compared initial test plans to the tests that were actually completed at the time of the low-rate production decision.

To evaluate estimated costs, we reviewed the latest approved cost estimate as of June 1, 1987, an independent cost analysis, and the December 1986 selected acquisition report. We also reviewed key events that have changed or may change the assumptions supporting the cost estimate and discussed the status of selected cost reduction efforts with responsible Air Force and contractor officials.

The views of Air Force and Navy officials were obtained and incorporated, where appropriate. As requested, we did not obtain formal agency comments on this report.

Our review was made from August 1986 to July 1987 in accordance with generally accepted government auditing standards.

Unstable Design Increases Production Risk

To meet its planned 1989 deployment schedule, the Air Force plans to begin AMRAAM production with an interim design that will not meet the full-performance requirements. At the time of the June 1987 low-rate production decision, the interim design was not stable or fully tested. The Air Force assessed various areas of production risk and found the design risk to be significant. The functional configuration audit,[2] which was originally scheduled to begin about 5 months before the low-rate production decision, is now scheduled to begin in October 1987, about 4 months after the decision.

A stable design provides confidence that development problems have been overcome and that a system will meet defined technical and operational performance requirements. Beginning production before the design has stabilized increases the risk that production schedules will be disrupted, the system will not perform satisfactorily, and retrofit programs will be required.

The Air Force plans to complete the full-performance design prior to making its full-rate production decision. However, additional design changes under the producibility enhancement program are planned after that decision.

Low-Rate Production With an Interim Design

At the time of the June 1987 low-rate production decision, design and development of a full-capability missile had not been completed. Additional hardware and software were needed to meet the full-performance requirements.

The AMRAAM software development effort is divided into five separate incremental builds. Each stage is referred to by its software version: tape 1, 2, 3, 3A, or 4. As of June 1, 1987, the Air Force was testing the interim 3A missile and continuing to develop the full-capability tape 4 design. The contractor plans to deliver the first tape 4 missile in October 1987.

The primary difference between the tape 3A and tape 4 missiles is that the tape 4 missile is able to perform effectively in certain electronic countermeasure environments. An enemy would use electronic countermeasures to try to confuse AMRAAM and prevent it from successfully

[2]The purpose of a functional configuration audit is to validate that development has been satisfactorily completed and that tests have demonstrated required performance

engaging target aircraft. AMRAAM has electronic counter-countermeasures designed to recognize and overcome various electronic techniques.

When the Air Force restructured the AMRAAM program in 1985, it recognized that the contractor would not be able to complete the tape 4 design in time for low-rate production. The Air Force decided, therefore, to begin low-rate production and initially field the interim tape 3A design.

Additional hardware and software are needed to upgrade the tape 3A design to the tape 4 design. In the hardware area, special detector circuitry is being developed to enable the missile to detect and react to additional countermeasure techniques. Also, additional software is needed to correctly process the countermeasure information and respond appropriately.

Interim Design Is Changing

The interim design selected for low-rate production is undergoing changes, and more changes will likely be identified as tests continue. Contractor plans for delivering the tape 3A software proved optimistic and, since delivery, several revisions have been necessary to correct software problems. Hardware changes are also being made because the missile did not pass vibration and other environmental tests intended to show that it can withstand an operational environment. The number of changes to the engineering drawings has been greatly reduced, but continuing changes may cause the missiles delivered by the two contractors to differ. Redesigns to enhance producibility are continuing to be developed as planned.

Software Changes

Several revisions have been made to the low-rate production software, but the full extent of the required changes will not be known until additional tests are completed. The tape 3A software underwent five revisions before it was first used in flight tests and is continuing to be revised. Table 2.1 shows the date of each flight test and the software revision tested.

Table 2.1: Tape 3A Software Revisions

Flight test	Date	Revision
1[a]	Feb. 20 1987	5
2	Mar 3, 1987	4
3	Mar. 31, 1987	8
4	Apr. 9, 1987	8
5	Apr 27, 1987	9
6[a]	Apr 29, 1987	10
7[a]	May 1, 1987	11

[a]Two missiles were fired during these tests.

As of May 1, 1987, the contractor was developing revision 12 to correct problems identified during a recent test. For example, software revisions were identified to improve the missile's ability to perform in an electronic countermeasure environment. Officials responsible for managing AMRAAM's software development could not predict when the final revision will be made. They told us that development tests are intended to identify needed corrections and that these tests are scheduled to continue until July 1988.

Hardware Changes

During development, military systems are subjected to a variety of tests to ensure that they can withstand vibration, shock, dampness, temperature extremes, and other environmental elements to which they will be exposed. These tests are referred to as environmental qualification tests.

AMRAAM qualification tests revealed several problems that could cause the missile to malfunction. Corrosion formed in various areas, the guidance section did not seal properly, and cracks formed in the target detection device. Also, the Safe-Arm-Fuze, which ensures that the warhead fires at the proper time, did not pass these tests.

As of May 1987, design changes and analyses were under way to correct these problems; however, retests were not scheduled to be completed until September 1987—3 months after the low-rate production decision.

Engineering Changes

The AMRAAM is a complex system requiring more than 1,500 drawings to define it. As changes to the drawings are made, Hughes notifies the Air Force and Raytheon. Once development is complete and the functional configuration audit is performed, the government will take control of

the design. This is not scheduled until October 1987 for tape 3A and April 1988 for tape 4.

The number of engineering changes decreased from a high of 380 a month in August 1985 to 55 a month in April 1987. Air Force program officials told us that continuing changes could cause the missiles produced by the two contractors to differ. This is because Raytheon, the second-source contractor, in order to begin manufacturing, will have to stop accepting changes earlier than Hughes.

Producibility Enhancement Changes

At the time of the low-rate production decision, the contractor was redesigning many of the missile's components. None of the redesigns intended to reduce cost is scheduled to be completed before production begins.

When the Air Force restructured the AMRAAM program in 1985, a number of design changes were identified to make the missile more affordable. The AMRAAM producibility enhancement program is intended to reduce missile procurement cost by making design changes to high-cost assemblies to reduce the number and cost of parts and to reduce the number of labor-intensive manufacturing methods.

The program consists of 25 separate projects to redesign various components, but none of the projects was completed at the time of the low-rate production decision. Current schedules show that the redesigns will begin to be incorporated in the second year of low-rate production; most of the redesigns will be incorporated during the third and fourth production years, which are the first 2 years of full-rate production.

Functional Configuration Audit

When the program was restructured in 1985, the functional configuration audit to ensure design completion was scheduled for November 1986—5 months before the low-rate production decision then scheduled for April 1987. The latest schedule shows the audit is to be completed in October 1987—4 months after the June low-rate production decision. Program officials said that the audit had been delayed to ensure that sufficient test data will be available to confirm that the design and performance specifications have been met and that other aspects of development have been completed.

Production Readiness Assessments

During the final development phase, one or more reviews are normally conducted to assess a system's readiness for production. These reviews involve many contractor and government personnel who review various aspects of production readiness, such as design maturity, adequacy of production engineering, production planning, and industrial resources. As of May 1, 1987, there had been five reviews at Hughes and two at Raytheon.

The latest of these assessments concluded that design risk was "significant." According to the current definition, this means that increased management attention is needed to ensure that production will not be disrupted. The report on the assessments pointed out that (1) Raytheon deliveries may be delayed because of an incomplete or inaccurate data package from Hughes and (2) design changes in the missile may result in additional changes in the special production test equipment. The report also pointed out that further missile qualification and flight tests may uncover the need for even more design changes.

Design Status at the Time of Full-Rate Production

At the time of the May 1989 full-rate production decision, the design should be more stable for several reasons. The decision is to be made almost 1 year after the full-scale development program is to be completed. Also, by that time, the Air Force plans to have tested 15 full-capability (tape 4) missiles, and the government is to have accepted control of the tape 3A drawings and technical data package. Finally, delivery of missiles from the first year of low-rate production is scheduled to be near completion. However, at the time of the decision, only 3 of the 25 producibility enhancement projects are scheduled to be incorporated.

Conclusions

At the time of the low-rate production decision, AMRAAM design risk was significant. The final tape 4 design was not complete, and the interim design selected for low-rate production was undergoing changes. Beginning production before the design has stabilized increases the risk that production will be disrupted, the system will not perform satisfactorily, and retrofit programs will be required.

When the full-rate production decision is made, the design should be more stable but will still be undergoing changes. Development will have been completed, including the full-capability design needed to meet all performance requirements, and missiles from the first low-rate production year will have been delivered. However, most of the redesigns to enhance producibility will not yet be incorporated.

Tests Are Under Way but Not Complete

To meet the 1989 initial operational capability date, the Air Force decided to begin AMRAAM production before beginning tests of a full-capability missile and before demonstrating the full performance of the interim design selected for low-rate production. Flight testing of the interim design is behind schedule, and many of the more difficult development tests and almost all of the more realistic operational and combat tests have not yet been completed.

In 1986, the Congress mandated that certain capabilities be demonstrated before fiscal year 1987 funds appropriated for low-rate production were expended. The first test that could have satisfied the mandate was not successful. The Air Force considered the second flight test of April 29, 1987, successful in meeting the congressional requirement; however, changes to the test were made that reduced the test's realism and the risk of failure.

At the time of the full-rate production decision, performance capabilities should be more fully tested. All development and initial operational tests using development missiles are to be complete by that time. However, follow-on test and evaluation using full-capability production missiles, which ideally should be conducted prior to the full-rate production decision, are not scheduled to begin until January 1990—about 8 months after the full-rate production decision.

Full Performance Has Not Been Demonstrated

At the time of the low-rate production decision, the Air Force had conducted several flight tests of the interim design missile but had not flight-tested a full-capability missile. The contractor does not plan to deliver the first missile with hardware and software needed to meet all performance requirements until October 1987—4 months after the low-rate production decision.

The major difference in the interim (tape 3A) and full-capability (tape 4) missiles is that the tape 4 missile will be able to counter certain electronic countermeasures. While the interim design will not meet the full-performance requirement, it is to have improved capabilities over the Sparrow. These include higher speed and the ability to simultaneously engage multiple targets.

Interim Design Not Fully Tested

At the time of the low-rate production decision, the full performance required of the interim design was not fully demonstrated. Some performance criteria used for the decision are lower than, but represent

progress toward, AMRAAM full-performance requirements. Many of the planned tests of the interim design have not yet been completed.

Decision Criteria Less Stringent Than Performance Requirements

The restructured AMRAAM program was reviewed by the Office of the Secretary of Defense. Based on this review, the Deputy Secretary of Defense, in a memorandum dated October 25, 1985, required the Air Force to recommend decision criteria for the low-rate and full-rate production decisions. Most of the recommended performance criteria adopted by the Department of Defense for use in making the low-rate production decision were less demanding than the full-performance requirements. AMRAAM documents specify 40 separate full-performance requirements. Nine of the low-rate production decision criteria were the same, 20 were less stringent, and 11 full-performance criteria were not included.

Several of the 20 less demanding criteria involve critical performance parameters and, in some instances, the criteria do not give specific values. For example, the criterion for multiple target attack is less than the minimum threshold established for acceptable performance. The criterion for the target discrimination requirement permits some tests without electronic countermeasures or in a very limited countermeasure environment. The decision criteria do not specify acceptable values for other important parameters, such as probability of kill and probability of guidance. The criteria for these areas are stated only as "acceptable progress" toward the full-performance requirements.

Program officials said that the criteria for the low-rate production decision had to be less stringent than full performance requirements because of concurrency in the program. The decision was scheduled 13 months before the completion of all development and initial operational tests and before sufficient data was available to ensure that all requirements were met.

Many Planned Tests Have Not Been Completed

The AMRAAM test program is about 7 months behind the revised schedule. Delays were initially caused by contractor missile delivery problems and more recently by the nonavailability of various test resources such as delivery aircraft and targets. When the program was restructured, the revised flight test plan showed that 47 of the total 90 missiles to be flight tested were to be launched by May 1, 1987. As of that date, however, only 33 of the 47 missiles had been launched. The overall results showed that 23 of the launches were fully successful, 4 were partially

successful, 5 were unsuccessful, and 1 was considered a "no test." Between May 1 and July 1, 1987, two more flight tests were conducted on June 5 and June 12, 1987, neither of which was fully successful.

As shown in table 3.1, most of the tests conducted by May 1, 1987, had used tape 1, 2, or 3 software configurations. Only 10 of 22 planned tests of the tape 3A configuration had been completed.

Table 3.1: Number of Tests Planned and Completed (as of May 1, 1987)

	Developmental tests		Operational tests		Total tests	
Software	**Planned**	**Actual**	**Planned**	**Actual**	**Planned**	**Actual**
Tapes 1, 2, and 3	21	21	4	2	25	23
Tape 3A (low-rate production missile)	13	9	9	1	22	10
Total	**34**	**30[a]**	**13**	**3**	**47**	**33**

[a]This figure includes two tests that were repeated due to earlier failures and one no-test

Difficulty Satisfying Congressional Mandate

The fiscal year 1987 Defense Appropriations Act dated October 30, 1986, provided that no funds could be obligated for initial AMRAAM production, with the exception of long-lead procurement, until the missile's capability to engage a minimum of two targets with two missiles on the same intercept in an electronic countermeasure environment had been successfully tested.

The AMRAAM flight test schedule showed that three tests were planned that could demonstrate the capabilities required by the legislation. As of June 1, 1987, the Air Force had conducted two of the tests.

The first test, conducted on February 20, 1987, was not successful in meeting the requirements of the act. This was a developmental test under the control and direction of the AMRAAM program office. The test plan called for two missiles to be fired at two targets flying close together. The primary purpose of this development test was to demonstrate the missiles' abilities to select and guide to their targets in an electronic countermeasure environment of chaff.

In the test, one missile failed to guide to either target because the target were close together, and one missile guided to the wrong target because of an incorrect message from the launch aircraft. According to the program manager, a missile software problem was identified and corrected. Two missiles with these changes were successfully tested on May 1,

1987. Further tests are planned to more fully demonstrate that the problem has been corrected. Aircraft software changes are also under way and are scheduled to be available before production missiles are delivered.

The second test was to be a more demanding operational test under the control of the Air Force Operational Test and Evaluation Center. It called for two missiles to engage two targets in an electronic countermeasure environment that included a self-screening jammer on one of the two targets, a stand-off aircraft jamming the missile, and another stand-off aircraft jamming the launch aircraft's radar. This was to be the first operational test involving two missiles and two targets.

Before conducting the second test, the Operational Test Center and the program office agreed to make certain changes because of difficulties in arranging the test resources. However, because the program office proposed additional changes that were not acceptable to the Test Center, the test was redesignated a developmental test under the control of the program office. Some of the program office's changes improved the missiles' probability of success. These are described below.

- The Operational Test Center proposed deleting a planned maneuver that increased the distance between the targets. The program office did not accept this proposal because the closer target spacing would require performance capabilities beyond those of the interim design missile. The program office, in the revised test, increased the separation between the targets to the originally planned distance.
- The technical characteristics of the self-screening jammer were changed, thus increasing the probability that the missile would guide to the target. The program manager said that it made the jamming more representative of the threat.
- The jammer designed to disrupt the delivery aircraft radar was deleted during the final test rehearsal. The program manager stated that the jammer was not required by the Appropriations Act.

In addition, because of an aircraft software problem, the pilot had to implement a training launch procedure that he would not use in combat. The program manager said that this was not a missile problem and that the Warner-Robins Air Logistics Center is correcting it.

The revised second test was completed on April 24, 1987, but was aborted after the missiles were loaded onto the delivery aircraft. Analysis revealed that a wire inside one of the missiles had been damaged

when the missile's fins were installed. Earlier, another wiring problem had been corrected in this same missile because it had not passed ground tests to ensure that the missiles were ready for launch.

The revised second test was completed on April 29, 1987. According to the Air Force, this test met the requirements of the Appropriations Act. One missile scored a direct hit on its target, and the other missile passed sufficiently close to its target to be considered a success. However, certain problems were identified that would be unacceptable for low-rate production missiles. Air Force test officials rated the missile fired at the target with the self-screening jammer as marginal in guidance and unacceptable in fuzing. (Fuzing detonates the warhead when it passes within the optimum lethal distance of the target.) Air Force program officials pointed out that these problems did not prevent the missile from guiding to within the warhead's lethal radius. The program manager told us that the problems will be corrected before production starts, that corrective actions for the fuze problem are under way, and that guidance problems are under investigation.

The third test, which was to be in June, before the July contract award, has been rescheduled for October 1987. The Air Force has concluded that, since the second test was judged successful, the third test is not needed to satisfy the Appropriations Act's requirements.

Operational Test Realism

The Director of Defense Operational Test and Evaluation has not made a final judgment on the adequacy and realism of the total AMRAAM test plan. Based on a preliminary assessment, the Director approved planned tests through the time of the low-rate production decision but has not yet assessed or approved many of the more difficult and realistic tests scheduled to occur after the decision.

Approval by the Director of Operational Tests

Department of Defense Directive 5000.3 requires the Director to approve operational test plans. The AMRAAM test plan provides for combined development and initial operational tests. Development tests are designed to ensure that specific performance parameters have been achieved. Operational tests are designed to ensure that the weapon will be effective in a realistic combat environment and that it can be operated and maintained by military personnel.

Based on preliminary assessments of the AMRAAM combined test plan, the Director provided interim approval of the plan in February 1987.

The approval was only for tests planned through the time of the low-rate production decision. The Director, with contractor support provided by the Institute for Defense Analysis, was continuing to assess the adequacy of the total test plan.

Realistic Tests After Production Begins

Many of the more difficult development tests and most of the initial operational tests will occur after the low-rate production decision.

At the time of the low-rate production decision, nine development tests using low-rate production design (tape 3A) missiles had been completed. Many of the more difficult development tests had not yet been conducted, including most of the electronic countermeasure and maneuvering targets tests.

When the low-rate production decision was made, only 1 of the 14 total tape 3A operational tests had been completed. At that time, 9 of the 14 were planned to have been completed. As with the development tests, most of the more difficult operational tests were not completed before the low-rate production decision. The primary reason is the amount of concurrency between development and low-rate production. The low-rate production decision was made 13 months before the scheduled completion of development tests. Also, slippage of the flight test program has increased the amount of concurrency and the risk associated with the low-rate production decision.

Test Status at the Time of the Full-Rate Production Decision

Current performance uncertainties and the large number of tests remaining to be completed make it difficult to project the missile's status at the time of the full-rate production decision scheduled for May 1989. However, if current problems are resolved and the schedules remain basically intact, more information on AMRAAM performance will be available at that time.

At the time of the full-rate production decision, all development and initial operational tests are scheduled to be completed, including 15 guided flight tests of full-capability prototypes. These tests and the large number of simulated flight tests will provide a large data base for assessing AMRAAM's performance capabilities.

Follow-on operational tests to validate initial assessments are to begin in January 1990—7 months after the planned full-rate decision to produce 2,900 missiles and after the planned production of 810 low-rate missiles.

These tests are to use full-capability production missiles. Air Force officials responsible for operational testing told us that these follow-on tests cannot begin earlier because the low-rate production missiles will not be the full-capability design.

Conclusions

At the time of the low-rate production decision, all AMRAAM's performance requirements had not been demonstrated. The contractor had not delivered the first full-capability missile, and the full performance of the low-rate production design had not been demonstrated. The test program is about 7 months behind schedule. A final judgment of the adequacy of the operational test plan has not been reached; however, many of the more difficult development tests and almost all of the more realistic operational tests have not yet been completed.

At the time of the full-rate production decision, development and initial operational tests, including flight tests of 15 full-capability missiles, are scheduled to be complete. However, follow-on operational tests using full-capability missiles will not have begun.

Procurement Costs Remain Uncertain

There were a number of uncertainties about AMRAAM's procurement costs at the time of the June 1987 low-rate production decision. The cost estimate is well documented; however, the out-year projections include a number of assumptions that collectively reduce confidence in the estimated amounts. Historically, similar assumptions for other major weapon system acquisitions have changed over time. Assumptions such as savings resulting from competition and the cost of a performance warranty were based on experience with other programs. Detailed estimates for AMRAAM have not been completed.

Uncertainties at the Time of the Low-Rate Production Decision

The latest available AMRAAM production cost estimate is $5.2 billion (1984 dollars) for 17,123 missiles (Air Force only) and $7.0 billion (1984 dollars) for 24,335 missiles (combined Air Force and Navy). This estimate is based on an Independent Cost Analysis completed in December 1984,[4] which included the following assumptions:

- Design modifications to enhance producibility will result in major cost reductions.
- Competitive procurement will reduce costs by over $400 million in 1984 dollars.
- Warranty costs will be similar to warranty costs for other programs and will eventually be absorbed by the contractor.
- Procurement funding will be stable.
- No major missile design changes will occur over the next 11 years.

At the time of the low-rate production decision, there was uncertainty about all of these assumptions. For instance, it was too early to assess the savings related to the AMRAAM producibility enhancement program and competition. Also, decisions involving specific AMRAAM performance warranty provisions had not been made.

Producibility Savings

When the AMRAAM program was restructured in 1985, the Air Force established a producibility enhancement program to reduce missile procurement cost by making design changes to high-cost assemblies to (1) reduce the number of parts, (2) use less expensive components, and (3) use fewer labor-intensive manufacturing methods. For example, less expensive large-scale integrated circuitry is to replace most of the missile's hybrid circuitry.

[4]This estimate was updated for the low-rate production decision, but was not available at the time of our review

The Air Force estimates that the producibility enhancement program, composed of 25 proposed design changes, will save $1.6 billion in 1984 dollars. However, the actual cost savings will not be known until the design changes have been selected and incorporated into the production program. The determination of which changes to incorporate will be based on updated cost and return on investment analyses, which will be done after additional design and integration work is completed.

Competition Savings

The $7.0 billion estimate assumed that competition will reduce procurement cost by $428 million (1984 dollars) after the investment required to establish Raytheon as a second production source is considered. This estimate was based on experience with other missile programs. Competition for AMRAAM production is to begin in the third production year—the first year of full-rate production. The two low-rate production years are to be awarded noncompetitively. The current estimate assumes that the costs of competing AMRAAM production will be fully recovered after 10,000 missiles are produced.

The accuracy of projected savings resulting from competition will not be known until competitive contracts are negotiated. A December 1984 Independent Cost Analysis concluded, based on experience with other programs, that AMRAAM's costs could decrease by an additional 6 percent if the contractors compete aggressively. If they do not, the analysis concluded that costs could increase by 9 percent.

Performance Warranty

Another area of uncertainty relates to warranty costs. The uncertainty results from relying on experience with other systems to project AMRAAM's warranty costs. A full-performance warranty for AMRAAM has not been defined.

The $7.0 billion cost estimate included about $99 million for the warranty, assuming that it would cost about 5 percent of the missile's hardware cost for the first three production years and then gradually decline until it reached 0 by the ninth year. The assumption was based on information about other systems, which indicated that warranty costs ranged from 3 to 15 percent of hardware costs and averaged 3 to 5 percent during the low-rate production years. Program officials told us that warranty costs are expected to decline as the system matures; however, there is limited experience to support this assumption.

The cost of AMRAAM's warranty cannot be estimated with confidence until the specific warranty provisions are defined and negotiated with the contractors. An Air Force study defining the elements of the performance warranty is expected to be completed early in 1988. A full-performance warranty is expected to be incorporated in the third production year.

Budget Profile

The $7.0 billion estimate assumed a certain procurement budget and quantity profile beginning in fiscal year 1987. However, the 1987 Defense Appropriations Act reduced the AMRAAM fiscal year 1987 production funding and the fiscal year 1988 advance procurement funding. According to the program office, the funding reduction will cause the estimate to increase because it lowered the number of missiles scheduled to be purchased during the early production years when savings from competition are expected to be the greatest. The program office currently estimates that production cost will increase by $123 million to $7.123 billion in 1984 dollars.

Although the total number of missiles planned for production remains unchanged, according to the Air Force, the funding reductions will delay delivery of 583 production missiles until the tenth production year and delay achievement of a full-production rate by one year. Future congressional funding reductions could have similar effects.

Stable Design

Another assumption is that there will be no major design or model changes for 11 years. However, the Department of Defense has already endorsed a new advanced air-to-air missile seeker and signal processor that could be used on AMRAAM. These components have recently successfully completed laboratory flight tests. The next step will be to conduct a technology demonstration or incorporate the advanced components into the AMRAAM program. In either case, it is likely that one or both of these improved components will be included in AMRAAM production within the next 11 years.

Cost Status at the Time of the Full-Rate Production Decision

At the time of the full-rate production decision scheduled for May 1989, the procurement cost estimate should be better defined, but some uncertainties will remain. Contract negotiations for full-rate production in the third production year will be under way. This third production year will be the first year of competition and will include the AMRAAM full-performance warranty. A majority of the tests and design reviews for

most of the producibility enhancement design changes should also be complete at that time.

However, uncertainties about AMRAAM's producibility enhancements, budget funding levels, and design will still exist. At the time of the scheduled full-rate production decision, only three of the producibility enhancement design changes are to have been incorporated into production. The remaining 22 changes are to be made in full-rate production, beginning in the third and fourth production years. Producibility enhancement projects, which account for 43 percent of the estimated $1.6 billion savings, will begin to be incorporated in the fourth production year.

Conclusions

At the time of the low-rate production decision, there were many cost uncertainties. Design changes needed to reduce earlier estimates by $1.6 billion and to achieve the current estimates were under way; however, most will not be ready for production until the third and fourth production years. Also, other assumptions, such as savings from competition and the cost of performance warranties, had not been validated. In addition, the assumed funding levels have not materialized and, as a result of congressional funding cuts in fiscal year 1987, the procurement cost estimate will increase by $123 million in 1984 dollars.

At the time of the full-rate decision, the procurement cost estimate should be better defined. However, cost uncertainties regarding AMRAAM's producibility enhancement program and design will still exist. The potential effects of these and other uncertainties, such as the assumption that a certain budget profile will be maintained, reduce confidence in the estimate's accuracy.

Prior GAO Reports

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

Effectiveness of Advanced Medium Range Air-to-Air Missile Is Uncertain, GAO/C-MASAD-81-17, Aug. 4, 1981.

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

Status of Certification, GAO/NSIAD-86-66BR, Feb. 1986.

Legal View Concerning AMRAAM, GAO/NSIAD-86-88BR, Mar. 1986.

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

AMRAAM Cost Growth and Schedule Delays, GAO/NSIAD-87-78, Mar. 1987.

Advanced Medium Range Air-to-Air Missile Preproduction Test Results, GAO/NSIAD-87-165FS, June 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

Address Correction Requested

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