United States General Accounting Office

GAO

Report to the Honorable
Denny Smith, House of Representatives

September 1989

MISSILE PROCUREMENT

AMRAAM Not Ready for Full-Rate Production

GAO/NSIAD-89-201

GAO

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

National Security and
International Affairs Division

B-221734

September 7, 1989

The Honorable Denny Smith
House of Representatives

Dear Mr. Smith:

This report, prepared at your request, addresses the status of the Advanced Medium Range Air-to-Air Missile (AMRAAM) at the scheduled full-rate production milestone. As requested, we focused on the missile's demonstrated performance and design stability, and the contractors' readiness to produce quality missiles at the required rates.

The report concludes that there were too many unknowns in the AMRAAM program at the completion of GAO's work in July 1989 to warrant the approval of full-rate production. The Air Force had not demonstrated that the missile can meet some critical performance requirements, and the missile's operational reliability was unacceptable. Further, the missile's design had not stabilized, and it was unclear whether the contractors would be able to achieve the higher production rates on schedule.

Unless you publicly announce its contents earlier, we plan no further distribution of this report 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.

This report was prepared under the direction of Harry R. Finley, Director, Air Force Issues. Other major contributors are listed in appendix I.

Sincerely yours,

Frank C. Conahan
Assistant Comptroller General

was scheduled for June 1989 but was recently postponed to October 1989. Similarly, a full-rate production decision scheduled for September 1989 has slipped to November 1989 at the earliest and possibly to March 1990 or later. The President's fiscal year 1990 budget contains a request for $1.05 billion to fund full-rate production of 1,600 missiles.

Results in Brief

At the completion of GAO's work in July 1989, there were too many uncertainties in the AMRAAM program to warrant the approval of full-rate production. The Air Force had not demonstrated that the missile can meet some critical performance requirements, and the missile's operational reliability was unacceptable. The missile design had not stabilized; changes were continuing to be made. More design changes may be needed to correct reliability problems. Further, it was unclear whether the contractors would be able to achieve the higher production rates on schedule. Both contractors were behind in deliveries under the first production contract, and neither had produced a sufficient quantity of missiles to demonstrate its full-rate production capabilities.

GAO's Analysis

Critical Performance Requirements Not Yet Demonstrated

Although completed tests had demonstrated many performance requirements such as maximum speed, range and altitude, and autonomous guidance, other important requirements had not been proven. For example, the Air Force had not shown that AMRAAM can engage four targets simultaneously and can meet its probability of kill requirement. Additional tests with initial production missiles were to address these and other outstanding issues, but they were not completed as of July 31, 1989.

Operational Reliability Is Unacceptable

On May 1, 1989, the Air Force's independent test organization stopped the fourth attempt to prove that AMRAAM can withstand the temperature, vibration, and other environmental extremes it will be exposed to on the F-15 aircraft. As with the three earlier attempts, the high number of failures that occurred early in testing showed that reliability requirements could not be achieved and that additional design changes were

Abbreviations

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

Hughes Aircraft Company is the prime development contractor under a leader-follower acquisition strategy. During full-scale development, Raytheon Company, the follower, monitored the Hughes design effort and produced 15 missiles to qualify as a second-source producer. During production, Raytheon continues to monitor design changes to the missile.

The Department of Defense has approved total production of 603 missiles: 180 funded in fiscal year 1987 and 423 funded in fiscal year 1988. Hughes and Raytheon are manufacturing 105 and 75 missiles, respectively, in the first production year. Hughes was allocated 223 missiles and Raytheon 200 missiles for the second production year. The Air Force and Navy plan to buy 906 missiles in the third production year. A final Department of Defense decision on that plan has been delayed and is now scheduled for October 1989. If approved, Hughes and Raytheon will manufacture 534 and 372 missiles, respectively.

The President's fiscal year 1990 budget request includes $1.05 billion for 1,600 missiles in the fourth production year—the first year of full-rate production. Starting in fiscal year 1991, the Air Force and the Navy plan to buy a total of 3,000 missiles each year.

The Air Force and the Navy expect to spend a total of about $1.3 billion for AMRAAM research and development. According to the December 1988 Department of Defense Selected Acquisition Report, the total procurement cost for 24,320 missiles will be $10.3 billion.

Program History

The AMRAAM program began in October 1975 when an Air Force and Navy tactical working group defined 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 competitive 33-month validation phase in February 1979 to determine the primary design contractor for full-scale development. The Air Force awarded Hughes a 54-month full-scale development contract in December 1981.

AMRAAM's schedule slipped and cost increased significantly during its full-scale development phase. In January 1985 the Secretary of Defense expressed concern over the program's schedule delays and rising costs and ordered a complete program review to determine if and how program costs could be reduced. On the basis of this review, the Air Force began a program to reduce production costs by redesigning many of the

although it could be made as early as November 1989, a full-rate production decision would probably not be made until at least March 1990.

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 make several certifications, including 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. On February 28, 1986, the Secretary certified to these items.

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 act stipulated that the cap would not apply to cost increases that result from congressional funding actions. The Air Force believes the current cap should be $7.585 billion (1984 dollars) based on congressional funding and missile quantity reductions for fiscal years 1987 and 1988.

Prior GAO Reports

Shortly after the June 1987 program review, which recommended approval of AMRAAM's initial production, we reported (GAO/NSIAD-87-168)[1] that the missile's unstable design and small number of completed tests increased its production risks. The initial low-rate production decision was made 13 months before the then-scheduled completion of development. Later development delays increased the overlap between development and production to 19 months.

Shortly after the May 1988 program review, which recommended approval of AMRAAM's second production year, we reported (GAO/NSIAD-88-186) that the Air Force had not completed tests needed to make a full and accurate assessment of AMRAAM's performance and that completed tests had identified performance and reliability uncertainties that had not been resolved. Therefore, we concluded that the combat effectiveness and reliability of missiles to be produced for the operational inventory were uncertain.

[1]This and other related GAO products are listed on the last page of this report.

and discussed test results with Air Force, Navy, and Office of the Secretary of Defense officials responsible for conducting and monitoring the tests.

We did not make a formal assessment of the contractors' readiness for full-rate production because of the large number of design changes and uncertainty about the missile's reliability when used on the F-15 aircraft. The Air Force deferred its production readiness reviews from March to November and December 1989. However, we reviewed the results of previous production readiness reviews and the extent to which contractors were meeting scheduled deliveries under the first production year contracts.

As requested, we did not obtain official agency comments on this report. However, we obtained the views of Air Force, Navy, Office of the Secretary of Defense, and contractor officials during the course of our work and incorporated them where appropriate. We conducted the review from October 1988 through July 1989 in accordance with generally accepted government auditing standards.

Development Tests Have Proven Many Capabilities, but Critical Tests Remain

The AMRAAM program completed full-scale development flight testing in January 1989. During full-scale development, the Air Force and Navy flight tested 100 missiles: 95 produced by Hughes and 5 produced by Raytheon. Of these missiles, 21 were launched in tests directed and controlled by the Air Force's independent test organization, the Air Force Operational Test and Evaluation Center, and 5 were launched to qualify Raytheon as a second production source.

The tests demonstrated that AMRAAM can meet many of its critical performance requirements. For example, tests have shown that the missile can be effective against a high-flying, high-speed target and against a variety of electronic countermeasures that an enemy might use to confuse AMRAAM's guidance and degrade its performance. Other tests have shown that AMRAAM can meet its speed and range requirements and that it is effective when launched at low-flying targets.

Between February and September 1989, the Air Force planned to flight-test 21 initial production missiles. Of these, 10 were to determine whether AMRAAM can be effectively launched during a variety of aircraft maneuvers, speeds, and altitudes. Through July 1989, 5 of the missiles had been successfully launched under these conditions. The Director, Operational Test and Evaluation, designated that 8 tests using the remaining 11 missiles are mandatory for an adequate initial operational test and evaluation to support the full-rate production decision. The following sections describe in more detail the issues, objectives, and status of the eight tests.

Multiple Targets

AMRAAM is required to be capable of simultaneously attacking multiple "resolved" targets, that is, multiple targets that appear as discrete symbols on the aircraft's radar display. The Air Force's Tactical Air Command, which represents operational units that would use the missile in combat, has stated that this capability is a critical requirement.

In two separate operational tests conducted in 1987 and 1988 to demonstrate AMRAAM's multiple target capability, two missiles were launched at two resolved targets. Neither test was successful, partly because a software design problem caused the missiles to guide to the wrong targets. The contractor modified the software design, and additional tests with six modified initial production missiles were planned for June and July 1989. The initial production missiles were specially modified because the needed software upgrade will not be in production missiles until the second production year.

Improved Capability Against Electronic Countermeasures

Several missile launches during development showed AMRAAM's capability against a number of specific electronic countermeasures. One technique, however, was not tested because the needed software was not available. The software has since been successfully demonstrated in a flight test. On April 13, 1989, AMRAAM scored a direct hit on a target employing the technique. The program office expects most of the first production year missiles to have this improved software.

Weapon System Compatibility

AMRAAM's compatibility with the Sparrow missile and the F-15 radar system needs to be demonstrated because the F-15 is to be capable of carrying both missiles. A flight test was scheduled for May 12, 1989, to demonstrate this compatibility, but it had to be postponed because the F-15 radar display indicated that the radar was not locked-on to both targets. The Air Force independent test center director said that a minor software change has been made but the test has not been rescheduled at this time.

Major Reliability Problems Identified

On May 1, 1989, the Air Force's independent test center stopped the fourth attempt to demonstrate AMRAAM's operational reliability. This attempt was stopped because of the high number of failures during the first 3 months of the 7-month test period. The three earlier attempts were also stopped because of missile failures.

To demonstrate AMRAAM's reliability under realistic flight conditions[5], the Air Force's independent test center planned to have missiles carried on the F-15 aircraft—which is to be the first aircraft to become operational with the AMRAAM—and periodically tested for failures. The missile's built-in-test feature is used before, during, and after each flight to determine if the missile is functioning properly. A failure on such a test would prevent a missile from being launched in a combat situation. The original plan provided for accumulating 1,200 hours on 6 Hughes full-scale development missiles and an additional 800 hours on 7 Raytheon initial production missiles.

The first attempt to show AMRAAM's reliability was terminated in April 1987 during integration tests—which preceded tests by the independent test center—when a control fin failed after about 20 hours of flight on

[5]Although many combat missions would not expose the missile to long periods of stressful flight on the aircraft, other combat and peacetime training and patrol missions could subject the missile to many hours of stressful flight

AMRAAM's Design Continues to Evolve

Although the AMRAAM program has completed its development phase and is approaching its full-rate production phase, the missile's design continues to evolve. Some changes identified late in development will not be incorporated until the second or third production years. More recent tests have also shown that in some flight maneuvers the missile experiences vibration levels on the F-15 aircraft that are significantly greater than the levels for which AMRAAM was built. As of July 1989, the Air Force was assessing the impact of the greater vibration levels on AMRAAM's reliability and the extent of required changes to the missile.

Importance of Design Stability

Until the design stabilizes, the effectiveness and suitability of a weapon system cannot be predicted with certainty. According to Department of Defense Manual 4245.7-M, "Transition from Development to Production," a stable design provides confidence that a system has overcome development problems and that it will meet defined technical and operational performance requirements. Beginning full-rate production before the design stabilizes increases the risk that production schedules will be disrupted, weapons will not perform satisfactorily, different missile configurations will enter inventory and have to be maintained, and costly retrofit programs will be required.

Design Continuing to Change

AMRAAM production began before its development and testing phases were completed. As a consequence, all of the design changes identified in these phases will not be incorporated into the first production missiles. The Air Force is using a block approach to implement planned design changes for the initial production year. This approach groups changes and incorporates them as blocks of changes at preplanned production stages. This approach helps to reduce the number of different missile configurations entering the operational inventory.

Initial Inventory Missiles Will Not Have All Needed Upgrades

To meet initial inventory requirements, the Air Force began production before completing development and tests to ensure that AMRAAM will be effective and reliable. For example, to prevent further slippage of the planned initial fielding in 1989, the Air Force decided to begin low-rate production with an interim missile design that is not fully capable against some sophisticated electronic countermeasures that an enemy may use to confuse the missile's guidance system. The interim capability missile, referred to as the software tape 3A design, does not have all software and hardware needed for full performance. All 180 of the first

were minor and may not have a significant impact on the performance of the missile.

Other Development Problems Have Not Been Resolved

Conducted late in the development process, a functional configuration audit verifies that military systems have met performance requirements and specifications and that the systems have satisfactorily completed development. The audit begins with individual components and ends with a complete system-level review. AMRAAM component reviews began in May 1987, and the system-level review was completed in December 1987. At the completion of the audit, 162 items required corrective action. As of June 29, 1989, 18 of these items had not been resolved, and a schedule for completing these corrective actions has not been finalized.

One of the required corrective actions is for Hughes to conduct another analysis of the strength of the missile's surface when exposed to a range of vibration levels and temperature extremes. The Air Force did not accept the original analysis that Hughes submitted. As of July 1989, the Air Force had not received the revised analysis. Another required corrective action is that the missile be loaded on and unloaded from an aircraft within specified time constraints. Hughes plans to complete this action in November 1989.

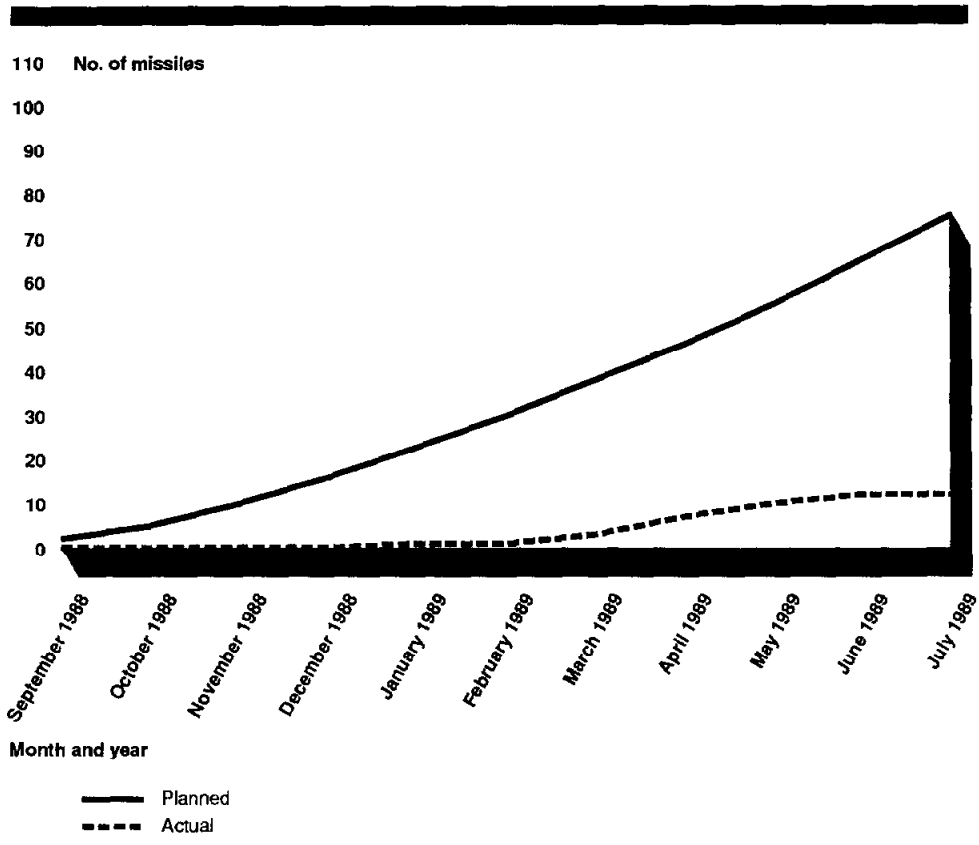
Changes to Improve Operational Reliability

Recent events have demonstrated that the design specifications that guided AMRAAM development and environmental qualification tests were not adequate. Ongoing measurements indicate that vibration levels on the F-15 fuselage stations[8] are much greater than the missile was designed to withstand. As a consequence, the missile's reliability in realistic operational testing has not been acceptable. Some missile components are already being redesigned and others may have to be in order to improve the missile's reliability.

Early in development, technical parameters are established to ensure that a weapon will perform effectively and reliably in combat. For air-to-air missile systems, it is important to ensure that the missiles can withstand the vibration, shock, and temperature extremes they will encounter when carried on fighter aircraft. The developing activity establishes the technical parameters through a variety of measures

[8]Tests have shown that the vibration levels on the F-15 are greater than on other aircraft that carry AMRAAM.

Figure 4.2: Raytheon's Scheduled and Actual Production Deliveries as of July 31, 1989



the receiver/range correlator. Hughes also experienced schedule delays due to design problems with several missile components including the warhead and rocket motor. These and other changes will require the contractors to conduct additional qualification tests before they can deliver missiles to the Air Force.

Design changes have also forced both contractors to scrap some components and rework others. For example, many sophisticated electrical components such as hybrid circuit boards and flexible cables were scrapped after the contractors identified needed design modifications. In some instances, the contractors have had to retrofit production missiles with the redesigned components.

Conclusions and Recommendation

The Defense Acquisition Board had planned to conduct its last major AMRAAM program review in September 1989 but that has been postponed at least until November 1989 and possibly to March 1990 or later. When it is held, this review will result in a recommendation to the Secretary of Defense on whether the program should proceed into full-rate production.

Conclusions

AMRAAM, for a variety of reasons, is not ready at this time to proceed into full-rate production. For example:

- AMRAAM's reliability is not at an acceptable level. Efforts are underway to better understand the impact of the F-15 operational environment on the missile's reliability and determine the design changes that may be needed for the missile to withstand that environment. Only when these efforts are completed and needed design changes are incorporated into production can a meaningful operational reliability evaluation take place.
- AMRAAM's design is continuing to evolve. As a result, the contractors are producing a variety of missile configurations that will be delivered to the operational inventory. Proceeding into full-rate production without a stable missile design would significantly increase the program's cost, schedule, and performance risks.
- Neither contractor has been able to meet its original or revised production delivery schedules. Until the missile design stabilizes, the contractors may not be capable of producing quality missiles at steadily increasing rates.

Recommendation

We recommend that the Secretary of Defense not authorize AMRAAM for full-rate production until realistic tests demonstrate that the missile has met its performance and reliability requirements, the missile design stabilizes, and the Air Force's production readiness reviews show the contractors can produce quality missiles at the required rates.

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.

Related GAO Products

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

Missile Development: Advanced Medium Range Air-to-Air Missile Legal Views and Program Status (GAO/NSIAD-86-88BR, Mar. 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, Mar. 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, Aug. 14, 1987).

Missile Development: AMRAAM's Combat Effectiveness at Production Not Fully Tested (GAO/NSIAD-88-186, July 7, 1988).

Major Contributors to This Report

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

Paul L. Jones, Associate Director, Air Force Issues, (202) 275-4265
Robert L. Pelletier, Assistant Director
William R. Graveline, Assignment Manager

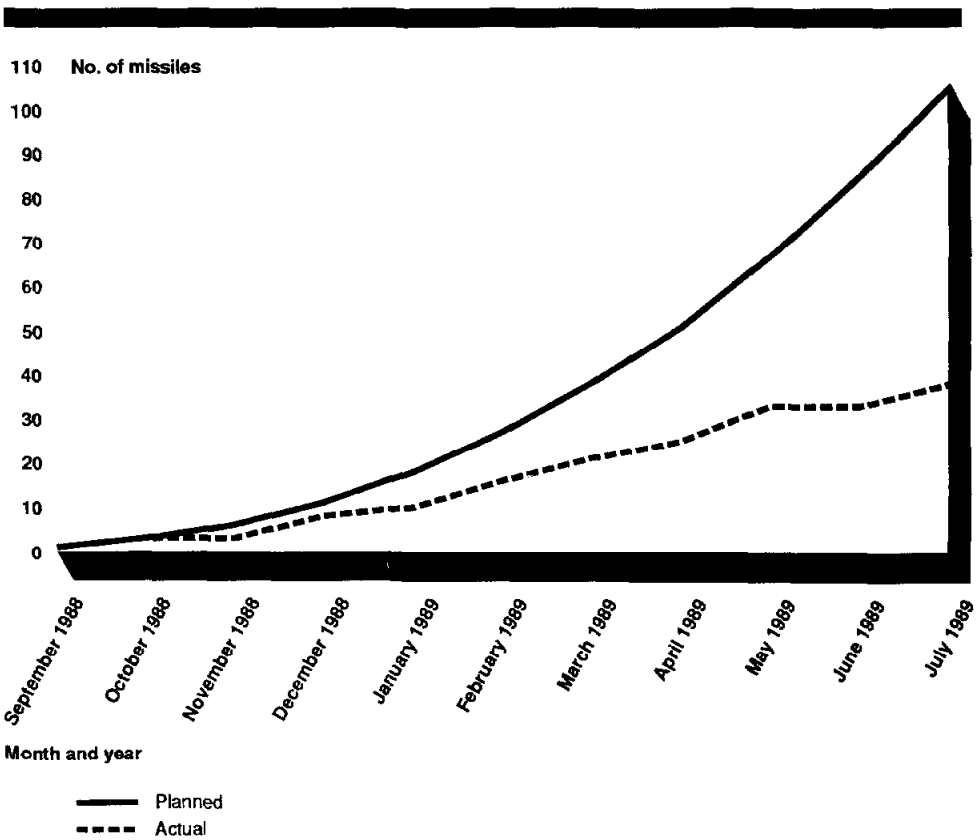
Atlanta Regional Office

Lee A. Edwards, Regional Management Representative
John L. Grant, Evaluator-in-Charge
Donald C. Dunham, Evaluator
Richard B. Smith, Evaluator

Full-Rate Production Reviews Delayed

The Air Force has rescheduled the production readiness reviews for full-rate production from March to November and December 1989. The AMRAAM program's Director of Manufacturing, who is responsible for the reviews, told us that he could not see a benefit in conducting the reviews at the originally scheduled date. He said that until the contractors overcome the present design problems, full-rate production would not be possible.

Figure 4.1: Hughes' Scheduled and Actual Production Deliveries as of July 31, 1989



Delivery schedules for both contractors have been revised to accommodate delays, but even the revised schedules have not been achieved. As of July 31, 1989, Hughes was to have delivered 105 missiles under the revised schedule, but it delivered 38 missiles. Raytheon's latest revised schedule called for 33 missiles to be delivered by July 31, 1989, but it delivered 12 missiles. The AMRAAM Program Office expects Hughes to complete its initial production deliveries of 105 missiles by the end of September 1989 and Raytheon to complete its initial production deliveries of 75 missiles by the end of December 1989.

Design changes delayed both contractors' production deliveries during the first production year. For example, Raytheon's production was delayed twice—for a total of 6 months—to incorporate design changes. The first delay was caused by a series of design changes that Hughes identified soon after initial production contracts were awarded. Raytheon's other delay occurred when Hughes identified design problems in

including actual flight tests with equipment that can measure and record the vibration and other environmental extremes. The technical parameters are included in the contract specifications that guide the detailed design. In addition to guiding development, the parameters are used in qualification tests to ensure that the system can withstand the environmental elements.

Although AMRAAM completed environmental qualification tests in September 1988, the Air Force has since learned that the technical parameters used to design and test the missile were not representative of the actual environment in which AMRAAM will have to operate. After the missile's production began, the Air Force discovered that the F-15 fuselage environment is much more severe than the parameters included in the missile's design specifications. Additional environmental measurements indicate that the specification should be adequate for the F-15 wing stations, notwithstanding the four missile failures on these stations during the most recent reliability testing.

At the end of June 1989, the Air Force completed flight tests to gather missile vibration data to better define the F-15 environment. As of July 31, 1989, the Air Force was continuing to analyze and characterize the effects of the F-15 vibration levels on missile components. Some components such as the missile's fins, wings, and attachment mechanism have been redesigned to accommodate the higher vibration levels; other components may also have to be redesigned. According to the AMRAAM Program Manager, until the problems are corrected, restrictions will have to be imposed on F-15 operational aircraft that carry initial production missiles.

year production missiles have the interim capability. The full performance design, referred to as tape 4, is planned for the second production year and beyond.

Additional design changes identified since the initial low-rate production decision have been grouped for incorporation into the first production year missiles, whereas others will be incorporated into the second or third production year missiles. For example, Hughes will deliver first production year missiles in three blocks. Missiles from Hughes' second block will include an automatic built-in test capability that permits the pilot to check the pressure in the missile's guidance section while on the ground or in flight. For missiles from Hughes' first block, the pressure can only be tested manually before flight. Without the required pressure, the missile would likely malfunction. None of Raytheon's first production year missiles will include the automatic pressure test feature and other design upgrades planned for Hughes' second and third block missiles because of the additional time required to implement the changes. Raytheon plans to incorporate these changes into its second production year missiles.

Another example is a safety device intended to split the rocket motor if a fire occurs while the missile is in storage. Splitting the motor keeps the missile from propelling through the storage space and causing damage or injuries to personnel. The Air Force plans to complete testing in 1990 and incorporate the device into missiles to be delivered in the third production year.

Recent tests have identified additional needed design changes. For example, the missile software, rocket motor, fuze mechanism, receiver/range correlator,[7] and other components have been or are in the process of being redesigned and tested. The updated software and redesigned components will be incorporated into future production missiles at various stages.

Initial low-rate production missiles will not meet some of the technical specifications stated in the production contracts. The Air Force has approved over 200 deviations from the specifications in the first production year, and additional deviations are being approved for the second production year. In many instances, the Air Force approved the deviations to avoid additional schedule delays. Many of these deviations

[7]This a major component in the missile's guidance section.

the F-15. The second attempt was terminated by the test center in August 1988 after the missile failed 4 times in 126 hours. The third attempt was again terminated in December 1988 during integration tests due to a failure after only 13 hours. Because of these failures and contractor production problems, the Air Force decided to conduct the tests with first production year missiles manufactured by Hughes. The tests were to be conducted between February and August 1989.

These tests began in February 1989, but they were also suspended by the test center on May 1, 1989, because the missiles failed 11 times in 458 flight hours, which computes to a mean time between maintenance rate of 42 hours. (The required mean time between maintenance rate is 300 hours.) The AMRAAM program manager attributes most of the reliability problems to the unexpectedly severe environment the missile encounters on the F-15 aircraft fuselage station.[6] However, 4 of the 11 failures occurred on the F-15 wing stations. Program officials could not explain these failures because recent measurements indicate that the missile's design should be adequate to withstand the environment encountered when it is carried on the wing stations. Air Force efforts to better define the environment and assess its impact on AMRAAM are discussed in chapter 3.

Originally, the reliability testing was to be completed before the full-rate production decision. However, the Air Force now plans to restart operational reliability testing in October 1989 and, under the revised schedule, the tests are scheduled to be completed in February 1990. If the full-rate production decision is made in November 1989—the earliest date under consideration for that decision—the amount of reliability test data available will be limited. Therefore, it is unlikely that the Air Force will be able to prove at that point that the system will be reliable when used under combat conditions.

[6]The F-15 aircraft can carry eight AMRAAMs, four on its fuselage stations and four on its wing stations.

Two tests were conducted in June 1989, and, according to the program office and the Air Force's independent test center, both were successful. In each of the tests, two targets were used, but only one missile was fired. The objective of the tests was to show that the missile would guide to its assigned target.

A four-missile test, scheduled for August 1989, was intended to demonstrate that one aircraft can engage four resolved targets simultaneously. To comply with a specific concern of the Director, Operational Test and Evaluation, the Air Force planned to carry each of these four missiles on operational F-15 aircraft for 15 to 25 hours before launch in order to demonstrate their reliability. However, because of known reliability problems, the missiles were not carried on the F-15 before the test, as planned. The test was conducted on August 2, 1989, but was not successful. According to the Air Force, three of the four missiles missed their targets due to aircraft fire control system problems and the fourth missed its target due to a missile software problem. After completing its analysis of the test results, the Air Force plans to reschedule the four-missile test as soon as possible.

Probability of Kill

Probability of kill is the probability that the missile can be successfully launched and guided to the target and that its fuze and warhead will function properly to destroy the target. At the completion of development, the Air Force's independent test center concluded that AMRAAM's probability of kill had not been determined. The center plans to continue monitoring initial production missile tests to see if the probability of kill improves.

The Air Force is also conducting ground tests to calculate the lethality of AMRAAM's warhead against actual threat aircraft. The Director, Live Fire Testing, required the ground tests after concluding that the warhead's lethality had not been clearly demonstrated. As of July 31, 1989, the tests were underway and scheduled to be completed by August 1989.

Improved Control Fins

Development tests showed that AMRAAM's control fins—which permit the missile to change direction and/or altitude—had to be redesigned to make them stronger because they were twisting and bending during flight. The fins and attachment mechanisms have been redesigned and have performed well when carried on the F-15 aircraft. The Air Force planned to launch a missile with the new design in June 1989 but that test has been delayed for several months.

Effectiveness and Reliability Questions Remain

At the completion of our review in July 1989, AMRAAM's operational effectiveness had not been fully demonstrated. Completed tests had shown that AMRAAM met many of its performance requirements but that additional planned tests were needed to address outstanding performance issues. AMRAAM's operational reliability, however, was clearly unacceptable. Although extensive efforts were underway to address the problems, the missile's reliability will not be known at the time of the full-rate production decision if the decision is made as early as November 1989.

On May 1, 1989, the Air Force's independent test organization stopped the fourth attempt to show that AMRAAM will be reliable when carried on the F-15, the first aircraft to become operational with the missile, because of the high number of missile failures during the testing period. (The first three attempts were stopped for the same reason.) Although flight tests continued under the direction of the AMRAAM Program Office, their focus changed from demonstrating reliability to identifying design problems and investigating possible design changes. Independent operational reliability testing is scheduled to resume in October 1989 and will not be completed until February 1990.

Importance of Testing Before Production

Department of Defense Directive 5000.3, "Test and Evaluation," requires that test objectives be accomplished before committing significant resources to a weapon system or advancing a system from one acquisition phase to another. Public laws or Department of Defense regulations governing major system acquisitions stipulate that a system may not proceed beyond low-rate production until (1) independent tests prove that the system will be effective and reliable when used under combat conditions, (2) the Director, Operational Test and Evaluation, assesses the system's operational effectiveness and suitability and reports the results to the Secretary of Defense and to the House and Senate Committees on Armed Services and on Appropriations, and (3) realistic survivability or lethality testing of the system is completed and the Secretary of Defense submits a report on the testing to the defense committees of the Congress.

Objectives, Scope, and Methodology

Representative Denny Smith asked us to review and report on AMRAAM's status before the Secretary of Defense's decision on full-rate production. Specifically, he asked us to assess if

- operationally realistic tests have demonstrated AMRAAM's required performance,
- the AMRAAM design is complete and stable, and
- the contractors have shown the ability to produce quality missiles at the required production rates.

We 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.

Office of the Secretary of Defense

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

Department of the Air Force

- Headquarters
- Headquarters, Tactical Air Command
- Systems Command, Munitions Systems Division
- Operational Test and Evaluation Center

Contractors

- Hughes Aircraft Company
- Raytheon Company

We reviewed pertinent regulations and the results of key activities intended to determine design progress. These activities included design reviews, component qualification tests, engineering change proposals, deviations and waivers, functional and physical configuration audits, and the plan for resolving open items from these reviews.

We compared planned and actual test schedules and correlated the individual test results with the critical performance issues that were to be addressed. We examined the results of flight tests, various ground tests, and air-to-air missile firings. We witnessed selected guided flight tests

missile's components to make them more producible. The Air Force also extended the program's full-scale development phase from 54 to 79 months and postponed the initial operational capability date from 1986 to 1989.

In June 1987 the Secretary of Defense approved funding for the initial low-rate production. For the first year of low-rate production, the contractors are in the process of producing 180 interim design missiles, referred to as the tape 3A configuration.[3] The Air Force will use some of the missiles for additional testing, and some of the missiles produced by each contractor will be placed in inventory to achieve the initial operational capability on the F-15 aircraft. The Defense Acquisition Board reviewed the program's status and test results in May 1988. On the basis of the Board's recommendation, the Secretary approved the production of 423 full-capability missiles, known as tape 4, for the second production year. The tape 4 missiles are expected to perform better than the tape 3A missiles against some enemy electronic countermeasures designed to confuse AMRAAM and degrade its performance.

In May 1988 the Board also reviewed the Air Force's request to begin procuring long-lead items for the first year of full-rate production. However, the Board chose to defer its decision until September 1988 when more tape 4 developmental and operational test data were to be available. In September 1988 the Board's Conventional Systems Committee decided that AMRAAM was not ready for full-rate production. As a result, the Committee recommended that the quantity of missiles for the third production year be reduced from 1,270 to 906 to continue low-rate production. The Committee also recommended that the Air Force be permitted to proceed with the procurement of the long-lead items but decided to review the program again before authorizing fabrication of the 906 missiles. In June 1989, the Committee decided to postpone a final decision on fabrication of the 906 missiles until more reliability data can be obtained.

The Committee also planned to review, in September 1989, the Air Force's request to begin full-rate production. However, at the June 1989 meeting, the Committee decided to delay the September review. According to the AMRAAM Program Element Monitor in the Office of the Assistant Secretary of the Air Force, the Committee will decide on an appropriate date for the full-rate production decision in October 1989, after considering Air Force alternatives. That official also stated that,

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

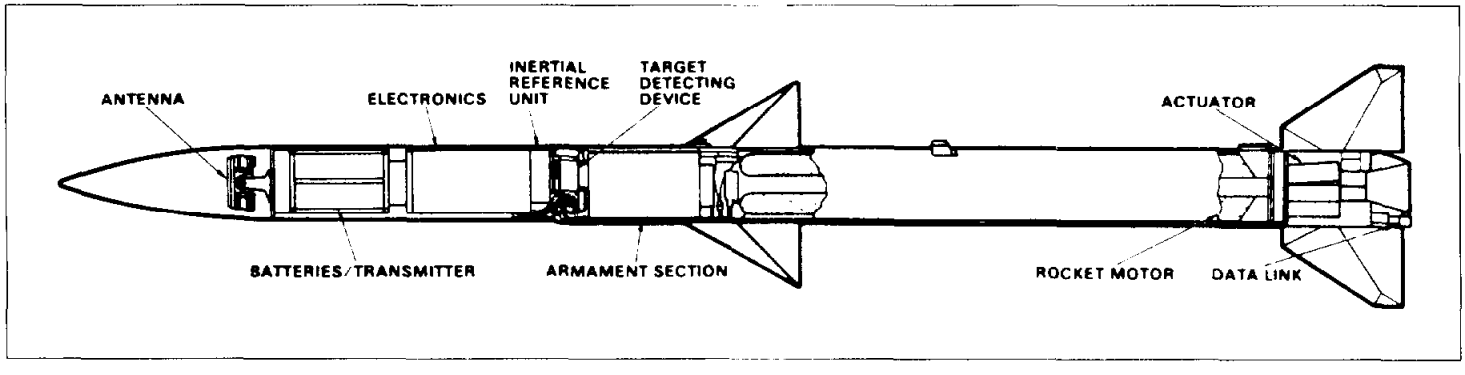
Introduction

The Air Force and the Navy are jointly developing the Advanced Medium Range Air-to-Air Missile (AMRAAM) to meet their air-to-air missile requirements into the next century.[1] The primary goal 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. It is to be compatible with the services' latest fighter aircraft: the F-14, F-15, F-16, F/A-18, and Advanced Tactical Fighter. Because the missile's initial operational capability is planned to be achieved on the Air Force's F-15, most of its developmental and initial operational testing has been conducted using that aircraft.

AMRAAM is to replace the Sparrow missile and is intended to improve aircraft combat effectiveness. The missile is also intended to be more reliable and maintainable than the Sparrow and has improved performance features over the Sparrow, such as 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 track multiple targets, launch multiple missiles, and maneuver to avoid counterattack.

The AMRAAM is about 12 feet long and weighs about 345 pounds (see fig. 1.1). It is designed to guide close to the target and to detonate its warhead within lethal range of the target.

Figure 1.1: The AMRAAM



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

[2]This enables the missile's on-board radar to acquire and guide to a target autonomously.

Contents

needed. Ongoing efforts to more completely measure the missile's vibration levels on the aircraft indicate that the original missile design specifications were significantly below that required to ensure reliability on the F-15 aircraft.

AMRAAM Design Continues to Evolve

The AMRAAM design continued to evolve through the end of development and into the first year of production. The Air Force had completed design reviews of the initial production configuration, but all corrective actions had not been resolved. Also, because additional time is required to make design corrections, missiles being delivered do not meet all performance specifications. Some changes are being incorporated into succeeding blocks of the initial production missiles. However, other required changes will not be available until later production years. Continuing reliability tests will likely identify other needed changes.

Full-Rate Production Readiness Not Yet Determined

Continuing design problems must be resolved before the contractors can demonstrate their ability to manufacture quality missiles at increasingly higher rates. These problems have disrupted initial production deliveries. For example, as of the end of July, Hughes had delivered only about one-third of its original scheduled deliveries, and Raytheon had delivered only a small fraction of its originally scheduled deliveries. The Air Force had delayed its full-rate production readiness reviews from March to November and December 1989.

Recommendation

GAO recommends that the Secretary of Defense not authorize AMRAAM for full-rate production until realistic tests demonstrate that the missile will be effective and reliable, the design stabilizes, and production readiness reviews show that the contractors can produce quality missiles at the required rates.

Agency Comments

As requested, GAO did not obtain official agency comments on this report. However, the views of Office of the Secretary of Defense, Air Force and Navy officials responsible for managing the AMRAAM program were obtained during the course of GAO's work and have been incorporated where appropriate.

Executive Summary

Purpose

If production of a weapon system is authorized before tests demonstrate that it will be effective and reliable, the risk that design changes will be required to the system increases. Such changes could disrupt production schedules and result in costly modifications after deployment.

Representative Denny Smith requested that GAO review and report on the status of the Advanced Medium Range Air-to-Air Missile (AMRAAM) before the Secretary of Defense's decision to begin full-rate production. Specifically, GAO assessed whether

- operationally realistic tests have demonstrated the missile's required performance,
- the missile's design is complete and stable, and
- the contractors have demonstrated the ability to produce quality missiles at the required production rates.

Background

The Air Force and the Navy are jointly developing AMRAAM to meet their medium range air-to-air missile requirements into the next century. 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 Advanced Tactical Fighter.

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

The Air Force and the Navy plan to procure more than 24,000 missiles over an 11-year period. The program's total cost is estimated at $11.6 billion, including estimated inflation.

Hughes Aircraft Company is the prime development contractor under a leader-follower acquisition strategy. Raytheon Company, the follower, monitored the Hughes design effort to qualify as a second-source producer.

The Department of Defense has approved funding for total production of 603 missiles: 180 interim design (less-than-full-capability) missiles in 1987 and 423 full-capability missiles in 1988. In May 1988 the Department approved funds for long-lead items for 906 missiles in the third year of low-rate production. A final funding decision on the 906 missiles