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GAO

Report to the Congress

Joint Review by the U.S. General Accounting Office and the Federal Court of Audit of the Federal Republic of Germany

August 1990

NAVY SHIP DEFENSE

Concerns About the Strategy for Procuring the Rolling Airframe Missile

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Comptroller General
of the United States

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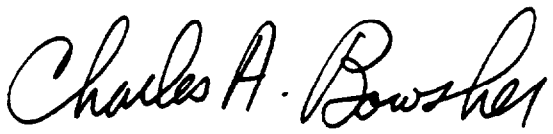
To the President of the Senate and the
Speaker of the House of Representatives

This report is the result of a joint U.S. General Accounting Office and Federal Court of Audit of the Federal Republic of Germany (Germany) review of the Rolling Airframe Missile program. This close-in defense system is designed to protect naval vessels against antiship cruise missiles equipped with active radar guidance systems. Both countries share the development and production costs, and Germany provides a second source for missile production.

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

This report was prepared under the direction of Martin M Ferber, Director, Navy Issues, U.S. General Accounting Office, and Dr. Gerald Guentzel, Chief Auditor, Navy Issues, German Federal Court of Audit. If you or your staff have any questions, Mr. Ferber can be reached on (202) 275-6504. Major contributors to this report are listed in appendix IV.



Charles A. Bowsher
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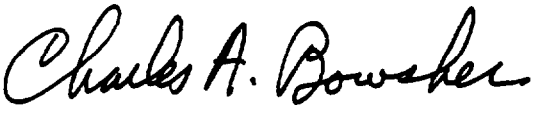
Preface

Within the North Atlantic Treaty Organization, more and more weapon systems are cooperatively developed and procured as multinational programs. Important decisions concerning the implementation of these programs are no longer made nationally but are made internationally (for example, by steering committees and program offices). Therefore, audit institutions are faced with the task of finding new ways of cooperation to ensure that these programs are audited as comprehensively and efficiently as possible.

Hence, the U.S. General Accounting Office and the German Federal Court of Audit have for the first time conducted a joint review of a German-American cooperative program, that is, the Rolling Airframe Missile program, and have agreed on combined findings and recommendations.

The report, which is based on the jointly developed audit results, recommends measures to review requirements and to improve the efficiency of the procurement procedure.



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Comptroller General
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Executive Summary

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The Rolling Airframe Missile program, a U.S. and German cooperative effort, is designed to provide naval vessels close-in defense against antiship cruise missiles with active radar guidance systems. Under formal agreements beginning in 1976, both countries share development and procurement costs, and Germany is providing a second source for missile production. Development and procurement costs are estimated to be about $2.5 billion.

Due to anticipated cost, schedule, and performance problems that could affect the full-rate production decision, the German Federal Court of Audit (BRH) proposed a joint review with GAO to determine (1) changes in the antiship missile threat and the Rolling Airframe Missile's capabilities in countering that threat now and in the future and (2) the cost-effectiveness of the dual-source acquisition strategy. These issues necessarily involve a review of the scope of operational testing and defined operational requirements.

Background

The Rolling Airframe Missile began advanced development in 1976 and is now concurrently in full-scale engineering development and low-rate initial production. The participating governments are also considering the feasibility of developing an alternate guidance system to engage passive (nonradiating) threat targets and other improvements.

During development, the missile faced numerous difficulties that threatened the program's continuation. Full-scale engineering development, originally planned to last 4-1/2 years, has taken 11 years due to an underestimate of the system's complexity, development test failures, and temporary loss of U.S. congressional support in the mid-1980s. In October 1989, the program office finalized the low-rate initial production contract for the first 500 missiles with the U.S. producer and awarded contracts to the German second source for assembly line setup and low-rate initial production of 350 missiles. Operational tests and evaluation were completed in April 1990, and a full-rate production decision is tentatively planned for September 1990. After approval of full-rate production, the two sources will compete for the combined U.S. and German fiscal year 1990 requirement of 980 missiles.

Results in Brief

Approval of full-rate production of the Rolling Airframe Missile in September 1990 is premature for the following reasons:

- The basic Rolling Airframe Missile will have increasing difficulties in engaging a major portion of the threat in various regions of the world. By the end of the 20th century, at least three times as many types of antiship missiles will be deployed as existed when development of the Rolling Airframe Missile began. Many of these antiship missiles have advanced capabilities that are difficult to defend against.
- Due to target and safety limitations, the Rolling Airframe Missile's capabilities will not be fully tested before the upcoming full-rate production milestone.
- The U.S. and German navies may need less than half of nearly 7,000 basic missiles planned for procurement.
- The decision to establish a second German source for production likely will not meet the objective of reducing overall costs. GAO and BRH estimate that dual-sourcing will increase the cost of combined U.S. and German production of nearly 7,000 missiles by $225 million to $260 million.

Principal Findings

The Antiship Missile Threat Is Changing and Increasing

The number and the capability of antiship missiles available in various regions of the world have increased significantly since development of the Rolling Airframe Missile began. Although the majority of threat missiles operate with active radar guidance systems, the Rolling Airframe Missile's capabilities will be stressed or surpassed by most of the antiship missiles currently deployed or planned for the future. These antiship missiles have advanced performance characteristics such as smaller size and lower emissions, supersonic speeds, steep approach angle, dual-mode guidance systems that turn on late in flight, and the capability to maneuver and attack at very low altitudes. The technology to counter these increased threats is yet to be developed.

Performance and Capability Cannot Be Fully Assessed

The missile will not be fully and realistically tested in its expected operating environment before the planned full-rate production decision in September 1990. Due to test limitations, operational and technical evaluation tests can demonstrate only the missile's potential to be operationally effective and suitable. For example, testing against representative supersonic targets has been limited, since targets replicating supersonic, sea-skimming antiship missiles are expensive, in short supply, or

unavailable. Also, tests of the system configured with an upgraded computer and new target evaluation software are scheduled after the full-rate production milestone. Further, the German Navy has not planned any tests on its vessels before introducing the missile into its fleet.

Current Operational Plan Exceeds Minimum Known Requirements

GAO and BRH estimate U.S. and German minimum fleet requirements for basic missiles to be significantly less than the planned procurement of about 7,000 missiles. For example, GAO questions the U.S. Navy's plans to use missiles on FFG-7 frigates, since the Navy has not determined how best to launch the missiles from these vessels or whether funds will be available for modernizing the vessels. Likewise, the BRH believes the German Navy's plan to stockpile about 1,000 missiles is questionable in view of the declining threat facing German vessels in the North and Baltic Seas.

Dual-Source Competition Will Not Reduce Overall Costs

Throughout development, the Rolling Airframe Missile program has experienced significant cost growth. The program office has attempted to reduce costs; for example, it has combined fiscal years 1988 and 1989 missile procurement requirements to achieve greater economies of scale. Further, citing cost reduction as an objective, the United States and Germany have negotiated a memorandum of understanding that provided for establishment of a second production source.

GAO and BRH estimate, however, that the dual-source strategy will not likely reduce costs. GAO and BRH found a savings under the dual-source arrangement only by assuming that both sources would offer significantly large price reductions during the competition or that production would increase due to sales to other countries and continue well into the 21st century.

Recommendations

GAO recommends, with BRH concurrence, that the U.S. Secretary of Defense direct the U.S. Secretary of the Navy to

- postpone the full-rate production decision until the operational capabilities of the basic missile have been fully evaluated, the actual costs of producing the initial 850 missiles are known, and the feasibility of upgrading the missile to counter the emerging antiship missile threat has been determined.

GAO and BRH also recommend that the U.S. Secretary of the Navy and the German Minister of Defense direct the Rolling Airframe Missile Program Office to

- limit procurement of the basic missile during low-rate production to the number needed to meet minimum U.S. and German requirements,
- assess separately the longer term requirement, cost, and schedule for developing and producing an advanced configuration of the missile system, and
- assess the cost and benefit of continuing the dual-source procurement procedure by (1) considering the experience of the initial low-rate production of 850 missiles and changes in defense priorities, (2) combining production quantities authorized in fiscal years 1990 and 1991 to achieve greater economies of scale, (3) soliciting a full range of offers without establishing a minimum sustaining quantity, and (4) determining the single producer or production split that minimizes costs for both governments.

Agency Comments

In commenting on a draft of this report, the Defense Department's Director of Defense Research and Engineering and the German Ministry of Defense did not concur with the majority of the findings and recommendations.

Defense Department Comments

The Defense Department believes that (1) a substantial number of antiship missiles still use active guidance systems that the Rolling Airframe Missile can be effective against; (2) since restructuring, the program has met cost, schedule, and performance targets; (3) sufficient testing has been done to consider a full-rate production decision; (4) current inventory objectives are appropriate; and (5) the dual-source acquisition strategy has saved the U.S. government development costs and will save production costs as well.

Ministry of Defense Comments

The German Ministry of Defense believes that (1) despite the changing threat, the limitations in the Rolling Airframe Missile's guidance system, and the limitations of detection and tracking equipment installed on German ships, the Rolling Airframe Missile will be capable of countering most targets directed at German vessels, and has the potential for further development; (2) testing on U.S. ships, complemented by simulation tests at German facilities, is adequate to initiate full-rate production;

(3) although a large number of missiles are for German stockpile supplies, production quantities should not be reduced; and (4) the dual-source cost analysis is based on incorrect input data and assumptions.

GAO and BRH Response

Although GAO and BRH agree that the majority of antiship missiles being deployed in various regions of the world use active guidance systems, the Ministry of Defense and the Defense Department overestimate the missile's success rate. GAO and BRH found that the Rolling Airframe Missile will likely be fully effective against less than one- fourth of the existing types of antiship missiles. The remaining threat missiles—those with either advanced design characteristics or passive guidance systems—will stress or surpass the basic Rolling Airframe Missile's capabilities. Further, the German Navy needs to improve the electronic sensors installed on its vessels before the basic missile's full operational capability can be realized.

GAO and BRH agree that the missile's performance experience has improved since the program was restructured. However, the program has stabilized because of the large increases in U.S. and German funding made available to correct development problems and transition the missile to procurement.

GAO and BRH do not believe a full-rate production decision is prudent at this time because of limitations that prevent full and realistic testing of missile capabilities. For example, available targets cannot replicate the emerging threat from supersonic, sea-skimming antiship missiles.

GAO and BRH believe the U.S. and German navies need substantially fewer basic missiles than are planned due to the difficulties the missile faces in countering the threat and changes in global defense priorities. The cost of the dual-source acquisition strategy further increases uncertainties about inventory requirements.

GAO and BRH found that the U.S. Navy did not do a cost-benefit analysis of the dual-source acquisition strategy. In reviewing this decision, GAO and BRH case studies were based on the most recently available Department of Defense and Ministry of Defense data and optimistic assumptions about operational requirements and estimated missile costs. GAO and BRH analyses show that dual sourcing will not likely achieve savings during missile production. U.S. and German contributions for development and transition to production increased in part because of the need to transfer missile technology and provide additional field support to

the German producer. Further, the two governments invested at least $110 million to establish the second production line and will share the increased production costs during full-rate procurement due to higher second-source prices, which GAO and BRH estimate to be as much as $150 million.

Contents

Abbreviations

ASM	Antiship Missile
BRH	Bundesrechnungshof, or Federal Court of Audit
DOD	Department of Defense
GAO	General Accounting Office
MOD	Ministry of Defense
MOU	Memorandum of Understanding
NATO	North Atlantic Treaty Organization
RAM	Rolling Airframe Missile

Background

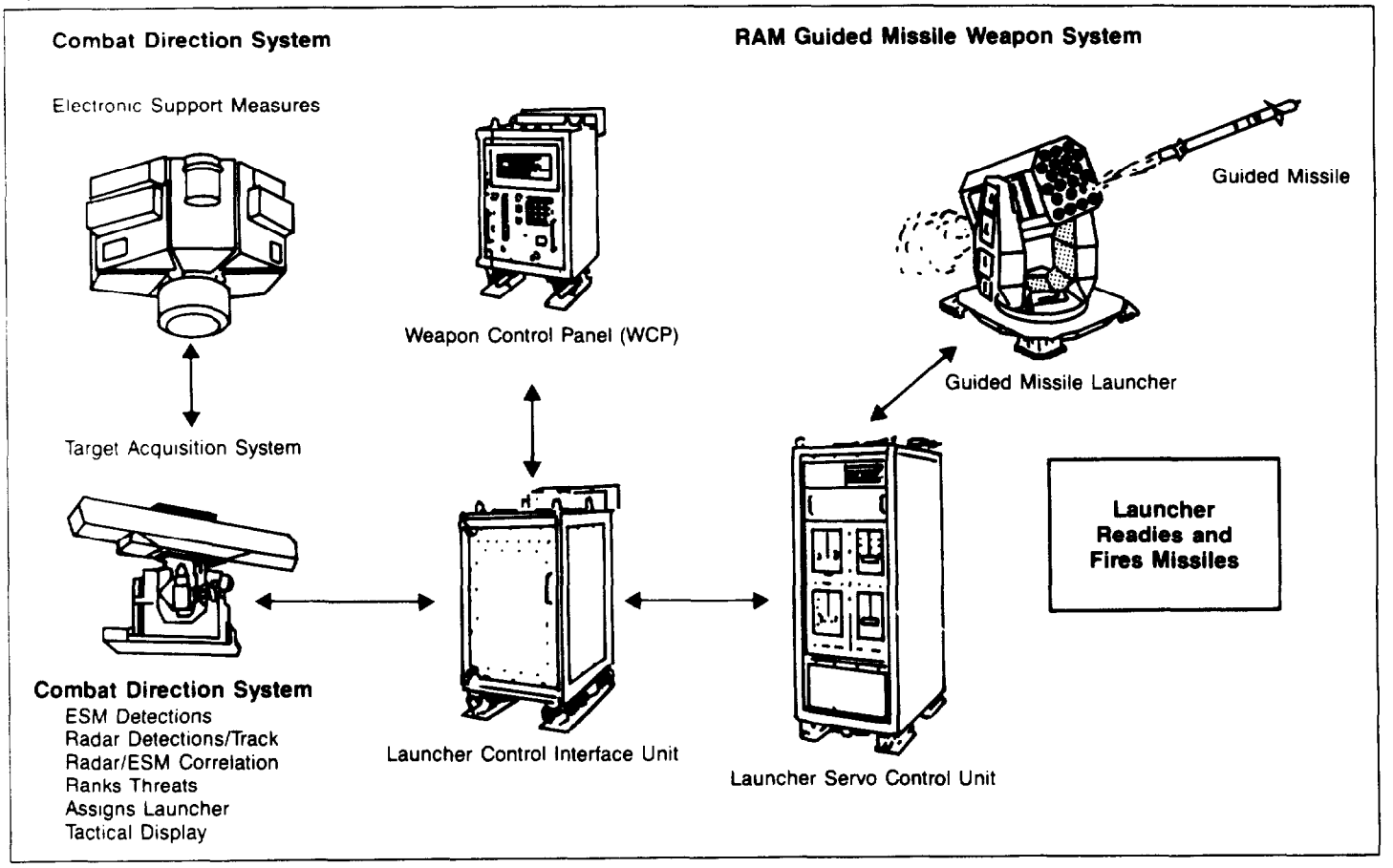
The Rolling Airframe Missile (RAM) system is designed to provide quick-reaction close-in defense against antiship cruise missiles (ASM) that penetrate the outer layer and area defense systems.[1] In 1976 the United States and the Federal Republic of Germany (Germany) signed a memorandum of understanding (MOU) under which they agreed to develop this system together. RAM's principal mission is to increase the survivability of undefended ships and provide complementary defense for ships with other self-defense weapons, such as the Phalanx Close-In Weapon System. The U.S. Navy plans to use RAM systems in place of short-range Basic Point Defense Missile Systems on certain amphibious ships and is considering RAM for use on FFG-7 frigates, DD-963 class destroyers, aircraft carriers, and other support ships in later years. The German Navy plans to deploy RAMs on fast patrol boats, frigates, and destroyers.

RAM's Design

Components of the RAM system are the missile, launching canister, weapons control system, and the launching system (see fig 1.1). RAM is intended to defend ships against incoming missiles equipped with active radar guidance systems. As currently designed, RAM cannot counter ASMs equipped with nonradiating (passive) guidance systems and is unlikely to successfully engage very low flying missiles. RAM is designed as a fire-and-forget system—once launched it will not require shipboard fire control radars to guide the missile to the target. Other features are RAM's 5-inch rolling airframe, which enhances guidance capabilities; its fully automatic, passive dual-mode radio frequency/infrared seeker; and its increased speed and maneuverability. Current efforts to respond to the emerging ASM threat include the development of an infrared-all-the-way guidance system capable of engaging nonradiating targets and a modified low altitude proximity fuze to counter very low flying missiles.

[1] A "layered" defense is divided into three major zones. In the outer zone, U.S. carrier-based aircraft are the main intercepts. Area defense is provided in the middle zone predominantly by ship-launched and air-to-air missiles. In the inner zone, short-range "point defense" systems, such as RAM and North Atlantic Treaty Organization (NATO) Sea Sparrow followed by the Close-In Weapon System, provide defense for otherwise undefended ships or are the weapons of last resort.

Figure 1.1: The Rolling Airframe Missile System



Cooperative Development

In 1973 the U.S. Chief of Naval Operations established a need to develop a low cost, self-defense missile system based on known technology.[2] Under the 1976 and subsequent MOUs, the United States and Germany have shared the cost of developing and transitioning the system into production.[3]

[2]Major acquisitions typically proceed through four milestone decisions. First, mission need is established and alternative systems concepts are identified. Then, during the demonstration and validation phase a few test articles are fabricated. The next milestone decision authorizes full-scale engineering development. The final production phase may be divided into two milestones—low-rate initial production and full-rate production.

[3]The government of Denmark was also a participant during the development phase but discontinued financial support in May 1985 due to launcher size and space problems on its potential platforms.

The full-scale engineering development MOU was signed in 1979. Full-scale development, initially expected to take about 4-1/2 years is now expected to last 11 years and be completed in 1990. Delays were caused by an underestimate of the system's complexity, reliability failures during development tests, the time required to make engineering changes, subsequent loss of U.S. congressional support, and funding limitations. In 1985, after a series of flight failures, early developmental testing was suspended. The U.S. Congress did not approve fiscal year 1986 procurement funding for transitioning RAM to production. Before approving funding in fiscal year 1987, the Congress (1) set development and recurring missile unit flyaway cost ceilings and (2) required the Department of Defense (DOD) to certify that RAM would meet original development specifications and approve a revised Test and Evaluation Master Plan.

Initial operational tests held between December 1986 and February 1987 demonstrated that RAM had the potential to be operationally effective and suitable, and subsequently the U.S. Navy approved low-rate initial production. In August 1987, the United States and Germany signed a production MOU requiring (1) dual-source production of the guidance and control sections, tail assembly, and canister and associated integration hardware, with competition between U.S. and German industry; (2) coproduction of the launching system; and (3) provisions of U.S. government-furnished equipment, including the rocket motor with the arming and firing device, the ordnance package target detector and contact fuze, and the warhead and safe and arm device. According to two principles for cooperation in the MOU, the participating governments agreed to

- base all procurements of the RAM weapon system on the mutual objective of reducing overall costs and enhancing competition and
- make available to each other all components of the RAM weapon system, both those produced jointly and others procured nationally, at equal prices and on essentially equal terms.

Although the U.S. and German contractors plan to compete for annual missile requirements during full-rate production, the production MOU provides for split awards during low-rate initial production or until the second source is fully qualified. As a result, the U.S. source will produce 500 missiles for the U.S. Navy, and the German second source will produce 350 missiles for the German Navy. In October 1989, the RAM Program Office (1) definitized the U.S. missile contract, (2) awarded a contract for the German production line, and (3) awarded a contract for production of the initial German missile requirement. Also, during that

month a contract was awarded to a U.S. and German joint venture, which established a not-to-exceed price for coproduction of six U.S. and 45 German launching systems.

Background of Joint GAO-Federal Court of Audit Review of RAM

Over the past several years both GAO and the German Bundesrechnungshof (BRH, or the Federal Court of Audit) have individually reported on the RAM system.[4] BRH contacted GAO about the need for continued review of the missile, the cost estimates, and the economy of the acquisition strategy. Because of the longer term issues identified during the GAO and the BRH independent reviews of RAM and the increasing number of weapon development programs financed by the United States, Germany, and other allied countries, GAO and BRH agreed to undertake a joint effort to gain a broader perspective of RAM at a time when it was transitioning into low-rate initial production and preparing for operational tests that would justify a full-rate production decision.

Objectives, Scope, and Methodology

The overall purpose of this review was to provide both the U.S. and German governments and defense communities a broader perspective of the cooperative effort to develop and produce the RAM weapon system. Two primary objectives of our review were to identify

- changes in the ASM threat and RAM's capabilities in countering that threat now and in the future and
- the cost-effectiveness of the dual-source acquisition strategy.

Those issues necessarily involved a review of (1) the scope of operational testing and (2) the cost of acquiring the system given known capabilities, planned improvements, and defined operational requirements.

We focused primarily on the missile and secondarily on the launcher and other support equipment. In the United States, we obtained pertinent information concerning the ASM threat and RAM costs and performance from the joint U.S.-German RAM Program Office, DOD activities, and the prime contractor's facilities. In Germany, we interviewed officials at the Ministry of Defense (MOD), the Federal Agency for Armament Technology and Procurement, the second-source contractor's facilities, and another defense-related commercial activity knowledgeable of RAM's capabilities and the ASM threat.

[4]A list of related GAO and BRH reports on RAM is on the last page of this report.

GAO obtained information on the threat by reviewing the China Lake Naval Weapons Center study Antiship Cruise Missile Threat Definition to Year 2000, June 1989; the Naval Technical Intelligence Center's System Threat Assessment Report (Ship Air Defense Systems), June 1989; the RAM Program Office's Test and Evaluation Master Plan approved in January 1990; and various operational requirements documents. GAO also spoke about the threat with representatives of the Defense Intelligence Agency, Naval Technical Intelligence Center, the RAM Program Office, and the prime contractor.

BRH contracted with Industrieanlagen-betriebsgesellschaft, a commercial organization familiar with defense-related issues, for an analysis of the ASM threat in the areas Germany intends to deploy RAM.

Test results were obtained from and discussed with officials representing the RAM Program Office, the Navy's Operational Test and Evaluation Force, and the prime contractor. Cost data for the dual-source acquisition strategy was obtained from the RAM Program Office, budget data, reviews of contract documents, and through discussions with knowledgeable U.S. and German officials and contractor representatives. In addition to GAO and BRH analyses, we used the Competition Evaluation Model developed for use by the Defense Systems Management College to analyze various cost projections under different economic, technical, and program assumptions.

German MOD comments were for official use only and could not be published. References to MOD comments come from a BRH report to the German parliament.

GAO did the review work between May 1989 and June 1990 in accordance with applicable generally accepted government auditing standards.

Agency Comments and Our Evaluation

The Department of Defense (DOD) partially concurred with the GAO and BRH assessment of RAM's technical and reliability problems that were experienced during the early stages of testing. However, DOD believes that since restructuring in 1985, the program has met cost, schedule, and performance targets. DOD stated that many of the technical problems and the resulting stretch-out of program schedules could be traced to engineering constraints imposed by early funding shortfalls. Further, development and production costs have remained within the

congressionally imposed ceilings, and the program's schedule is now being met or exceeded, as in the case of operational evaluation testing.

GAO-BRH Evaluation

We agree that RAM's performance has improved in recent years, as shown in the Navy's initial operational and more recent technical evaluation tests (see ch. 3). However, funding shortfalls have been only one of several causes for RAM's earlier cost, schedule, and performance problems. Other factors include an underestimate of system complexity, missile reliability failures, and the time required to make engineering changes (see chs. 1 and 5). As shown in figure 5.1, the United States and Germany have contributed almost $400 million for full-scale engineering development of the basic RAM. During 1985 and 1986 alone the United States provided almost $60 million for RAM development requirements, despite testing failures and congressional disapproval of funding requested to transition RAM to procurement.

Although the Navy believes that the amount needed for the basic design of RAM is below the congressionally mandated development cost ceiling, actual development expenses are still unknown, since estimates do not include total obligations under existing development contracts or the cost of developing an alternate launching approach for use with RAM on ships with space and weight limitations.

Further, we agree that the estimated U.S. recurring unit flyaway cost for low-rate initial production is below the congressionally mandated ceiling of $145,000. However, the average unit flyaway cost for all missiles will likely be above the mandated unit ceiling cost of $100,000. Also, the U.S. Navy's definition of flyaway costs excludes several recurring cost elements, such as canisters, initial spares, shipping containers, and other fleet support expenses. When all recurring costs are considered, U.S. and German unit costs for fiscal years 1988 and 1989 low-rate initial production of RAMs are estimated to be $179,000 and $234,000, respectively (see ch. 5 and app. II).

The Antiship Missile Threat Is Changing and Increasing

In 1989 the U.S. Navy reconfirmed the need for a self-defense missile system like RAM in its analysis of the ASM threat to the U.S. and German navies to the year 2000. GAO used this threat analysis and other defense intelligence information to analyze the changes in the ASM threat in various regions of the world and RAM's potential defensive capabilities. BRH obtained an analysis of the ASM threat in the operating areas Germany plans to deploy RAM. In summary, many ASMs currently deployed or planned for the future will likely stress or surpass the capabilities of defensive systems such as RAM.

Defending Against Antiship Missiles

RAM evolved from a concept introduced in 1975 as a derivative of the Redeye missile to combat threats guided by radar. RAM's seeker uses radio frequencies emitted from ASMs for initial acquisition and guidance and either uses the radio frequency mode to guide the RAM all the way to the target or switches to infrared for more accurate homing. RAM would need an infrared-all-the-way seeker to counter ASMs using passive guidance systems. Other needed improvements include development of a passive infrared search, detection, and tracking system for U.S. ships and a low-altitude proximity fuze for RAM to counter very low flying targets. However, these improvements may be long-term initiatives. For example, the infrared search, detection, and tracking system is scheduled for testing through fiscal year 1991 when the Navy plans to begin designing individual systems for specific platforms. The U.S. and German navies are still studying the cost and feasibility of an alternate infrared-all-the-way guidance system for RAM.

ASM Threat in the Early 1970s

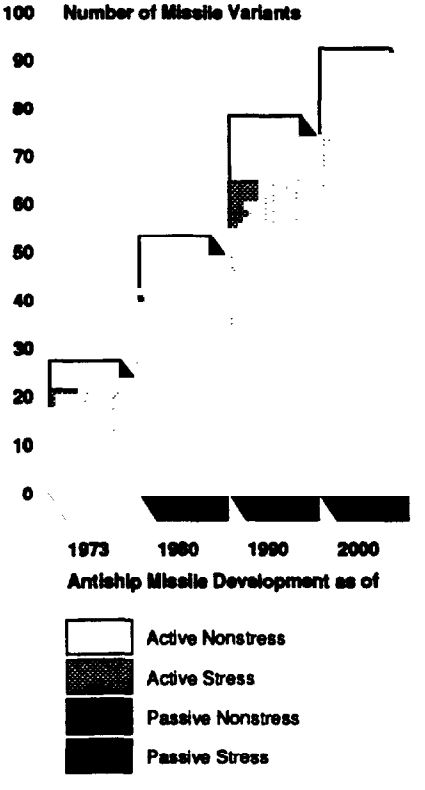
In the 1970s when RAM began development, the majority of ASMs had active radar guidance systems. At that time, several types of active missiles also had advanced performance characteristics, including dual-mode (both active and passive) guidance systems, steep attack angles, or very low attack altitudes, that were difficult to defend against.

Figure 2.1 illustrates ASM development in selected years between 1973 (when the need for RAM was established) and 2000. The figure shows the number of missile variants deployed with active and passive guidance systems and also missiles with advanced performance characteristics that would stress or surpass the capabilities of defensive missiles such as RAM. These advanced design characteristics include

- higher terminal speed,
- steeper terminal approach angle,

- dual-mode guidance systems,
- guidance systems that turn active late in flight,
- reduced radar cross section and infrared signatures (smaller size and lower emissions that make ASMs difficult to detect and track)
- very low terminal attack altitudes, and
- more maneuvering capability.

Figure 2.1: ASM Threat Development (Through the End of the 20th Century)



ASM Threat in the 1980s and 1990s

As shown in figure 2.1, by 1980, both the number[1] and capability of ASMs had increased dramatically. Today, the majority of ASMs still rely on active radar guidance systems. Compared to the early 1970s, however, 2-1/2 times as many ASM variants are equipped with passive guidance systems. Further, many more ASMs have advanced designs that

[1]Distinct variants or types of ASMs that are deployed in various regions of the world or are available for sale.

stress the performance of defensive systems such as RAM. In many regions of the world, countries are deploying both active and passive ASMs that have one or more of the design characteristics which stress the RAM.

ASM Threat by the End of the 20th Century

The intelligence community envisions that by the end of the 20th century more than three times as many types of ASMs will be deployed as existed when development of RAM began in 1973. These missiles could pose a significant threat and challenge to defensive systems due to continuing design improvements and export to more countries. A larger number of ASMs will have smaller radar cross sections; either passive, active, or dual-mode guidance systems (the majority will continue to use active radar seekers at least in the terminal phase of their flight); supersonic rocket motors; and the capability to maneuver and attack at very low altitudes.

ASM Threat in the Baltic and North Seas

BRH contracted with a commercial establishment to analyze the ASM threat facing German vessels operating in the Baltic and North Seas. Based on the analysis, BRH estimates that RAM would likely be effective against about half of the current Warsaw Pact missiles types. However, RAM's performance may be less than estimated due to certain factors.

- RAM's performance is highly influenced by the quantity and quality of available targeting data. Thus, if the German navy elects to avoid attack by maintaining radar silence, only limited targeting data would be available.
- Design limitations reduce RAM's effectiveness against ASMs with more advanced flight profiles. For example, RAM seeks ASMs that emit continuous radar signals of sufficient strength and duration. Also, the smaller physical size and increased speed of newer ASMs are likely to decrease the RAM system's detection and interception range.
- During the 1990s, more advanced, Western-type ASMs will likely be deployed with higher speed rocket motors, lower cruise altitudes, more maneuvering capability, higher hit probability, and multi-mode seekers.

BRH estimates that RAM will perform less effectively against the more advanced ASMs expected to become operational in the Baltic and North Seas during the 1990s. Alternate configurations and improvements for RAM, such as the infrared-all-the-way guidance system and a low-altitude fuze, are essential for Germany to defend against future ASMs deployed in the Baltic and North Seas.

Conclusions

In its current configuration, RAM will face increasing difficulty keeping pace with the emerging ASM threat. ASMs will become more difficult to detect, track, and engage as technological improvements come into wider use. Several improvements either underway or planned, such as an infrared search and track system, a low-altitude fuze, and an infrared-all-the-way guidance system, would improve RAM's effectiveness. However, they potentially face the same cost, schedule, and performance hurdles as the basic RAM system faced throughout its development.

Agency Comments and Our Evaluation

Both DOD and MOD partially concurred with our findings concerning RAM's capability against the ASM threat. They both agreed that the threat is changing in terms of types of guidance, but they believed there are a substantial number of active radar guided missiles that tests have shown RAM can effectively stop.

MOD believed that the basic RAM is likely to engage most ASMs deployed against German vessels and will increase the survivability of those vessels significantly, despite limitations in RAM's guidance system and in detection and tracking equipment installed on German ships. MOD believed that further development will improve RAM's effectiveness.

DOD disagreed with what it perceived as an implication in the report that RAM is ineffective against the "baseline radiating threat" or that the need to evolve RAM in response to changing threats was not foreseen. DOD stated that the reality of a changing threat and the need for future upgrades to meet that threat are not unique to RAM. DOD also objected to what it saw as an assertion that planned improvements potentially face the same cost, schedule, and performance hurdles as the basic system. DOD believed the RAM has been managed by a mature program office and has enjoyed stable funding in recent years.

GAO-BRH Evaluation

We do not disagree with the MOD that the basic RAM will increase the survivability of German naval vessels operating in the Baltic and North Seas, based on the results of the BRH threat analysis, and therefore do not oppose RAM procurement in principle. However, we believe that MOD overestimates the likely success rate in deploying RAMs against threat missiles because (1) electronic sensors installed on German vessels cannot provide sufficent guidance and control data to support RAM's targeting requirements and (2) advanced flight profiles of threat missiles reduce RAM's effectiveness. We believe the German Navy needs to

improve its fire control system (FL 1800S) before the basic RAM's full operational capability can be realized. We did not find, as DOD stated, that RAM will likely be ineffective against a "baseline radiating threat" of active nonstress missiles, as shown in figure 2.1. However, we did find that RAM will likely be fully effective against only part of the radiating threat missiles, which is less than 1/4 of all types of deployed ASMs, due to the advanced design of radiating ASMs. Further, more than three times as many types of ASMs are being deployed in various regions of the world as there were when RAM began development. Many of these ASMs have advanced designs that will stress or surpass RAM's capabilities.

This report does not imply that DOD has not forseen either the need to improve RAM to meet the emerging threat or that the need for future upgrades is unique to RAM. In fact, we agree that DOD and MOD should pursue further RAM development efforts. However, considering the advances in ASM technology, the rapid change in East-West relations, and global financial pressures, RAM improvements will certainly face greater technical hurdles and funding scrutiny than the basic system, which was developed when defense funds were more readily available. Further, RAM's Program Office will likely be affected by the uncertainties about changing budget priorities and long-term weapon procurement.

RAM's Performance and Capability Cannot Be Fully Assessed

Since development test failures in the early 1980s, RAM's performance has improved. The U.S. Navy considers testing in recent years to be very successful. However, as in various weapon systems programs, RAM development, production, and improvements have been proceeding somewhat concurrently before testing requirements have been fully satisfied. Thus, RAM will reach its full-rate production milestone before its performance and capabilities can be fully tested in its expected operating environment.

Initial Operational Tests and Evaluation

During initial operational tests completed in February 1987, RAM successfully hit the target in 11 of 13 firing events. Although these tests did not fully stress RAM's expected performance capabilities (due to missile and target availability and test facility limitations), the Navy's Operational and Technical Evaluation Force concluded in July 1987 that RAM had the "potential" to be operationally effective and suitable and recommended approval for limited fleet introduction. After initial operational tests were completed, the Navy approved low-rate initial production.

Technical Evaluation Tests

In technical evaluation tests from July through December 1989, 13 missiles were fired in 11 test events. The first two missiles tested in July (only one was actually fired), which the program office considered pre-technical evaluation events, failed due to a guidance system problem. Further tests were suspended for diagnosis and corrective action on all remaining missiles.

In August 1989, testing resumed and resulted in 11 successful missile engagements out of 12 firings. Nine of the 12 firings were direct hits. Two were within the lethal kill radius of the warhead. The twelfth firing was identified as a "no test" because the previous missile had already destroyed the target. Ten of the 11 successful firings were against subsonic targets configured to simulate the infrared emissions of threat missiles. In one maximum range and medium altitude test, RAM scored a direct hit against a supersonic target.

These tests were more challenging than in earlier years but had certain limitations. For example, although U.S. tests involving multi-target, wave, and stream attacks[1] were done at sea, these tests were against subsonic targets. Due to safety and target availability issues, the single

[1]Wave attacks involve multiple ASMs approaching from different angles at the same distance and speed. Stream attacks involve missiles approaching sequentially from the same direction.

test against a supersonic target was done from a land-based test site. Further, the German Navy has not planned any tests on its vessels before introducing RAM into the fleet.

RAM's Capability Cannot Be Fully Tested Before Full-Rate Production Decision

Test limitations hamper the Operational Test and Evaluation Force in assessing RAM's full performance. For example, during the initial operational tests and evaluation,

- the Navy tests against supersonic targets were limited to missile-only tests, the nature of which did not demonstrate system capabilities against the threat;
- certain tests required to complete evaluation of operational effectiveness (which are classified) were not performed; and
- missile, target, and test facility limitations impeded testing at certain operational performance levels.

Although the subsequent 1989 development tests addressed many concerns, remaining limitations will preclude a full assessment of RAM's operational effectiveness and suitability prior to the full-rate production milestone decision tentatively scheduled for September 1990. For example, tests of the combat system configured with an upgraded computer and the unique target evaluation and weapons assignment software are scheduled to occur after the full-rate production decision.

Certain test limitations will likely continue throughout the early 1990s. Representative targets—a critical resource for replicating a potential threat—are expensive and in short supply or unavailable. Moreover, according to a DOD source, target development programs under consideration are unfunded and vulnerable to delays. For example, the initial operating capability of the new target being developed to replicate a supersonic, sea-skimming ASM has been delayed due to problems with the guidance and control system. In addition, the Navy estimates that its new test site, which is needed to safely test RAM's capabilities against close-in, maneuvering, supersonic targets over water, will not be available until late 1992.

RAM's Test and Evaluation Master Plan

The National Defense Authorization Act for Fiscal Year 1987 directed DOD to approve a revised Test and Evaluation Master Plan before starting RAM's operational tests and evaluation. According to Navy guidance, this plan had to define and integrate test objectives, critical operational issues, system characteristics, responsibilities, resource

requirements, and schedules. It also had to identify the threats against which RAM was designed to be effective, the critical operational issues that had to be examined to determine the system's capability, and test limitations. The system has to meet the plan's criteria during operational tests and evaluation for full-rate production to be recommended.

In May 1989 the Office of the Secretary of Defense rejected the draft plan mainly due to concerns about the ASM threat and threat replication during operational tests. The RAM Program Office was required to (1) clarify the threats that RAM must defeat, (2) determine whether threat representative targets were available for operational tests and evaluation, (3) identify test limitations, and (4) assess the availability of adequate operational test information to support a full-rate production decision. After substantive revisions and clarification, on January 2, 1990, the Office of the Secretary of Defense approved the revised plan, and operational tests and evaluation proceeded as scheduled. These tests were completed in April 1990, and the U.S. Navy's Operational Test and Evaluation Force is evaluating the results.

Conclusions

RAM's performance has improved since development test failures in early 1985. Initial operational and technical evaluation tests completed in February 1987 have shown that RAM has the potential to be operationally effective and operationally suitable. Based on the results of the technical evaluation tests from July through December 1989, RAM was certified to proceed into further operational tests and evaluation. However, due to the nature of test limitations, the U.S. Navy cannot fully assess the system's capability before the scheduled full-rate production milestone.

Agency Comments and Our Evaluation

DOD partially concurred with the GAO-BRH assessment that RAM's capability cannot be fully assessed. However, DOD did not agree with the implication that RAM had not been tested in its operational environment or that the test limitations precluded a meaningful assessment of the system's operational effectiveness and suitability. DOD stated that testing had been done in accordance with the approved Test and Evaluation Master Plan. Test limitations noted in the plan were either recognized and accepted in advance or considered as not critical to the full-rate production decision and deferred to follow-on test and evaluation. DOD further stated that not all testing specified in the plan had been completed but that there were valid reasons for this. The reasons that the tests had not been done will be addressed at the time of the full-rate

production milestone. The system has been tested against a variety of targets, but, as with any test program, the facts of life impose certain limitations. DOD believes that it has done sufficient testing to proceed to the full-rate production decision with reasonable confidence that the system is performing as designed.

MOD disagreed with the GAO-BRH assessment of RAM testing. MOD considered testing on U.S. ships, complemented by simulation tests at German facilities, to be adequate and estimated the remaining risk to be low.

GAO-BRH Evaluation

We agree that RAM's performance during testing has improved. However, in contrast to DOD and MOD comments, we believe that testing has not been sufficient to justify proceeding to full-rate production. Our review of the classified plan does not support DOD's view that certain tests were either recognized and accepted in advance or considered as not critical to the full-rate production decision. We found that due to target and safety limitations, critical tests will likely be deferred well into the 1990s. Further, although the cooperative agreement provides for sharing of development expenses, it does not provide for testing of RAM's capabilities in the German operating environment. We believe that the changing nature of the threat, test limitations, deferral of planned operational tests, and the lack of testing on German vessels are critical issues that should be resolved prior to approving full-rate production.

Current Procurement Plan Exceeds Known Minimum Requirements

The U.S. and German navies estimate that they need 6,823 basic RAM missiles—missiles that meet the original development specifications without upgrades such as an infrared-all-the-way guidance system. The U.S. Navy plans to buy 4,900 missiles and 85 launching systems through about fiscal year 1996, of which 500 missiles were authorized in fiscal years 1988 and 1989 as part of the low-rate initial production decision. In addition, the German parliament authorized procurement of 1,923 missiles and 45 launching systems through fiscal year 1993, of which 350 missiles are part of low-rate initial production. Considerably fewer basic RAM systems may be needed than are currently planned, and regardless of the actual production level, the U.S. and German navies may need to retrofit the basic RAM with an infrared-all-the-way guidance system, low-altitude fuze, and other improvements to meet the current and emerging threat.

U.S. And German Operational Requirements

According to the current plan, the U.S. Navy will put 2 RAM systems each on 14 amphibious command and control ships, including 2 LCCs (amphibious command ships), 5 LHAs (amphibious assault ships—general purpose), and 7 LPHs (amphibious assault ships—helicopter), and is considering using 2 systems each on 5 new amphibious ships (LHD-5 class). The U.S. Navy is also planning to install RAMs on 54 FFG-7 frigates using the Standard Missile launchers and on destroyers, aircraft carriers, and other support ships in later years. The German Navy plans to put RAMs on 10 fast patrol boats and 2 launchers on each of 12 frigates and 3 destroyers. In addition, the German Navy has identified additional stockpile requirements.

Fewer basic RAM missiles may be needed than are currently planned for procurement, as shown in table 4.1. We estimate U.S. and German minimum fleet requirements to be 2,869 missiles. This amount includes 1,176 missiles needed to fill two 21-cell launchers and a magazine on 14 U.S. amphibious ships and 853 additional missiles needed for reloading, including an additional 15 percent for pipeline, depot supply, testing, and training purposes. Our estimate excludes missiles being considered for use on FFG-7 class frigates, since plans for modernizing these vessels are uncertain. Further, we estimate that Germany needs only 840 missiles to fill all launchers, since its fast patrol boats and other intended platforms do not have on-board storage capability. Due to the current security environment in the German defense sector, the need to stockpile additional basic RAMs seems unlikely.

Table 4.1: Estimated U.S. And German Missile Requirements (Through Fiscal Year 1996)

Source	Estimated missile requirements	
	RAM Program Office	GAO/BRH
United States		
Amphibious ships	1,176	1,176
Frigates	2,268	0
Other ships, pipeline, depot, testing, or training	1,456	853
Subtotal	**4,900**	**2,029**
Germany		
Fast patrol boats	210	210
Frigates	504	504
Destroyers	126	126
Stockpile requirements	1,083	0
Subtotal	**1,923**	**840**
U.S. and German Total	**6,823**	**2,869**

Changes in Operational Requirements

In estimating operational requirements, the U.S. and German navies have not determined the minimum number of basic RAMs that are needed or requirements for an improved RAM to counter the emerging ASM threat. Further, they have not considered the effect of global changes on defense priorities and other uncertainties. First, the potential operational requirement for basic RAMs is unclear due to the increasing number and capabilities of ASMs being deployed in various regions of the world. As discussed in chapter 2, design improvements may be needed if RAM is to remain effective against the more advanced ASMs.

Second, changes in launching approaches have increased uncertainties about which vessels should be modified for use with RAM. For example, the U.S. Navy originally intended to install RAM in the North Atlantic Treaty Organization (NATO) Sea Sparrow launching system on certain ships, but this plan was dropped due to cost and technical difficulties. As an alternative, the Navy is considering using RAM in its stand-alone configuration on those ships to complement the NATO Sea Sparrow. However, since the Navy is also developing a dual-mode guidance system for the Sea Sparrow to improve its capabilities against ASMs, RAM may not be used on ships equipped with Sea Sparrow systems.

Further, the U.S. Navy intends to study the feasibility of modifying the Standard Missile launcher for use with RAM on FFG-7 frigates, a class of ships whose weight and space limitations preclude installation of the RAM launcher. However, this study had not been funded as of April 1,

1990. Plans for modernizing FFG-7s are also uncertain due to funding priorities.

Finally, global financial pressures and the recent rapid changes in East-West relations have increased uncertainties about budget priorities and long-term weapon procurement requirements. For example, long-range plans for developing the NATO Anti-Aircraft Warfare System, which may have relied on RAM for close-in defense, are uncertain.

RAM Procurement Plan

Under the production MOU, the United States and Germany agreed to procure missiles jointly, using industrial capability in both countries to compete for annual requirements on a dual-source basis. To maintain both production lines, the two partners also agreed to establish a minimum production rate, projected to be 30 sets of dual-source components per month (or about 360 sets annually) at each facility. As shown in table 4.2, when this MOU was signed in 1987, RAM production was to last 5 years and be completed by the end of fiscal year 1992. Subsequently, due to budget difficulties, the U.S. Navy extended production through fiscal year 1996.

We estimate that both navies could produce a minimum number of basic RAMs in 4 years. We anticipate no further construction of basic RAM missiles after fiscal year 1991 until the feasibility and cost of upgrades have been determined.

Table 4.2: RAM Production Schedule

	RAM Program Office estimate[a]		
Fiscal year	**(As of 8-3-87)**	**(As of 10-1-89)**	**GAO/BRH estimate**
1988/89	850	850	850
1990	1,400	980	1,010
1991	2,150	855	1,009
1992	1,830	1,000	
1993		1,063	
1994		670	
1995		815	
1996		590	
Total	**6,230**	**6,823**	**2,869**

[a]As of August 3, 1987, the RAM Program Office planned to produce 6,230 missiles in fiscal years 1988 through 1992, but the plan was extended due to budget difficulties.

Criteria for Advancing From Low-Rate to Full-Rate Production

The RAM Program Office completed operational tests and evaluation in April 1990 and plans to seek approval for full-rate production in September 1990. DOD has stated that weapon systems advance to higher acquisition milestones by meeting quantifiable technical specification and operational effectiveness standards during operational tests and evaluation. Under this criterion, the Operational Test and Evaluation Force may not recommend full-rate production of RAM due to the test limitations discussed in chapter 3. However, the U.S. Navy could approve full-rate production based on other factors, such as the cooperative nature of the U.S. and German partnership, the decision to establish a European second source, and the success of recent tests. Even without approval, the total planned procurement could be met in a low-rate initial production status.

In response to concerns that too many weapon systems are being procured before they successfully meet technical specifications and design deficiencies are corrected, in fiscal year 1990 the Congress redefined low-rate initial production[1] as the minimum quantity necessary

"(1) to provide production-configured or representative articles necessary to conduct operational tests...; (2) to establish an initial production base for the system; and (3) to permit an orderly increase in the production rate sufficient to lead to full-rate production upon the successful completion of operational testing."

According to the applicable conference report,[2] this definition recognizes the establishment and maintenance of a single production source, but it was the view of the conferees that "this recognition is not intended to condone a continuing reapproval of low-rate initial production quantities that eventually may total to a significant percentage of the total planned procurement."

Conclusions

Approval of full-rate production or continued production of RAM under a low-rate initial production status may not be prudent until issues concerning operational requirements are resolved. We believe that the U.S. and German navies need substantially fewer basic RAMs than are planned. Current procurement plans suggest that RAMs are needed on a wide variety of vessels and for pipeline and depot supplies. Such extensive use has become increasingly uncertain due to the difficulties RAM

[1]See section 803 of the Fiscal Year 1990 National Defense Authorization Act.

[2]H.R. Conf. Rep. No. 101-331, 1st Sess. 601 (1989).

faces in countering the advanced ASM threat and changes in long-term defense priorities.

Agency Comments and Our Evaluation

DOD and MOD did not concur that RAM inventory objectives are inappropriate and should be reduced. MOD disagreed that fewer RAMs should be procured, even though missile requirements have not been definitized and a large quantity of missiles will be used as stockpile supplies. MOD stated that the missiles to be deleted would be procured at the end of the procurement period, when production is least costly. Further, upgrading existing missiles would be less costly than stopping production early and then later restarting production for an improved missile.

DOD disagreed that extensive deployment of RAM had become increasingly uncertain due to limitations in the basic system's ability to counter the emerging threat. DOD stated that RAM is capable of engaging a majority of existing threat missiles and that planned upgrades will meet the evolving threat. DOD justified the need for effective self-defense of maritime forces by highlighting incidents in recent years and the "potential synergy" between RAM and the NATO Sea Sparrow systems in terms of increasing firepower in a layered defense strategy.

DOD agreed that if the need for any acquisition program is uncertain, then full-rate production should be carefully considered. However, DOD disagreed that changing defense priorities have eliminated the need for effective self defense and stated that RAM has a valid operational requirement.

DOD concurred that production could continue and eventually exceed minimum requirements should low-rate initial production be reapproved but stated that acquisition procedures are in place to ensure that minimum inventory requirements are not exceeded.

GAO-BRH Evaluation

We did not question the need for self-defense systems such as RAM. However, there are uncertainties about the (1) basic RAM's capability to defend against threat missiles, which are continually being improved and deployed in various regions of the world; (2) feasibility of installing RAM on certain ships, such as the FFG-7 class frigates, with space and weight limitations; and (3) stockpile requirements.

We have been briefed in considerable detail about the potential for increasing firepower by deploying RAM and the NATO Sea Sparrow

together, but we found that the U.S. Navy has decided not to install RAM in the NATO Sea Sparrow launching systems, as originally planned, or consider alternate launching approaches due to anticipated cost and technical difficulties. Although incidents during recent years have highlighted the need for improved close-in defense on FFG-7 class frigates, the U.S. Navy has not determined the ways or means for modernizing these vessels.

We have no basis for agreeing or disagreeing about the cost and feasibility of upgrading existing RAMs or starting production for an improved missile, since the cost and feasibility of upgrading RAMs have not been determined. However, we believe that the need to procure and stockpile large quantities of missiles in either the U.S. or German navies is unjustified in light of the changing defense needs in various regions of the world. Further, in the event RAM production continues under a low-rate—rather than a full-rate—production status, we believe the RAM Program Office needs to establish a minimum inventory requirement, as provided for in DOD procedures, to prevent reapproval of low-rate initial production quantities that could eventually achieve the procurement levels now planned.

RAM Costs Have Increased Significantly

Throughout development, RAM costs have increased due to engineering design and missile reliability problems, an underestimate of system complexity, and program stretch-outs. The United States and Germany have shared these costs and have agreed to make available to each other all components of the RAM system at equal prices and on essentially equal terms. The two partners also agreed to base all RAM procurements on the mutual objective of reducing overall costs through dual-source competition. Thus far, the decision to establish a second production source has actually increased costs. Further, the cost of transitioning into production, the cost to establish a second assembly line, and the additional start-up costs are not likely to be offset by lower competitive prices.

Cost Overview

Throughout development the RAM program has experienced significant cost growth. For example, the 1979 MOU cost estimate for the full-scale engineering development phase has increased from $108.4 million to $368.7 million. Primary causes of increases were the test failures in early 1985 that resulted in a need to reevaluate the engineering design and correct numerous missile reliability problems. These difficulties led to schedule delays and increases in U.S. and German contributions for prime contractor and field support. For example, additional funds were needed to expand the role of the Naval Weapons Center at China Lake, which has provided a larger share of the engineering design support. Funds were also needed for a program to streamline missile production from the labor-intensive method used during development to the less costly, automated approach to be used on the assembly line.

Further, the decision to establish a second source for missile production has led to increases in start-up, test equipment, and missile acquisition costs. For example, the Navy has estimated that the additional U.S. costs associated with establishing a second production line in Germany will be more than $15 million.

In table 5.1, we estimate development and production costs for the basic RAM system through fiscal year 1996, excluding initial spares, administrative support, operations and maintenance, transportation, and modifications to shipboard equipment if RAM systems are installed on ships with weight and space limitations. Also excluded are the costs of proposed improvements (that is, the infrared-all-the-way guidance system[1]

[1]The RAM Program Office has estimated the cost of developing the infrared-all-the-way guidance system at about $60 million.

and an improved low altitude fuze) and RAM-unique upgrades to shipboard sensors.

Table 5.1: Estimated Basic RAM Development and Procurement Costs (Through Fiscal Year 1996)

Then year dollars in millions

Cost element	United States	Germany	Denmark[a]	Total
Basic RAM development[b] (FYs 1975-90)	$191.8	$198.3	$4.1	$394.3
Transition to production (FYs 1984-90)	50.2	47.8		98.0
Missile production[c] (FYs 1988-96)	807.6	518.3		1,325.9
Launcher Production[d] (FYs 1988-96)	425.0	247.9		672.9
Total	**$1,474.6**	**$1,012.4**	**$4.1**	**$2,491.2**

Note: Rows and columns may not add due to rounding.

[a]The government of Denmark withdrew from the cooperative development in May 1985.

[b]The RAM Program Office stated that although $191.8 million had been obligated for basic RAM development in fiscal years 1975-90, total funding available for obligation is estimated to be $211.6 million

[c]Includes recurring and nonrecurring procurements costs for 4,900 U.S. and 1,923 German missiles, or a total of 6,823 RAMs. Cost estimates were provided by the U.S. and German defense agencies.

[d]Includes 85 U.S. and 45 German RAM launching systems.

RAM Dual-Source Acquisition Strategy

Since the early 1980s DOD has viewed competition as key to reducing the cost of procuring weapon systems. In 1984 Congress passed the Competition in Contracting Act, which mandated specific annual increases in the amount of Defense Department contract funds obligated through competition. Under the law, noncompetitive awards have to be justified. In response, the Navy has increasingly advocated the use of second-sourcing and leader-follower arrangements as a means of introducing competition to systems acquisition and thereby reducing procurement prices.[2]

In a dual-source strategy, two or more companies are requested to submit price proposals for certain production quantities, and the contract award is split between them. Normally, the larger share is awarded to the low bidder. In a leader-follower arrangement, the contractor with production experience transfers technology to the second competitor so

[2]The United States has also used dual-source procurement to maintain an adequate industrial base for mobilization reasons. For example, using this strategy, both east and west coast shipyards could participate in a ship construction program.

that the latter may become a second competing source. Often, the government pays partial or all additional costs of establishing the second production line, assuming that those nonrecurring start-up costs will be more than offset by the savings accrued from increased competition. This acquisition strategy implies that a break-even point will occur at which the combined costs of the competitors (including both recurring and nonrecurring costs) equal sole-source costs.

On May 31, 1984, the Navy directed that a second-source contractor be qualified for production of RAM missiles to "achieve the full potential of competitive savings in order to afford the level of weapons inventory the Navy must have." In response to concerns about qualifying a second domestic source for RAM without German concurrence, Naval Sea Systems Command recommended a plan for establishing a German second source. The decision was justified because (1) German industry was involved extensively in the development program, (2) acceptable European industrial participation would be easier to achieve than a domestic second source and would prevent a U.S.-only funded effort, and (3) the increased production base in the United States and Europe would enhance NATO's defense capability. The U.S. Navy made this decision without analyzing the additional cost of establishing a second production line[3] or the likely effect this arrangement would have on missile prices.

Additional Costs of Establishing a Second Production Source

Based on information obtained from the U.S. and the German navies and the prime contractor, we estimated that additional U.S. and German costs associated with the establishment of production competition would be about $110 million (see table 5.2).

Table 5.2. U.S. And German Nonrecurring Costs of Establishing a Second Production Source

Fiscal year 1989 dollars in millions

Cost category	United States	Germany	Total
Technology transfer (prime contractor's assistance to the follower)	$3.3	$3.1	$6.4
Additional capital equipment, test equipment, and tooling (cost of the second production line and final acceptance test equipment)	12.5	91.2	103.6
Total	**$15.8**	**$94.3**	**$110.0**

[3]These costs are often referred to as nonrecurring costs.

Table 5.2 may not identify all the nonrecurring costs associated with establishing the German second source because they either are not clearly defined or are not distinguishable from other expenditures needed to resolve development problems that surfaced in the early 1980s. These include costs associated with efforts undertaken by the second source to translate or use design specifications, the cost of items fabricated by the second source for qualification and of government test facilities and personnel, and additional government and contractor management costs to facilitate the second source. For example, according to the prime contractor, engineers at the Naval Weapons Command at China Lake have provided major design support for RAM and field support to the German second source to ensure that the program could be brought to fruition. Also, the German MOD estimated that about $65 million would be needed for unforeseen events. These funds may be used for certain nonrecurring start-up costs, such as additional tools and test equipment expenses.

Analysis of RAM's Dual-Source Acquisition Strategy

We evaluated RAM's acquisition strategy using DOD's Competition Evaluation Model and found that dual sourcing will likely increase procurement costs. Even in the more optimistic case (that is, the two sources compete for a higher level of production by offering significantly large price reductions), costs will likely still be higher than they would be under a sole-source award. Based on the analysis, further described in appendix II, a dual-source strategy would result in cost increases that range about $130 million to $260 million (constant fiscal year 1989 dollars) above the cost of a sole-source strategy because of the cost to establish the second production line, higher start-up costs, and the higher second-source prices. In the cases evaluated, savings were realized only when it was assumed that both sources offered large price reductions during the competition or that production would increase due to foreign military sales and would continue well into the 21st century. This outcome is unlikely, considering the reduction in planned annual production quantities and recent DOD cost experiences in other dual-source awards.[4]

[4]Although DOD has reported cost savings in dual-source procurement programs, calculations of savings often have not considered DOD's additional cost for opening up the second production line.

Analysis of Dual-Source Production Splits

In dual-source contracts, suppliers are often required to propose prices for various quantities ranging from their minimum sustaining rate to 100 percent of annual production. Thus, contracting officers can split production between the two suppliers by awarding contracts based on the most favorable combined prices.

We analyzed the likely combined production awards for RAM and, based on current U.S. and German costs and operational requirements, found that annual production splits at or above the minimum sustaining rate are not likely to result in cost savings.

This analysis assumes

- production of about 1,000 RAMs per year,
- a minimum sustaining rate of about 30 missiles a month for each source,
- lower price offers for larger production quantities (due to economies of scale) from both sources, and
- fixed-price differences between sources within a given fiscal year.

We analyzed two cases. In case 1 we assumed that both suppliers would offer generally low prices that would decline only slightly for larger production quantities. In case 2, prices were higher but declined rapidly for larger quantities due to economies of scale. In both cases the suppliers would compete for 280 missiles above their minimum sustaining rate. Potentially, each producer could be awarded between 40 percent and 60 percent of annual production quantities.

Obviously, production costs would be lowest if 100 percent of production quantities were awarded to the source that offered the lowest prices. However, as shown in figure 5.1, splitting production at or above the minimum sustaining rate of either producer would likely increase overall costs above those of a sole-source award—even if the award were made to the higher-priced source.

The market for foreign military sales of RAM appears to be limited. NATO countries (except for Denmark) have expressed little interest in the system. Several non-NATO countries have requested information on RAM, and in January 1990 the RAM Program Office requested a technical security assistance review to expand the U.S. list of eligible countries outside of NATO. However, sales to those countries would also require approval by the German government. According to program officials, even with approval, sales are not likely until RAM is operational in the U.S. and German fleets.

Multiyear Procurement

Multiyear procurement is another approach to reducing costs. Germany commonly uses multiyear contracting, thereby authorizing procurement for major programs based on a total program requirement or quantity (rather than an annual requirement). Funding is then provided annually to cover required expenditures.

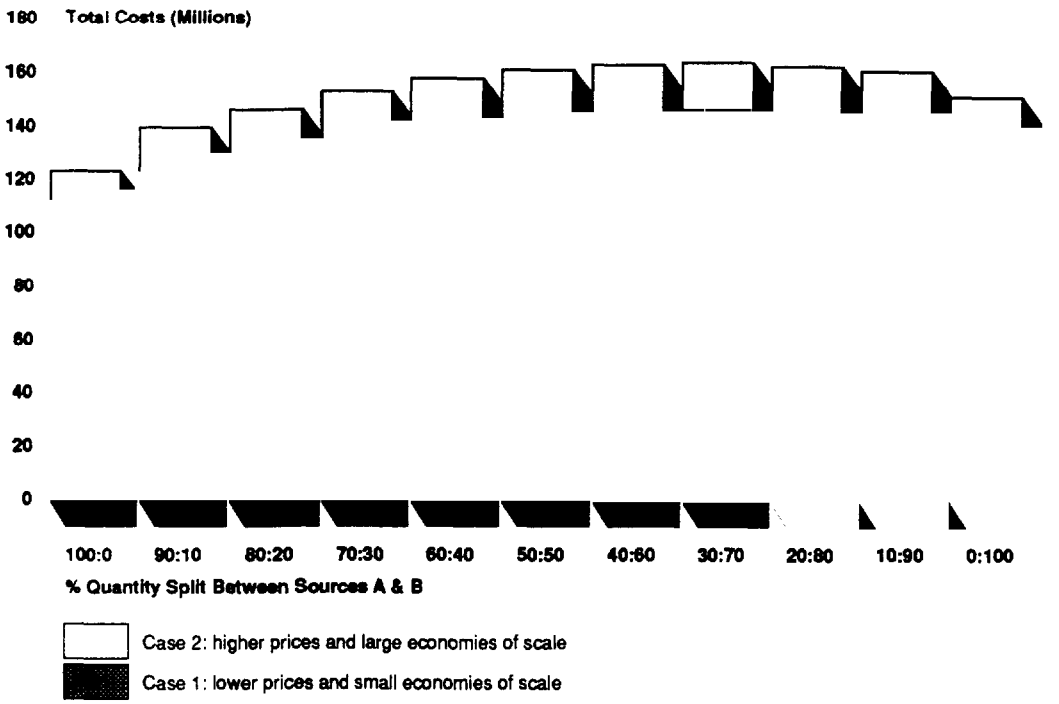
A recent Institute for Defense Analyses report,[5] which examined 82 major U.S. defense programs to determine the effectiveness of certain acquisition initiatives, supports the use of multiyear weapons procurement. The report concluded that cost growth has been lower in multiyear programs than in the general population of programs. (It also stated that dual sourcing of major weapons systems has had mixed success.)

In September 1989, GAO reported on an analysis of potential multiyear contract candidates in the Defense Department's fiscal years 1990-91 biennial budget to determine whether DOD had satisfied the legislative criteria for approval.[6] GAO found that although multiyear procurement can benefit the government by saving money and improving contractor productivity, it can also entail certain risks, including increased costs to the government should a multiyear contract later be changed or terminated. Criteria established in the DOD Authorization Act of 1982 (10 U.S.C. 2306(h)) require that (1) the estimated contract costs and projected savings be realistic, (2) the minimum requirement (total quantity, production rate, and procurement rate) for the system be expected to remain substantially unchanged, (3) sufficient funding be requested by DOD to carry out the contract, and (4) the design be stable. We concluded

[5] Acquiring Major Systems: Cost and Schedule Trends and Acquisition Initiative Effectiveness (Institute for Defense Analysis Paper P-2201, Mar. 1989).

[6] Procurement: Assessment of DOD's Multiyear Contract Candidates (GAO/NSIAD-89-224BR, Sept. 1989).

Figure 5.1: Cost of Splitting RAM Production Between Two Sources



Note: The dashed lines in figure 5.1 show that the cost of splitting production at or above the minimum sustaining rate is higher than the cost of awarding 100 percent of production either to source A (the lower price source) or source B (the higher price source).

Other Cost Reduction Acquisition Strategies

The U.S. Defense Department uses several acquisition strategies to reduce weapon system procurement costs, including foreign military sales and multiyear procurement. In general, expanding the annual level of production produces larger economies of scale and encourages greater price competition.

Foreign Military Sales

Foreign military sales have been used as one approach to increasing annual production quantities. According to the RAM MOU, third-party sales require prior written consent of each participating government, joint production (rather than one producer), and a charge for recoupment of a portion of development and other nonrecurring costs to be shared jointly by participating governments.

that each candidate should be judged on its own merits through a case-by-case assessment of the potential benefits and risks in awarding a multiyear contract instead of a series of annual contracts.

Conclusions

Unanticipated design and reliability problems have nearly quadrupled RAM development costs. Total contributions for development and transition to production, including the cost of establishing a second production source, are currently estimated to be almost $500 million. Development costs required for RAM improvements are excluded from the total.

Further, although the United States and Germany estimate dual-source missile production costs to be about $1.3 billion through fiscal year 1996, this procurement strategy will likely be more costly than a sole-source award. Two possible alternatives for reducing RAM costs—foreign military sales and multiyear procurement—do not seem feasible at this time. Additional sales to third countries are unlikely until the system is operational in the United States and Germany navies. The U.S. and German navies could consider two alternatives to minimize procurement costs: (1) reassess the advisability of continuing the dual-source procurement procedure or (2) combine annual production quantities, as in low-rate initial production, to achieve greater economies of scale.

Agency Comments and Our Evaluation

DOD and MOD did not concur with our dual-source analysis and the resulting conclusions. DOD stated that the U.S. Navy conducted a feasibility study of competitive procurements of both the missile and launching system and also complied with congressional and Secretary of the Navy direction by establishing a second source with minimal investment in the second production line. MOD stated that a limited analysis of the dual-source procedure was performed at that time due to a lack of available data on the use of this procedure. DOD believes that the Competition Evaluation Model is a teaching tool and its data base does not reflect the results of current competitive programs. Both DOD and MOD also disagreed with the assumptions used in the analysis, which they said were incorrect, and pessimistic. DOD stated that the result, which reflects GAO's bias, could be in error by two orders of magnitude. DOD stated that the Competition Evaluation Model and assumptions did not consider certain facts, that is (1) the second source was established in compliance with congressional and Secretary of the Navy direction, (2) German development contributions represent considerable savings, (3) the German source provides for more economical procurement when

exchange rates fluctuate, and (4) U.S.-European cooperative production has long-term political, economic, and interoperability benefits.

GAO-BRH Evaluation

Recently, more and more studies have shown that DOD dual-sourcing decisions have not resulted in cost savings. We believe that dual-source procurement of the RAM will also not likely produce cost savings due to the large up-front expenditure required to establish the second source and the higher estimates of second-source missile prices. The GAO-BRH analysis using the Competition Evaluation Model confirms this assessment.

In evaluating the RAM program, we found that the U.S. Navy did not use any recognized DOD analytical tool to determine whether or not to pursue a competitive production strategy or to determine the longer term political and economic ramifications of a dual-source acquisition strategy. During the GAO-BRH review, we were provided various correspondence, including the Secretary of Navy's directive that a second-source contractor be qualified for RAM. In a July 17, 1984, memorandum to the Chief of Naval Operations, the Commander of Naval Sea Systems Command stated that "a decision to establish a second source at this point not only makes this effort extremely complicated but will surely result in less than satisfactory workshare." He further stated that "no feasibility study has been undertaken to determine if there is a practical way to compete the RAM Missile and achieve the desired benefits..." and recommended "that action to proceed with the establishment of a second source for RAM be suspended until the Chairman and U.S. Representative of the RAM Steering Group has presented such a proposal to our partners, and they are allowed to respond." After considerable discussion, on October 3, 1984, the Naval Sea Systems Command recommended approval for a European producer. This decision was justified for several reasons, as discussed earlier in this chapter.

We disagree that the second source has been established with minimal investment in the second production line. U.S. and German funding for establishing the production line (estimated to be $110 million) and the higher price of second-source missiles (estimated to be as much as $150 million for 7,000 missiles), or a total of about $260 million, are in fact incremental expenditures that would not have been incurred under a sole-source strategy. Further, these costs may be higher than shown, since start-up cost elements, not clearly defined or distinguishable from other procurement expenses in the U.S. Navy's records, are not included in our estimate. Also, estimates of second-source missile prices are based

on very optimistic assumptions about cost decreases attributable to the producer's increased experience. For example, the U.S. Navy assumed that the higher second-source missile prices would decline far more rapidly over the production period than those of the first source.

We disagree that German contributions to the development effort should be counted as savings in assessing second-source costs. A primary principle of cooperation during procurement is to reduce overall costs for both partners, not to transfer costs from one partner to another.

We agree that the Competition Evaluation Model is a teaching tool; however, since its development in 1979, according to the Navy Competition Advocate General, the model also has been widely used throughout DOD and defense industry. In formulating case studies, we used the most recently available DOD and MOD data and optimistic assumptions about operational requirements, estimated missile costs, and the missile production schedule. For example, we assumed that DOD would approve full-rate production as planned and that missile sales to other countries would begin as early as fiscal year 1992. We assumed, like the RAM Program Office, that production prices would decrease substantially over time as the producer gained experience, and in most cases assumed that prices would be reduced further in response to competition. We applied the same exchange rate that the United States and Germany have used in RAM financial documents and contracts. Finally, we examined competitive costs in six cases, based on a wide range of potential procurement quantities, and found competition losses in individual cases varied by not more than 5 percent due to changes in estimated experience rates and competitive price reductions.

We do agree, however, with DOD's view that our analysis does not consider non-cost factors, such as the long-term political and interoperability benefits to be derived from the first U.S.-European cooperative production program. Our analysis does show that the United States and Germany are paying a high price for these benefits.

Summary Conclusions and Recommendations

Conclusions

GAO and BRH believe that it would be prudent to minimize the production of basic RAMs, as they are now configured, until the cost, capability, and need for an upgraded missile have been determined and the procurement strategy has been reassessed. Issues to address include (1) anticipated changes in the ASM threat, (2) the possible approval of full-rate production of RAM, (3) the number of basic missiles to be produced, and (4) increased costs.

The ASM Threat Is Changing and Increasing

During the development of RAM, technologically improved ASMs have become more widely used in various regions of the world. The improvements make ASMs more difficult to detect, track, and engage and thus increase the threat. The RAM, as currently configured, will find it increasingly difficult to meet this threat. Several improvements either underway or planned, such as an infrared search and track system, a low-altitude fuze, and an infrared-all-the-way guidance system, could increase RAM's effectiveness. However, they potentially face the same cost, schedule, and performance hurdles as the basic RAM system faced throughout its development.

RAM Performance and Capability Cannot Be Fully Assessed

Since 1986, progress has been made in demonstrating that RAM has the potential to perform according to development specifications. Initial operational and more recent developmental tests have shown that RAM can potentially defend against certain low-altitude, multi-target, wave and stream attacks. However, RAM development, procurement, and improvements are proceeding concurrently before fully satisfying testing requirements. Although test limitations will prevent a full assessment of the system's capability before the upcoming full-rate production milestone tentatively scheduled in September 1990, a significant portion of the planned procurement could be carried out by reapproval of low-rate production quantities. Further, the German Navy has not planned for any operational testing on its vessels before introducing the RAM system into the fleet.

Current Procurement Plan Exceeds Known Requirements

The U.S. and German navies plan to procure 6,823 RAM missiles—missiles that meet the original development specifications without upgrades such as an infrared-all-the-way guidance system--of which 850 are being produced as part of the low-rate initial production decision. Such extensive deployment has become increasingly uncertain due to limitations in the basic RAM's capability to counter the emerging ASM threat and

changing defense priorities. In our joint review, we found that substantially fewer basic RAMs may be needed than the navies plan to purchase. We estimate that the U.S. Navy may need less than half of the planned procurement, mainly because plans for modernizing FFG-7 class frigates for use with RAM are uncertain. Further, German ships and boats require only 840 missiles for one-time loading of RAM launchers. The present German defense environment does not call for urgent procurement of missiles for stockpile supplies.

Dual-Source Competition Will Not Reduce Overall Costs

We believe the procurement of RAMs using the dual-source acquisition strategy will cost more than it would if a sole-source strategy were used due to the additional cost of establishing the second production line, higher start-up costs, and higher second- source prices.

The U.S. and German navies share the cost of developing and producing basic RAMs. These costs, currently estimated to be almost $2.5 billion, increased significantly during full-scale engineering development due to unanticipated design and reliability problems. As part of the production strategy, the two partners agreed to base all RAM procurements on the mutual objective of reducing overall costs through dual-source competition. Program office officials have also discussed the use of foreign military sales and multiyear procurement to reduce costs.

We do not believe that these cost reduction measures are feasible at this time. Additional sales to third countries are unlikely until the system is operational in the U.S. and German navies. Further, since the RAM program will not likely meet the criteria for approval of multiyear procurement, the Navy needs to develop an alternate procurement strategy that will minimize the number and the cost of missiles to ensure the best use of scarce defense resources.

Recommendations

GAO recommends, with BRH concurrence, that the U.S. Secretary of Defense direct the U.S. Secretary of the Navy to postpone the full-rate production decision until the basic RAM's operational capabilities have been fully evaluated, the actual costs of producing the initial 850 missiles are known, and the feasibility of upgrading RAM to counter the emerging ASM threat has been determined.

GAO and BRH recommend that the U.S. Secretary of the Navy and the German Minister of Defense direct the RAM Program Office to take the following actions:

- Limit procurement of basic RAMs during low-rate initial production to the number needed to meet U.S. and German known minimum requirements.
- Assess separately the longer-term requirement, cost, and schedule for developing and producing an advanced configuration of the missile system.
- Assess the cost and benefit of continuing the dual-source procurement procedure by (1) considering the experience of the low-rate initial production of 850 missiles and changes in defense priorities, (2) combining production quantities authorized in fiscal years 1990 and 1991 to achieve greater economies of scale, (3) soliciting a full range of offers without establishing a minimum sustaining quantity, and (4) determining the sole-source producer or production split that minimizes costs for both governments.

Agency Comments and Our Evaluation

RECOMMENDATION 1. Nonconcur. DOD believes a full-rate production decision should be sought, assuming a positive recommendation from the Operational Test and Evaluation Force and the Director, Operational Test and Evaluation, and assuming the criteria for transitioning to full-rate production have been met.

GAO-BRH Evaluation

We do not believe that a full-rate production decision is prudent at this time due to the technical advances in ASMs and the need to upgrade RAM; the nature of test limitations, which prevent full and realistic testing of RAM capabilities; the uncertainties about inventory requirements; changes in global defense priorities; and the likely cost increases resulting from the dual-source acquisition strategy.

RECOMMENDATION 2. Nonconcur. DOD and MOD disagree with the GAO's suggested minimum inventory requirements. While not discounting the potential for global change and shifting fiscal priorities, DOD believes a realistic inventory must consider FFG-7 class frigate and reloading needs and that its established inventory requirement is valid. MOD does not concur that the number of missiles should be reduced further simply because the German Navy cannot connect missile requirements to an upgrade program that has not been assessed yet.

We believe that DOD should establish minimum inventory requirements due to the uncertainties about RAM's capabilities in countering technically improved threat missiles, launching approaches for U.S. ships with space and weight limitations, and the need to stockpile basic RAMs in light of the changing political situation. Further, in the event procurement continues under a low-rate initial production status, establishing a minimum inventory requirement would prevent the production of quantities that would eventually reach the total planned procurement.

RECOMMENDATION 3. Concur. DOD and MOD agreed that RAM has potential for further development. DOD agreed that the requirements, cost, and schedule for developing and producing an advanced configuration of RAM would be assessed separately but stated that changes could be incorporated into the missile configuration prior to fiscal year 1994 without a major disruption to the production lines.

The single most complex and costly component of the basic RAM—its dual-mode radio frequency/infrared guidance system—has been in development for more than 11 years. Based on RAM's development history, the nature of ASM technology, and changing budget priorities, it seems likely that development of an alternate infrared-all-the-way guidance system will face similar cost, schedule, and performance hurdles as the basic missile. Therefore, we disagree that RAM is likely to be reconfigured prior to fiscal year 1994.

RECOMMENDATION 4. Partially concur. DOD and MOD disagreed that further missile procurement should be postponed until actual experience from low-rate initial production is available. However, they agreed that savings could be achieved by combining multiyear requirements. They plan to solicit a full range of offers from both contractors in fiscal year 1990 with options for fiscal year 1991 to minimize costs over the 2-year period. DOD and MOD plan to request proposals without minimum sustaining quantities for the loser but with options—as the MOU allows—for award to a single contractor for an entire year's procurement. According to DOD, although the program office intends to maintain two sources, the U.S. Navy will award the split in quantities that is in the best interest of both governments.

We believe that it is essential to postpone further missile procurement until defense priorities are reassessed and actual cost data from low-rate initial production is available if the two partners are to achieve their mutual objective of reducing overall costs. If the program maintains two sources in light of evidence that dual sourcing is not producing the savings once anticipated, then the U.S. and German navies should employ a procurement strategy that will minimize the number and the cost of the missiles.

Comments From the U.S. Department of Defense

DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING

WASHINGTON, DC 20301-3010

1 JUN 1990

Mr. Frank C. Conahan
Assistant Comptroller General
U.S. General Accounting Office
Washington, DC 20548

Dear Mr. Conahan:

This is the Department of Defense response to General Accounting Office (GAO) Draft Report "NAVY SHIP DEFENSE: Concerns About the Strategy for Procuring the Rolling Airframe Missile," GAO/C-NSIAD-90-33, dated May 11, 1990, (GAO Code 394313), OSD Case 8338. The Department does not concur with a majority of the findings and recommendations contained in the report and questions the validity of the analysis that supports the conclusions.

The majority of anti-ship cruise missiles will continue to be engageable by the Rolling Airframe Missile throughout the 1990s and planned upgrades will meet tomorrow's threat. Since the restructuring in 1985, the program has met cost, schedule, and performance targets. Although the Operational Evaluation report has not been published, it is the DoD position that, given a positive recommendation, sufficient testing has been accomplished to consider a full production decision. Finally, the dual source cooperative acquisition strategy has yielded a savings to the U.S. Government in development costs and will achieve a savings in production costs.

The detailed DoD comments on the report and recommendations are provided in the attachment. The Department appreciates the opportunity to comment on the report.

Sincerely,

Charles M. Herzfeld

Charles M. Herzfeld

Attachment

GAO DRAFT REPORT DATED MAY 11, 1990
GAO CODE 394313/OSD CASE 8338

"NAVY SHIP DEFENSE: CONCERNS ABOUT THE STRATEGY FOR PROCURING THE ROLLING AIRFRAME MISSILE"

DEPARTMENT OF DEFENSE COMMENTS

* * * * *

FINDINGS

FINDING A: Background: Rolling Airframe Missile Program. The GAO reported that the Rolling Airframe Missile is designed to provide naval vessels close-in defense against anti-ship cruise missiles equipped with active radar guidance systems. The GAO reported that, in 1968, the United States and the Federal Republic of Germany (West Germany) signed a memorandum of understanding agreeing to develop the system together. The GAO also reported that the production memorandum of understanding calls for split awards during low-rate initial production or until the second source is fully qualified. The GAO found that the system began full- scale engineering development in 1979 and is currently in full-scale engineering development and low-rate production. (The GAO found that, in October 1989, the U.S. Navy finalized the low-rate initial production contract for the first 500 missiles with the U.S. producer, and, in November 1989, contracts were awarded to the West German second source for low-rate production of 350 missiles.) The GAO reported that, after approval of full-rate production, the two sources will compete for the combined U.S. and West German FY 1990 requirement of 980 missiles. The GAO observed that, during development, the Rolling Airframe Missile faced numerous cost, schedule and performance problems that threatened the program's continuation. The GAO noted that, following flight failures in 1985, the U.S. Congress disapproved funding for test and tooling equipment and low- rate initial production. The GAO reported that full-scale engineering development, envisioned to last 4.5 years, has now taken 11 years, due to an underestimate of the system's complexity, development test failures, and the congressional action. The GAO and Bundesrechnungshof (West German Federal Court of Audit) estimate U.S. and West Germany development and planned procurement costs to be about $2.5 billion. (pp. 2-3, pp. 8-13/GAO Draft Report)

Now on pp 4, 14-17, 35-36.

DOD RESPONSE: Partially Concur. The technical and reliability problems experienced during the early stages of testing have been resolved, as evidenced by recent and highly successful (11 of 12) Technical Evaluation flight tests. Many of the technical problems and the resulting

Enclosure

1

stretch-out of program schedules can be traced to engineering constraints imposed by early funding short falls.

It is also important to recognize that cost increases were exacerbated by the suspension of FY 1986 funding. Since program realignment in late 1985, however, the Rolling Airframe Missile Full Scale Engineering Development and transition to production costs, in constant dollars, have not increased. Unit costs have remained within the congressionally imposed ceiling of $145,000 ($133,000). Development costs have also remained below the ceiling of $220 Million. The program schedule, adopted in March of 1987, has been maintained and the actual completion of the Operational Evaluation firings was completed ahead of schedule.

FINDING B: The Anti-ship Missile Threat Is Changing And Increasing. The GAO found that the number and capability of anti-ship missiles available in various regions of the world have increased significantly since the system began development. The GAO observed that the Rolling Airframe Missile has been designed to counter missiles with active radar guidance systems, which constitute the majority of anti-ship missiles. The GAO found, however, that many missiles are operating with passive guidance systems and many more have advanced designs that reduce the Rolling Airframe Missile effectiveness. The GAO found that the improvements make anti-ship missiles more difficult to detect, track, and engage and, thus, increase the threat. The GAO found that, as currently designed, the system cannot counter anti-ship missiles equipped with nonradiating (passive guidance) systems or with very low flying missiles. In figure 2.1 of the report the GAO illustrates anti-ship missile development in selected years between 1973 and 2000. The GAO commented that, in 1980, there are nearly three times as many missiles equipped with passive guidance systems as in the early 1970s. The GAO also observed that in 2000 there will be many more missiles that could pose a significant challenge to defensive systems due to their design improvements and their export to more countries. The GAO reported that the Bundesrechnungshof contracted with a commercial establishment which provided an analysis concluding that the Rolling Airframe Missile would likely be effective against about half the current Warsaw Pact missile types. The GAO commented that there are other factors that indicate the Rolling Airframe Missile performance could be less than this. The GAO also noted that the Bundesrechnungshof estimates that the Rolling Airframe Missile will perform less effectively against the more advanced anti-ship missiles expected to become operational in the Baltic and the North Sea in the 1990s. The GAO concluded that, in its current configuration, the Rolling Airframe Missile will face increasing difficulty keeping

Enclosure

Now on pp 5, 20-24, 45.

pace with the emerging threat. The GAO also concluded that the several improvements either underway or planned (such as an infrared search and track system, a low altitude fuze, and infrared-all-the-way guidance system) could increase the system's effectiveness but that these potentially face the same cost, schedule, and performance hurdles as the basic system faced throughout its development. (p. 3, pp. 17-22, p. 51/GAO Draft Report)

DOD RESPONSE: Partially Concur. The DoD disagrees with the implication that the Rolling Airframe Missile is ineffective against the baseline radiating threat or that the need to evolve the Rolling Airframe Missile in response to changing threats was not foreseen. The reality of a changing threat and the need for future upgrades to pace that threat are not unique to the Rolling Airframe Missile. The need for a robust pre-planned product improvement program to counter an aggressive threat evolution was considered and provided for during preliminary design. Two such enhancements are currently under consideration -- the infrared-all-the-way guidance upgrade and a very-low-altitude proximity fuze.

While it is true that the anti-ship missile threat is changing in terms of types of guidance, there remain a substantial number of active radar guided missiles against which the Rolling Airframe Missile tests have indicated effectiveness. As correctly stated by the GAO "... these constitute *the majority of anti-ship missiles.*" It is the DoD position that **the majority of the threat will continue to be engageable by the Rolling Airframe Missile through out the 1990s** and that planned upgrades will meet the evolving threat.

The DoD objects to the assertion that planned improvements "potentially face the same cost, schedule, and performance hurdles as the basic system." The development of the Rolling Airframe Missile is managed by a mature program office and has enjoyed stable funding in recent years. The cited statement is supposition and completely unsubstantiated.

FINDING C: Rolling Airframe Missile Performance And Capability Cannot Be Fully Assessed. The GAO observed that, since development failures in early 1985, the Rolling Airframe Missile performance has improved, and that the U.S. Navy considers testing in recent years to be very successful. The GAO noted that, although initial operational tests (held between December 1986 and February 1987) did not stress the system's expected performance capabilities (due to missile and target availability and test facility limitations), the Navy Operational Test and Evaluation Force concluded that the Rolling Airframe Missile had the potential to be operationally effective and suitable

Enclosure

and recommended approval for limited fleet introduction. The GAO found that technical evaluation tests from July through December 1989 resolved many concerns but had certain limitations, such as that testing on supersonic, low altitude, close in and offset targets was done over land. (The GAO noted that the National Defense Authorization Act for Fiscal Year 1987 directed the DoD to approve a revised Test and Evaluation Master Plan, but in May 1989 the Office of the Secretary of Defense rejected the draft plan. The GAO found that a revised plan was approved on January 2, 1990 and operational tests were completed in April 1990.) The GAO commented, however, that the system's development, testing, procurement, and improvements are proceeding concurrently before fully satisfying testing requirements. The GAO observed that remaining test limitations will preclude a full assessment of the system's operational effectiveness and suitability prior to the full rate production decision scheduled for August 1990. The GAO found, for example, that tests with an upgraded computer and the unique target evaluation and weapons assignment software are scheduled to occur after this decision. In addition, the GAO noted that the Navy estimates that its new test site, needed to safely test Rolling Airframe Missile capabilities against close-in, maneuvering, supersonic targets over water, will not be available until 1993. Further, the GAO noted that the West German Navy has not planned for any operational testing on its vessels before introducing the system into the fleet. The GAO concluded that, due to test limitations, the milestone to decide on approving the Rolling Airframe Missile for full-rate production will be reached before the system has been tested in the environment in which it is expected to operate. (pp. 3-4, pp. 23-28, p. 52/GAO Draft Report)

Now on pp. 5-6, 25-28, 45.

DOD RESPONSE: Partially Concur. The performance of the Rolling Airframe Missile has improved markedly. The DoD does not agree that testing to date did not stress the Rolling Airframe Missile in its operational environment or with the implication that test limitations preclude a meaningful assessment of the system's operational effectiveness and suitability. The Rolling Airframe Missile performance has been successfully demonstrated over the past four years with 25 of 28 successful flight test firings -- an outstanding track record. Testing has been in accordance with the Office of the Secretary of Defense approved Test and Evaluation Master Plan. Although not all testing specified in the Test and Evaluation Master Plan has been completed, there are a variety of valid reasons why this is so. For that testing which is deferred, the acquisition system provides for a period of Follow-On Test and Evaluation to accommodate the additional testing. Limitations to scope of testing were either recognized and accepted in advance or considered as not critical to the full production decision and deferred to Follow-On Test and

Enclosure

4

Evaluation. The criticality of Test and Evaluation Master Plan specified testing, which was planned but not accomplished during the Operational Evaluation, will be addressed during the full production decision. The system has been tested against multiple targets; stream and wave attacks; low altitude subsonic and supersonic targets; and low visibility targets (including rain, fog and sun glint conditions). As with any test program, facts-of-life impose certain limitations to scope; for example, as noted by the GAO, threat representative targets are expensive and in short supply and, certainly, the test and evaluation budget is finite. Sufficient testing has occurred to proceed to the full production decision with reasonable confidence that the system is performing as designed.

FINDING D: Current Operational Plan Exceeds Minimum Known Requirements. The GAO reported that the U.S. and West German navies plan to procure 6,823 Rolling Airframe Missiles (4,900 missiles and 85 launching systems for the U.S., and 1,923 missiles and 45 launching systems for West Germany). The GAO observed that these missiles meet the original development specifications, but are without upgrades. The joint review found that substantially fewer basic Rolling Airframe Missiles (as shown in table 4.1) may be needed than the navies plan to purchase. The review found the U.S. and West German fleet requirements to be 2,869 missiles. This includes 588 missiles needed to fill two 21-cell launchers on 14 U.S. amphibious ships and another 1,441 for U.S. reload and pipeline requirements. (It excludes missiles being considered for U.S. FFG-7 frigates, since plans for modernizing these vessels are uncertain, according to the GAO.) For West Germany, the review found that only 840 missiles are needed. The GAO explained that this is to fill all launchers, since the intended platforms do not have on-board storage capability and, due to the present defense situation, the need to stockpile basic Rolling Airframe Missiles seems unlikely. The GAO reported further that, in estimating operational requirements, the U.S. and West German navies have not determined the number of basic Rolling Airframe Missiles that are needed or requirements for an improved Rolling Airframe Missile to counter the emerging threat. The GAO further observed that the navies have not considered the effect of global changes on defense priorities and other uncertainties. The GAO listed these uncertainties as (1) the number and capabilities of threat missiles deployed in various regions of the world, (2) questionable need for the Rolling Airframe Missile on ships equipped with North Atlantic Treaty Organization (NATO) Sea Sparrow missiles, (3) lack of funding for a feasibility study on modifying the Standard Missile launcher on FFG-7 frigates to accommodate the Rolling Airframe Missile (as well as the question noted concerning modification of these ships), and (4) uncertain budget priorities and long-term weapons procurement

Enclosure

Now on pp. 6, 29-31, 45-46.

requirements. The GAO concluded that extensive deployment of the Rolling Airframe Missile has become increasingly uncertain due to limitations in the basic system's capability to counter the emerging threat, competing defense systems, and changing defense priorities. The GAO further concluded that the U.S. and West German navies need substantially fewer basic Rolling Airframe Missiles than are planned. (p. 4, pp. 29-33,p. 36, pp. 52-53/GAO Draft Report)

DOD RESPONSE: Nonconcur. The DoD disagrees with the GAO conclusion that "extensive deployment of the Rolling Airframe Missile has become increasingly uncertain due to limitations in the basic system's ability to counter the emerging threat." Upon examination the "uncertainties" become less troublesome. The GAO fails to recognize the potential synergy between the Rolling Airframe Missile and the NATO Sea Sparrow. In a layered defense strategy, one will complement the other -- specifically, in terms of fire power. Although the FY 1991 President's Budget does not support procurement of the Rolling Airframe Missile for NATO Sea Sparrow equipped ships, the issue is currently under consideration to determine the costs and benefits of such a plan.

It is the DoD position that the **majority of the threat will continue to be engageable by the Rolling Airframe Missile throughout the 1990s** and that planned upgrades will meet the evolving threat. The capabilities of threat missiles that the Rolling Airframe Missile must defeat are known and, although the threat is changing, the U.S. is responding. Accordingly, current inventory objectives are appropriate. As with any program, budget priorities and long-term procurement requirements are continually revised and adjusted. The effects of global changes, while certainly affecting defense priorities on a macro scale, do not eliminate the need for effective self defense of maritime forces. Incidents during recent years have highlighted the need to upgrade the DD-963 and FFG-7 air defenses. An Institute for Defense Analyses study *Trends in Surface Ship Air Defense Capabilities*, September 1989; cites the Rolling Airframe Missile (with infrared-all-the-way) as an improvement that would allow the ships to pace the evolving threat. The GAO analysis fails to incorporate the results of that study.

FINDING E: Full-Rate Versus Limited-Rate Production. The GAO reported that the 1987 production memorandum of understanding, to ensure that production would continue without interruption in both countries, agreed to establish a minimum production rate (projected to be 30 sets of dual-source components per month) at each facility. The GAO found that, at the time, Rolling Airframe Missile production

Enclosure

6

was expected to last 6 years. The GAO found that, subsequently due to budget difficulties, the U.S. Navy extended production through FY 1996. On the other hand, the GAO/Bundesrechnungshof joint evaluation estimated that both navies could produce their known minimum requirements for basic Rolling Airframe Missiles in 4 years, with no further construction of basic missiles after FY 1991. (The GAO set this out in table 4.2 of the report.)

See p. 31

The GAO cautioned that, although the Navy Operational Test and Evaluation Force might not recommend full-rate production of the system due to test limitations, the Navy could approve full-rate production based on other factors such as the cooperative nature of the program, the decision to establish a West German second source, and the results of recent tests. The GAO pointed out that, even without approval, the total planned procurement could be met in a low-rate production status.

The GAO noted that, in response to concerns that too many weapon systems are being procured before they successfully meet technical specifications and design deficiencies are corrected, the congress recently redefined low-rate production. The GAO also noted that mature full rate production was already defined in 10 U.S.C. 2403 as the manufacture of all units of a weapon system after the initial production quantity or after the manufacture of the first 10 percent of the eventual production total, whichever is first.

The GAO concluded that a significant portion of the planned procurement could be carried out by re-approval of low-rate production quantities. The GAO also concluded that, since the current definition of low-rate production is still open to interpretation, missile production could continue at the low-rate production level and exceed what is needed to meet known minimum requirements. The GAO further concluded that approval of full-rate production or continued production under a low-rate production status may not be prudent until issues concerning operational requirements are resolved. (p. 4, pp. 33-36/GAO Draft Report)

Now on pp 6, 32-34.

DOD RESPONSE: Concur. The DoD agrees that, *if* a re-approval of Low Rate Initial Production occurs, a significant percentage of the inventory *could* be bought and, therefore, because the current definition of Low Rate Initial Production is subject to interpretation, missile production *could* continue and eventually exceed "minimum requirements". Should Low Rate Initial Production be continued, however, acquisition procedures (such as Navy Program Decision Meetings) are in place to ensure that minimum inventory requirements are not exceeded.

Enclosure

In terms of operational requirements as a definition of mission need, the DoD agrees that if, in any acquisition program, there is uncertainty about the need, full rate production should be carefully considered. The Department disagrees, however, with the implication that any such concern exists in this case; the Rolling Airframe Missile has a valid operational requirement.

FINDING F: Dual-Source Competition Will Not Reduce Overall Costs. The GAO reported that the U.S. and West German navies share the cost of developing and producing the basic Rolling Airframe Missile. The GAO found that these costs, currently estimated to be almost $2.5 billion (see table 5.1) increased significantly during full-scale engineering development, due to unanticipated design and reliability problems. For example, the GAO found that the full-scale development cost estimate has increased from $108.4 million to $394.3 million. The GAO noted that, as part of the production strategy, the two partners agreed to base all procurements on reducing overall costs through dual-source competition. The GAO found, however, that the U.S. Navy made the decision to establish a West German second source without analyzing the additional cost of establishing a second production line or the likely effect on missile prices. The GAO reported that the procurement using the dual-source acquisition strategy will cost more than it would if a sole-source strategy were used, due to the additional cost of establishing the second production line, higher startup costs, and higher production cost. Based on information from the U.S. and West German navies and the prime contractor, the GAO (table 5.2) estimated an additional cost of $110 million of establishing production competition. In the view of the GAO and the Bundesrechnungshof, higher costs for dual production would be the case even if both competitors responded to competition by offering price reductions. Using a DoD Competition Evaluation Model, the agencies found a competitive savings only by assuming that both sources offer extremely large price reductions and that production would increase due to military sales or would continue well into the 21st century. The analysis indicated that a dual-source strategy could result in cost increases that range from about $130 million to $250 million. The GAO concluded that foreign military sales and multiyear procurement are not feasible at this time. The GAO further concluded that there are two alternatives that the Navy needs to consider to reduce procurement costs: (1) reassess the advisability of continuing the dual-source procurement procedure or (2) combine annual production quantities to achieve greater economies of scale and solicit a full range of offers without regard to the minimum sustaining quantity for each producer. (p. 4, pp. 37-50, p. 53, pp. 56-61/GAO Draft Report)

Now on pp. 6, 36-38, 42-44, 63-66.

Enclosure

8

DOD RESPONSE: Nonconcur. The DoD disagrees with the GAO analysis and the resulting conclusions.

In May 1984, the Secretary of the Navy identified the Rolling Airframe Missile for accelerated competition emphasizing the need to develop innovative ways of increasing competition without requiring a large upfront burden on U.S. resources. Subsequently, the Navy conducted a feasibility study for competitive procurement of both the missile and launching system. The results of that study were reviewed and approved by the Secretary of Defense and the German Ministry of Defense and incorporated as the acquisition strategy contained in the Production Memorandum of Understanding of August 1987.

The Competition Evaluation Model is used as a teaching tool and its data base does not reflect the results of current competitive programs. In addition, the model is extremely sensitive to initial conditions and assumptions. The assumptions used in the GAO analysis, it appears, were heavily biased in the pessimistic direction and the results reflect that bias. The GAO estimates of cost increase attributed to the dual source strategy could be in error by two orders of magnitude.

Moreover, the Competition Evaluation Model and assumptions used by the GAO for determining that dual sourcing will not be cost effective fails to recognize several key facts:

1. The Navy complied with congressional and Secretary of the Navy direction by establishing a second source with minimal investment in the second production line. The model assumes that a single government bears the cost of establishing two sources, as well as all the development costs. The German contribution to the development costs alone were on the order of $190 Million. These are not insignificant savings and should be accounted for in any analysis.

2. The GAO analysis ignores the fact that by establishing a production line in each country, procurements can be made in the most economical manner in situations where fluctuation of exchange rates may have otherwise prohibited the procurement of an annual buy.

3. The long term political, economic, and interoperability benefits to be derived from the first successful U.S./European cooperative production program have not been considered.

The FY 1990 competitive missile procurement will solicit a full range of offers from both contractors. Although it is the intention of the program to maintain two sources, the

Enclosure

9

Memorandum of Understanding allows for the awarding of an entire year's buy to a single contractor. Based on the range of offers submitted, the Navy will award the split in production quantities that is in the best interest of both governments.

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RECOMMENDATIONS

Now on pp. 6, 46-47.

RECOMMENDATION 1: The GAO recommended, with the concurrence of the Federal Court of Audit of the Federal Republic of Germary, that the U.S. Secretary of Defense direct the U.S. Secretary of the Navy to postpone the full-rate production decision until the basic Rolling Airframe Missile operational capabilities have been fully evaluated, the actual cost of producing the initial 850 missiles are known, and the feasibility of upgrading the Rolling Airframe Missile to counter the emerging anti-ship missile threat has been determined. (p. 54/GAO Draft Report)

DOD RESPONSE: Nonconcur. It is the DoD position that, given a positive recommendation from the Operational Test and Evaluation Force and the Director, Operational Test and Evaluation (expected this summer) and given the criteria for transitioning to full rate production have been met, a full rate production decision should be sought.

Testing has been in accordance with the Office of the Secretary of Defense approved Test and Evaluation Master Plan. Although not all testing specified in the Test and Evaluation Master Plan has been completed, there are a variety of valid reasons why this is so. Deferred testing is accommodated by the acquisition system by a period of Follow-On Test and Evaluation. Nevertheless, all limitations to scope of testing were either recognized and accepted in advance or considered as not critical to the full production decision and deferred to Follow-On Test and Evaluation. Unfortunately, all Test and Evaluation Master Plan specified testing that was planned was not accomplished during the Operational Evaluation. This will be addressed during the full production decision.

Delaying additional procurements until the actual price of the limited production buy is known and until the feasibility of upgrading the Rolling Airframe Missile is determined is uneconomical. The FY 1990 competitive buy will be a firm fixed price contract, eliminating the Government's risk associated with cost growth. The benefits associated with delaying additional production buys until FY 1993, when actuals from limited production would be available, are outweighed by the disadvantages of a break in

Enclosure

10

production. Likewise, the delays associated with determining the feasibility of upgrading the Rolling Airframe Missile are also unacceptable. The establishment of a schedule based on achieving adequate Research and Development funding to evaluate fully the Rolling Airframe Missile improvements and a reevaluation of the Anti-Ship Missile threat would necessitate a break in production. @ Again, the full production decision will take into account the criticality of Test and Evaluation Master Plan specified testing that was planned but not accomplished during the Operational Evaluation

RECOMMENDATION 2: The GAO and the Federal Court of Audit of the Federal Republic of Germany recommended that the U.S. Secretary of the Navy and the West German Minister of Defense direct the Rolling Airframe Missile Program Office to limit procurement of basic Rolling Airframe Missiles during low-rate production to the number needed to meet U.S. and West German known minimum requirements. (pp. 54-55/GAO Draft Report)

Now on pp 7 47-48

DOD RESPONSE: Nonconcur. The DoD disagrees with the GAO's suggested minimum inventory requirements. Although final DoD decisions on which ship classes the Rolling Airframe Missile will be deployed have not yet been made, the GAO suggested inventory for current ships is too low. A more realistic inventory must consider the missiles required for magazine fills, which are, 42 missiles for each amphibious ship and 21 missiles for each frigate. While not discounting the potential for global change and shifting fiscal priorities, the DoD position continues to be that the established inventory requirement of 4900 U.S. missiles is valid. Again, the GAO report did not incorporate the Institute for Defense Analyses' conclusions concerning the Rolling Airframe Missile's contribution to FFG-7 self defense. Therefore, the current Low Rate Initial Production profile (500 in FY 1990) does not exceed the minimum requirements.

RECOMMENDATION 3: The GAO and the Federal Court of Audit of the Federal Republic of Germany recommended that the U.S. Secretary of the Navy and the West German Minister of Defense direct the Rolling Airframe Missile Program Office to assess separately the longer-term requirement, cost, and schedule for developing and producing an advanced configuration of the Rolling Airframe Missile system. (p. 55/GAO Draft Report)

Now on pp 7, 47-48

DOD RESPONSE: Concur. As a typical part of any development upgrade, the requirements, cost, and schedule are assessed prior to any undertaking. The Rolling Airframe Missile is currently in the pre-design stage of the infrared-all-the way guidance system upgrade and will, in the near term, be

Enclosure

11

evaluating the low altitude fuze improvement. It should be noted that the basic Rolling Airframe Missile can engage the threat it was designed to meet and that the upgrade programs were instituted to meet the evolving threat. Once a decision has been made, the changes can be incorporated into the missile configuration prior to FY 1994, without a major disruption to the production lines.

RECOMMENDATION 4: The GAO and the Federal Court of Audit of the Federal Republic of Germany recommended that the U.S. Secretary of the Navy and the West German Minister of Defense direct the Rolling Airframe Missile Program Office to assess the cost and benefit of continuing the dual-source procurement procedure by (1) considering the experience of the initial low-rate production of 850 missiles and changes in defense priorities, (2) combining production quantities authorized in FY 1990 and FY 1991 to achieve greater economies of scale, (3) soliciting a full range of offers without establishing a minimum sustaining quantity, and (4) selecting the sole-source producer or production split that minimizes costs for both governments. (p. 55/GAO Draft Report)

Now on pp 7, 47-49.

DOD RESPONSE: Partially Concur. The DoD disagrees with the implication of this recommendation that production should be held in abeyance. The DoD will evaluate, on a continuing basis, the experience gained during limited production by both contractors, as the program proceeds into full rate production. The experience gained from proposal evaluation and award of the first competitive buy will yield even greater insight into the benefits to be gained from dual sourcing on an international level.

The combining of multi-year requirements was successfully employed in the limited production launcher buy, achieving significant savings due to economies of scale. The FY 1990 contract is being bid with options for FY 1991, thus minimizing cost over the 2 year period.

The FY 1990 competitive missile procurement will solicit a full range of offers from both contractors. Although it is the intention of the program to maintain two sources, the Memorandum of Understanding allows for the awarding of an entire year's buy to a single contractor. Based on the range of offers submitted, the Navy will award the split in production quantities that is in the best interest of both governments.

Enclosure

Dual-Source Cost Analysis

We used the Competition Evaluation Model developed for use by the Defense Systems Management College to analyze the most current RAM cost data provided by the RAM Program Office.

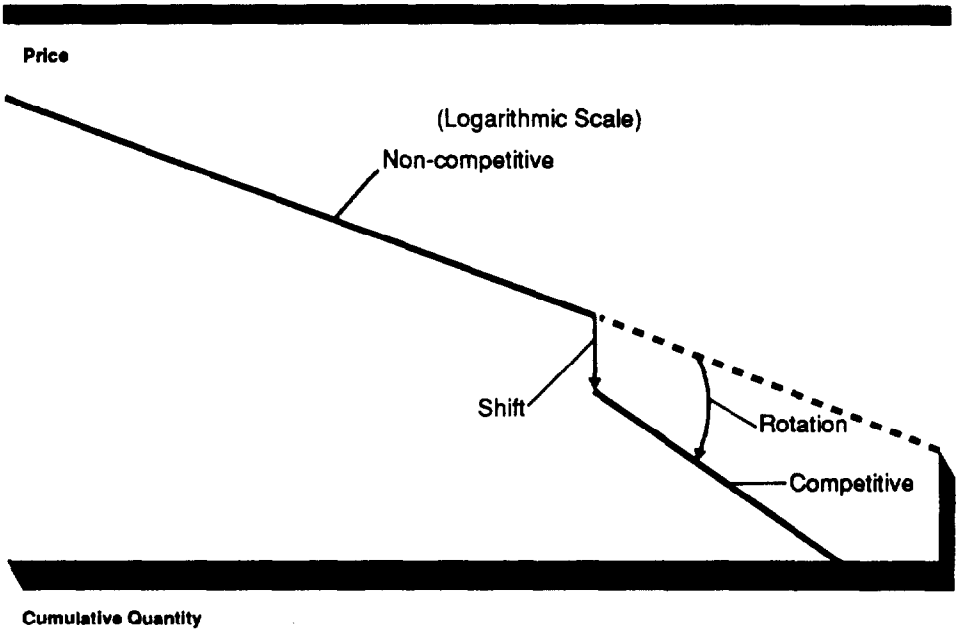
Theory Behind Model

The model uses the progress curve theory[1] as opposed to a "learning rate" to calculate production costs. The "learning rate" is defined as the rate at which unit costs decrease during production as a result of reductions in labor hours as workers become more skilled. In contrast, the "progress curve" theory implies that all recurring costs (labor, amortized capital cost, overhead, and profit) decrease as more quantities are produced over the production period.

Savings (or losses from additional costs) are calculated by the model as the difference between the sole-source costs and the combined competitors' costs. As shown in figure II.1, the model allows for two changes in the sole-source producer's behavior when competition is introduced. The first change is a downward "shift" as the initial producer reduces unit prices in response to competition. The second change is a steepening, or downward "rotation," of the curve as the initial producer continues to reduce unit prices more than if he had been the sole source.

[1]Further information is contained in the Defense Systems Management College handbook Establishing Competitive Production Sources, A Handbook for Program Managers (Defense Systems Management College, Fort Belvoir, Va., Aug. 1984).

Figure II.1: Effect of Shift and Rotation on Production Price Curves



A study of production competition summarized in the Defense Systems Management College handbook notes that shifts and rotations can be characterized as "making up for earlier cost improvements which were possible, but were unrealized due to the absence of competitive pressure," and suggests that shift and rotation values can be expected to range from 5 to 10 percent.[2] This theory assumes that the sole source incorporates inefficiencies into its production process and/or is making excess profits and that the government can select a second source that will rapidly achieve the same level of efficiency as the first source. Further, it assumes that a dual-source acquisition strategy results in adequate price competition.

Other studies have indicated that dual-source contracting has not decreased prices as much as expected. For example, a DOD Inspector General study applied a smaller rotation factor than used by the Office of the Secretary of Defense because "past studies have not produced a

[2]Shift and rotation values refer to the constant percentage reduction in unit cost associated with a doubling in production rate per period.

reliable predictive model to determine the effects of rotation for individual DOD procurements."[3] Further, GAO recently reported that competition in dual-source contracts does not always result in lower costs.[4]

Due to increasing evidence that dual sourcing may not reduce weapon prices as anticipated, we applied shift and rotation factors only in our more optimistic scenarios.

Our Use of the Model

Required data for the model include the first-unit cost and the expected decrease in contract prices resulting from competition, the number of years the program is expected to be in production, annual production quantities, and the likely production split between the two sources.

We calculated first-unit missile costs and progress rates based on U.S. and German navy data and prices in low-rate initial production contracts. Production quantities based on operational requirements, as stated by the United States and Germany, include potential foreign military sales. In assessing the potential split in production between the U.S. and German sources, we minimized costs by allocating larger competitive quantities to the lower cost producer. To determine the current value of potential savings (or losses resulting from additional costs), we used constant fiscal year 1989 dollars and the U.S. Navy's economic escalation data. German costs were converted to U.S. dollars at an exchange rate of one dollar to 1.8 deutsch marks.

In analyzing RAM missile costs, we developed several scenarios (see table II.1). We identified general assumptions that were used in all cases and specific assumptions that varied in individual cases, including the production quantity, the production period, the percentage shift and rotation, and the progress rate. Included for each case are the total production costs for each competitor acting as a sole source and the range of competitive losses when production is split between the two sources.

In table II.1, cases 1 and 2 represent the break-even cases based on the assumptions that both sources would reduce prices substantially in response to competition or that full-rate production would continue for

[3]Acquisition of the V-22 Joint Services Advanced Vertical Lift Aircraft (Osprey) (DOD Office of Inspector Audit Report No. 89-077, June 14, 1989).

[4]Contract Pricing: Dual-Source Contract Prices (GAO/NSIAD-89-181, Sept. 26, 1989).

15 years through the year 2005. Case 3 is also a more optimistic scenario, but losses occur despite assumptions that (1) the two competitors would reduce missile prices and (2) a higher level of production would be realized due to foreign military sales. Case 4 estimates the losses that would occur assuming (1) current production plans are realized and (2) dual sourcing results in limited price reductions. Cases 5 and 6 assess the savings potential if production were completed sooner than planned. Case 6, the least optimistic scenario, also assesses savings if the competitors were to respond to the lower production level by increasing unit prices. The results of our analysis and the range of competitive and sole-source costs that occur in each scenario are summarized in table II.1.

Table II.1: Dual-Source Competition Analysis - Assumptions and Results

Fiscal year 1989 constant dollars in millions

	Assumptions[a]				Results				
					Sole source costs[c]		Dual-source costs	Range of competitive savings or (losses)[d]	
Case	Quantity	Production ends FY	Shift rotate (Percent)	2nd source progress rate[b] (Percent)	1st	2nd			(Percent)
Break-even									
1[e]	16,850	2005	7 3	88	$2,235	$2,245	$2,231	$4	0.2
2[f]	7,651	1996	10 10	88	1,102	1,179	1,074	28	2.5
Competitive Loss									
3[f]	7,651	1996	3–7 3	88	$1,102	$1,179	$1,232–$1,272	($129–$169)	(12–15)
4	6,823	1996	0–3 0	88–90	995	1,074	1,220– 1,254	(225– 259)	(23–26)
5	4,748	1993	0–3 0	90–93	719	799	924– 956	(205– 237)	(29–33)
6	2,869	1991	0 & –5 0	90–93	458	530	647– 667	(189– 209)	(41–46)

[a]General assumptions used in all cases:
- Full-rate production begins in fiscal year 1990.
- Recurring costs based on U.S. and German navies' estimates of average costs during low-rate initial production for sole source and first competitor ($179,000) and second competitor ($234,000).
- Progress rate of sole source and first competitor is 93 percent.
- Nonrecurring costs are $110 million (fiscal year 1989 constant dollars).
- Production is split at 60·40.
- Production rate is 100 percent, which indicates no inefficiencies occur when production is split between the two sources.

[b]Progress rate is estimated based on quantities and costs in the low-rate initial production lot.

[c]Missile procurement costs over the production period when 100 percent of missile requirements are awarded to the first or second competitor

[d]Competitive savings (or losses) are calculated as the difference between the combined costs of the two competitors and the cost of the first competitor acting as the sole source.

[e]Case 1 assumes full-rate production of 1,000 missiles per year

[f]Cases 2 and 3 assume that foreign military sales start in fiscal year 1992 and are 20 percent of combined U.S. and German production quantities.

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