FAA'S EN ROUTE MODERNIZATION PROGRAM IS ON SCHEDULE BUT STEPS CAN BE TAKEN TO REDUCE FUTURE RISKS

Federal Aviation Administration

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Memorandum

U.S. Department of Transportation
Office of the Secretary
of Transportation
Office of Inspector General

Subject: ACTION: FAA's En Route Modernization Program Is On Schedule But Steps Can Be Taken To Reduce Future Risk
AV-2005-066

Date: June 29, 2005

From: David A. Dobbs
Assistant Inspector General
for Aviation and Special Program Audits

Reply to Attn. of: JA-10

To: Federal Aviation Administrator

This report presents the results of our review of the Federal Aviation Administration's (FAA) En Route Automation Modernization (ERAM) program plan. The purpose of ERAM is to replace FAA's existing air traffic control (ATC) system for high-altitude air traffic, which is called Host, at its 20 En Route centers nationwide.

We were directed to conduct this review by the Senate Appropriations Committee, Subcommittee on Transportation, Treasury and General Government.[1] In reviewing ERAM, our objectives were to (1) determine whether FAA's ERAM acquisition plan is executable, (2) identify risks to the executability of the program, and (3) assure that computer security design issues are being addressed. Exhibit A contains our scope and methodology for this review.

While ERAM is currently on schedule and within budget, we are making a series of recommendations to reduce risk with a multi-billion dollar program that will span almost 7 years. FAA officials stated that our report reflects a balanced assessment of the ERAM program and concurred with the findings and recommendations in this report. To enhance executability and reduce risks with complex software development, FAA agreed to defer development of advanced ERAM capabilities and consider fixed-price agreements to help control costs. FAA's written response to this report is contained in its entirety in the Appendix.

[1] Senate Report 108-146, "Making Appropriations for the Departments of Transportation, Treasury and General Government for FY 2004," September 8, 2003.

BACKGROUND

In the past, Congress has been critical of FAA's management of large and complex acquisition programs and of the Agency's inability to deliver projects within cost and schedule estimates. Most notable among these programs was the Advanced Automation System (AAS), which FAA dramatically restructured in 1994 after more than $2 billion was spent. More recently, FAA has encountered significant cost growth and schedule slippage with the Standard Terminal Automation Replacement System (STARS), which has more than doubled in cost and schedule length since 1996.[2] In its reports for fiscal year (FY) 2004 and FY 2005, the Senate Appropriations Subcommittee on Transportation, Treasury and General Government expressed concern about FAA's ability to deliver ERAM on time and within budget.[3]

RESULTS IN BRIEF

Currently, the ERAM program is progressing within cost and schedule parameters. For the last 2 years, the bulk of the work has focused on replacing a backup system to the current Host computer. The new backup entered service in April 2005 at Denver. Now, FAA is focusing on the more complex and time consuming task of developing, testing, and fielding a modern replacement for the *entire* Host Computer System. FAA also planned to pursue a number of advanced capabilities that have yet to be fully defined or priced.

Given the complex software development, testing, and integration required to replace the Host beginning in 2008, we believe FAA can take steps now while the program is on track to reduce risk. We are recommending that FAA maximize the use of fixed-price contracts, defer complex software development, examine ways to reduce life-cycle costs (by relying on fewer computers), and bolster risk assessments of ERAM security. FAA officials stated that our analysis reflects a balanced assessment of the ERAM program and concurred with all of our recommendations.

At an expected cost of $2.1 billion, the ERAM program is one of the most expensive and complex acquisitions in FAA's modernization portfolio. Because FAA expects the Host computer hardware and software to be obsolete within the next 5 years, the Agency has placed a high priority on fielding ERAM at all 20 En Route centers nationwide by FY 2011. The Agency is now more than 2 years

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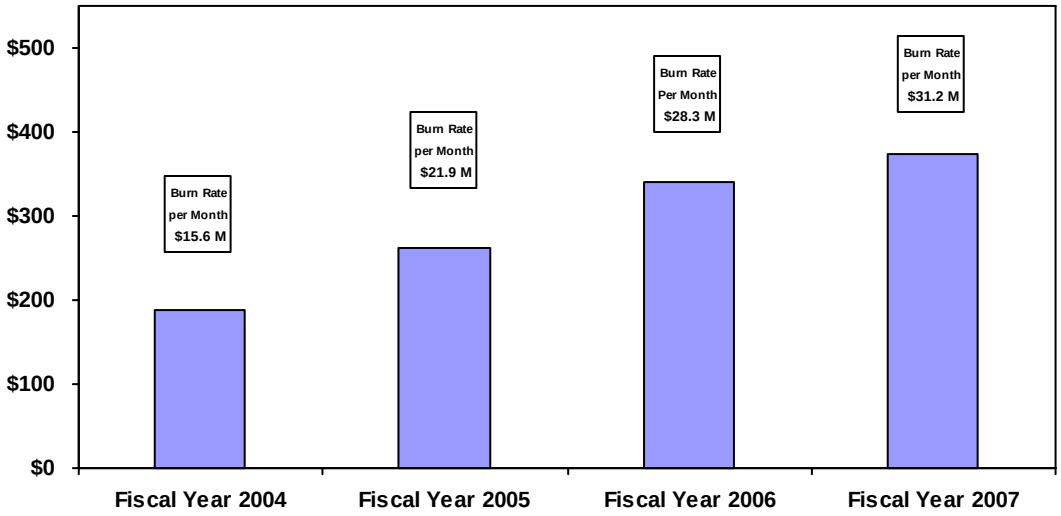
[2] OIG Report Number AV-1998-113, "FAA's Advanced Automation System," April 15, 1998; and OIG Report Number AV-2003-058, "FAA Needs To Reevaluate STARS Costs and Consider Other Alternatives," September 10, 2003. OIG reports can be found on our website: www.oig.dot.gov.

[3] Senate Report 108-342, "Making Appropriations for the Departments of Transportation, Treasury and General Government for FY 2005," September 15, 2004.

into the ERAM effort and spending more than $20 million a month on the program. Figure 1 displays FAA's yearly planned investments for ERAM and the corresponding monthly expenditures, or burn rates, for the next several years. Figure 1 also shows that beginning in FY 2006, FAA will spend almost $30 million a month, or almost $1 million per day, developing ERAM.

Figure 1. FAA's Planned ERAM Expenditure by Fiscal Year and Corresponding Monthly Burn Rate (Dollars in Millions)



Because of ERAM's size and importance, any cost increase or schedule delay will have cash flow implications for the FAA's entire modernization account. Cost increases could have a cascading effect on other modernization projects by limiting new starts and delaying or canceling other projects.

In FY 2009, the Agency plans to begin fielding the first phase of ERAM software (Release #1) with new hardware and modified workstations to the 20 En Route centers. FAA is pursuing ERAM through a predominantly cost-reimbursable contract already valued at about $1.2 billion. Cost-reimbursable contracts place most of the risk with the Government.[4] We note that FAA's problem-plagued AAS and, more recently, STARS development also used cost-reimbursable contract types. In both cases, requirements and cost growth became unmanageable.

[4] FAA uses two primary types of acquisition contracts: cost reimbursable and fixed price. A cost-reimbursable contract places most of the risk with the Government because the contractor is entitled to be reimbursed for all authorized costs, even if the contractor overruns estimates.

To avoid experiencing similar problems with ERAM, FAA can take proactive steps to keep this critical effort on track over the next several years.

FAA Can Reduce Risk With ERAM by Maximizing Fixed-Price Agreements

Our work on a wide range of major acquisitions over the years shows that FAA has been plagued by an inability to manage long-term complex automation projects with cost-reimbursable contracts, particularly when requirements are not well understood. This has led to significant cost growth and unmet expectations with major acquisitions. Although the ERAM contract is already valued at about $1.2 billion, the prices of a number of contract elements have not yet been negotiated. These include, among other things, maintenance, logistic support, and technical refresh. FAA needs to reduce cost risk with the multi-billion dollar ERAM by ensuring that requirements are well-defined and maximizing the use of fixed-priced agreements rather than cost-reimbursable ones for these elements.

Another element of contract management that is critical to ERAM success is establishing performance criteria early and designing and executing tests that demonstrate systems meet these criteria before FAA acceptance. We are concerned about this because in the past FAA has accepted systems that did not meet its performance criteria or met criteria that were inadequately defined and then the systems required corrective action.

For instance, FAA accepted the STARS system at some facilities although tests showed that problems existed.[5] Likewise, although FAA's contractor for the Advanced Technology Oceanic Procedures (ATOP) system completed factory acceptance testing 12 months late and numerous problems were identified, FAA allowed the program to proceed to the next phase, site acceptance. Subsequently, although FAA declared that ATOP was ready for initial operations at Oakland, problems persisted.[6] Resolving these problems has required FAA to twice increase its ATOP contract costs.

Thus far, FAA has awarded $5.8 million in incentives to the ERAM contractor for meeting early schedule and testing milestones for the backup system (called Enhanced Backup Surveillance) and the schedule for several early engineering design specifications for the first major ERAM software release. *We note, however, that the level of complexity to deliver the new backup system (with 145,000 lines of code) is far less than can be expected with much of ERAM Release #1 (with 1.3 million lines) and therefore it may be more difficult to*

[5] OIG Report Number AV-2005-016, "Terminal Modernization: FAA Needs To Address Its Small, Medium, and Large Sites Based on Cost, Time, and Capability," November 23, 2004.

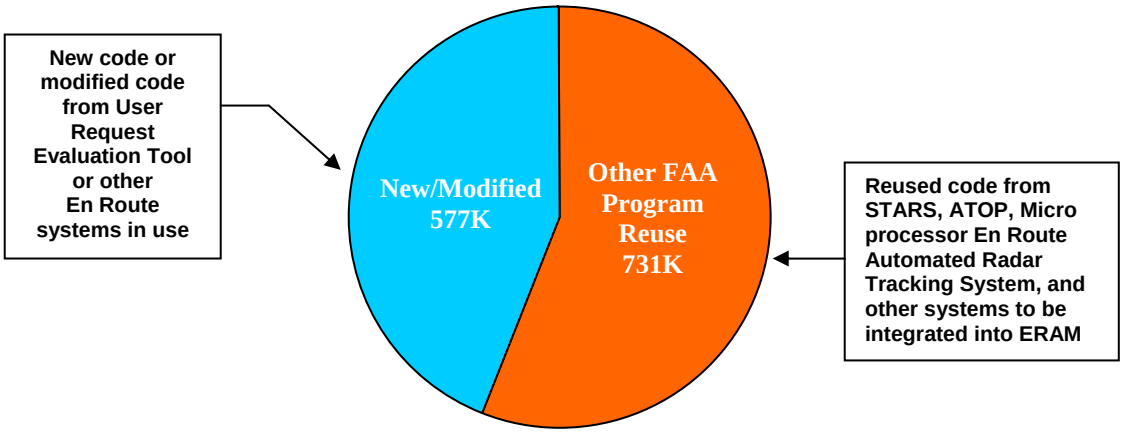
[6] OIG Report Number AV-2004-037, "FAA's Advanced Technologies and Oceanic Procedures," March 31, 2004.

achieve. FAA must ensure that ERAM meets both functional and operational requirements before accepting the system from the contractor. Moreover, the Agency must not award incentive payments unless the system successfully meets FAA performance criteria as demonstrated through testing.

FAA Can Reduce Risk With Complex Software Development by Limiting the Scope of Development

FAA can reduce schedule and technical risk by focusing ERAM development on the first software release (Release #1). Release #1 is well defined, focuses on Host replacement, and will provide some capabilities that do not exist today, such as increased surveillance coverage. We note that in addition to acquiring new hardware, Release #1 work involves developing, integrating, and testing 1.3 million lines of software code to replace the Host beginning in FY 2009. In the past, FAA has allowed complex software development to grow without sufficient consideration being given to cost implications. This was particularly true with STARS, for which the planned scope of software development grew from about 800,000 lines of code to more than 1.2 million, with major ramifications for cost and schedule. While there is still time, the Agency needs to limit program scope to ensure that ERAM software development does not follow suit. Figure 2 depicts the breakout and lineage of the 1.3 million lines of new and reused code that will constitute the software package for ERAM Release #1.

Figure 2. FAA Estimate for ERAM Release #1 Software Breakout of 1.3 Million Lines of Code



In November 2004, the ERAM contractor reported a modest increase in the lines of software, or "code growth," of about 70,000 lines (or 6 percent of the total). FAA believes this can be accommodated in the current baseline. A greater

concern, however, is that FAA plans to embark on future software development (Releases #2 and #3 for new capabilities) that has not been defined or priced. Moreover, although ERAM program officials have allocated about $83 million for development of the later releases, these remain to be negotiated and so their actual cost is undetermined. As a result, FAA faces uncertainty about what capabilities will be included and the affordability of the later software releases.

A combination of factors—code growth, undefined requirements, unspecified capabilities, and unknown costs—strongly argue for FAA to avoid these uncertainties and *focus on its primary ERAM objective of replacing the Host.* After future requirements become better defined, FAA should then pursue developing additional capabilities. This is consistent with the FY 2005 Senate Appropriations Committee Report that calls for FAA to divide ERAM into more manageable pieces.

A Value-Engineering Analysis of ERAM Is Needed To Optimize System Design and Identify Potential Cost Savings

The purpose of value-engineering is to analyze a series of design alternatives; consider appropriate trade-offs among system capabilities, schedules, costs, and other factors; and recommend the most cost-beneficial technical solutions to a given problem.[7] According to FAA, value engineering is to be performed in the early stage of system development. Although ERAM is well underway, FAA can still benefit from applying value-engineering principles to ERAM.

In particular, FAA needs to complete a value-engineering analysis to explore ways to deploy ERAM computers to support its En Route centers. Currently, FAA plans to deploy 20 computer systems to its 20 En Route facilities, which is the Host configuration setup established in the 1960s. However, technological advances may allow FAA to deploy ERAM computers at fewer than the 20 En Route centers and for potentially a lower cost. When FAA analyzed ERAM system design alternatives, it did not consider replacing the 20 Host computers on other than a one-for-one basis. Consequently, FAA does not know whether its one-for-one ERAM computer plan represents the most cost-effective way to deploy the new system. FAA can take steps now to analyze this option, independent of larger questions about facility consolidation, by examining the benefits of centralizing computer systems and how savings could be achieved.

FAA also needs to conduct an analysis of the long-term supportability of the Ada programming language, which Lockheed Martin, the prime contractor, selected for ERAM. Ada use has declined in recent years, and FAA needs to analyze the

[7] FAA policy directs that the following factors be included in a value-engineering analysis: reliability, testability, supportability, survivability, compatibility, and producibility.

impact this decline may have on ERAM. While Ada is not in immediate danger of becoming obsolete, it is clearly a specialty language. Therefore, FAA faces a risk that the number of trained Ada personnel may be limited in the future. In that case, costs to maintain the ERAM software over its life cycle could increase significantly.

Significant Work on Developing Effective Computer Security Plans Needs To Be Done Sooner Rather Than Later

FAA requires that computer security risks associated with acquisition projects be assessed early and that security plans and requirements be developed to ensure that the risks are properly mitigated during the system design phase. FAA developed a preliminary risk assessment for ERAM in 2004. However, the Agency has not yet completed specific steps called for in FAA guidance to produce mitigation plans and recommendations that address identified risks.[8] In particular, the Agency needs to develop mitigation plans for certain ERAM assets.[9]

FAA security planning guidance states that the Agency should develop mitigation plans for these risks. FAA's assessment did not include input from field personnel, which would have significantly bolstered the security assessment. Failure to take this step could result in increased cost to add improved security features later in the ERAM development cycle.

SUMMARY OF RECOMMENDATIONS

ERAM is in the early stages of a multi-billion dollar program that will span almost 7 years and completely replace the automation system for managing high-altitude traffic. FAA faces a number of risks but can take proactive steps to control costs, stay on track, and set expectations that are consistent with congressional direction. We are making a number of recommendations aimed at reducing ERAM risks and increasing the potential to successfully execute the program. The complete list of these recommendations can be found on page 21. We are recommending that FAA:

- Maximize the use of fixed-price agreements and ensure requirements are well defined to reduce cost risk for elements of ERAM, such as training and logistics support, that have not been negotiated. Moreover, FAA must withhold award of performance-related incentives and not accept ERAM from

[8] *FAA Information Systems Security Program Handbook*, Version 3, February 20, 2002, states an asset is defined as any person, material, equipment, or information used by a particular system to perform a function to meet an organization's mission.

[9] FAA policy does not allow public identification of assets considered to be at risk.

the contractor until the contractor demonstrates that the system meets the Government's performance criteria.

- Focus the scope of ERAM software development and maintenance on Release #1 and defer developing additional capabilities until Release #1 passes developmental and factory acceptance testing. This could allow FAA to put to better use projected funding for Releases #2 and #3. After ERAM Release #1 is tested and additional capabilities and costs become better defined, FAA should pursue developing additional capabilities using fixed-price agreements.

- Complete value-engineering analyses (a) within 12 months for life-cycle cost-benefits of fielding ERAM computers at fewer locations than planned, and (b) within 6 months for long-term supportability of the Ada programming language while developing a contingency plan for migrating ERAM from Ada to another software language.

- Engage personnel with En Route operational security experience to participate in developing the next release of the ERAM risk assessment and develop mitigation plans to protect the system assets deemed critical to ERAM operations.

AGENCY COMMENTS AND OFFICE OF INSPECTOR GENERAL RESPONSE

During our review, we periodically met with FAA officials responsible for managing the ERAM program. In January, we met with FAA's Chief Information Officer and the Vice President for En Route Services to discuss ERAM and the steps the Agency could take to reduce cost and schedule risk. At that time, FAA officials agreed that additional steps could be taken to reduce risk with ERAM.

On April 18, 2005, we provided FAA with a draft of our report and held a formal exit conference to discuss our findings, conclusions, and recommendations. FAA officials agreed with our analysis and recommendations. They stated that our draft report reflected a balanced assessment of the ERAM program.

On May 20, 2005, FAA provided us with its formal written response to our draft report, which is contained in its entirety in the Appendix. FAA concurred with all five of our recommendations and provided target dates for implementation. FAA concurred with our recommendation to defer developing additional ERAM capabilities until the first major software release passes factory acceptance, which is planned for the third quarter FY 2007. This will help FAA make better use of the $83 million planned for the later releases, will help manage costs with complex

software development (particularly when requirements are not yet well understood), and is consistent with Congressional direction.

FAA also concurred with our recommendation to rely more on fixed-price agreements for elements that have not yet been negotiated. The Agency states that future ERAM work activities, such as on-site maintenance and contractor logistics support, will be assessed to determine the appropriate contract pricing strategy, including fixed price.

In response to our recommendation that FAA not pay incentives unless ERAM meets performance criteria, the Agency agreed not to award incentives unless the contract criteria are appropriately satisfied. This is an important commitment. ERAM program officials have already withheld an award on one occasion after early testing of the Enhanced Back Up Surveillance (EBUS) revealed some problems. Since EBUS is the least complex part of the program and future work is expected to be more difficult, FAA's willingness to withhold incentive or award payments will be even more important. The Agency's continued commitment to this will help ensure that hardware and software meet FAA's specifications and performance criteria when they are delivered and prevent the Agency from having to fund modifications.

In addition, FAA concurred with our recommendation to conduct a value-engineering analysis to assess the cost and benefits of deploying ERAM computers to fewer locations. FAA stated that some initial work is underway and a cost-benefit study is expected to be complete in the second quarter of FY 2006. This represents an important opportunity to reduce ERAM costs—without jeopardizing redundancy or safety—and can be analyzed independent of larger questions about facility consolidation. It will be important for FAA to fully evaluate this issue and complete this study on time.

Finally, FAA concurred with our recommendation regarding use of personnel with operational security experience in its risk mitigation planning. FAA stated that operational staff will continue to be involved in the validation of all security documents including the ERAM Security Risk Assessment Plan, which will be available in the first quarter of calendar year 2008. This is important given that it is historically more expensive to add security features later than it is to add them during the system design phase.

ACTION REQUIRED

The actions taken and planned by FAA and the timeframes proposed for implementation are reasonable and address the intent of our recommendations. We note that these actions are subject to the follow-up provisions of DOT Order 8000.1C.

We appreciate the courtesies and cooperation of your staff during this review. If you have any questions concerning this report, please call me at (202) 366-0500 or Mr. Matt Hampton, Program Director, at (202) 366-1987.

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cc: FAA Deputy Administrator
FAA Chief of Staff
FAA Chief Operating Officer
Vice President, En Route Systems
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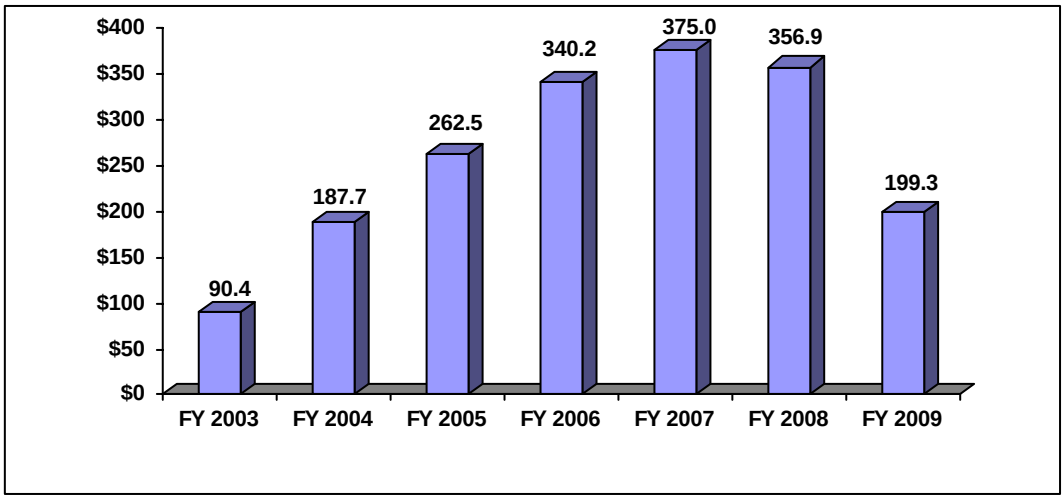
FINDINGS

The purpose of ERAM is to replace FAA's existing ATC system for high-altitude air traffic, which is called Host, at its 20 En Route centers nationwide. At an estimated cost of $2.1 billion, the ERAM program is the most expensive acquisition in FAA's modernization portfolio. Through December 2004, FAA had obligated approximately $283 million for ERAM. By FY 2007, FAA expects it will be spending about $30 million a month, or more than $1 million per day. In FY 2008, FAA plans to begin fielding ERAM. Figure 3 displays FAA's projected expenditures for ERAM through FY 2009.

Figure 3. FAA's Planned ERAM Facilities and Equipment Expenditures, FY 2003 to FY 2009 (Dollars in Millions)



FAA is pursuing ERAM through a predominantly cost-reimbursable contract, which places most of the cost risk with the Government, that is currently valued at about $1.2 billion. To reduce technical risk, FAA is taking a phased approach to ERAM software development. In FY 2009, the Agency plans to begin fielding the first phase of ERAM software with new hardware and modified workstations to its 20 En Route centers. Overall, our work shows that:

- FAA can reduce risk with ERAM by ensuring requirements are well defined and maximizing fixed-price agreements,

- FAA can reduce risk with complex software development by limiting the scope of development,

- A value-engineering analysis of ERAM is needed to optimize system design and identify potential cost savings, and

- Significant work on developing effective computer security plans needs to be done sooner rather than later.

Overview: FAA Estimates ERAM Program Will Cost $2.1 Billion

ERAM is a complex effort to replace by 2010 the current En Route system, which consists of the more than 30-year-old Host computer software and its backup, as well as more than 800 computer workstations at FAA's 20 En Route centers. (The Host hardware, but not the software, was upgraded to address Year 2000 computer issues in the late 1990s.) In addition to replacing Host, FAA expects ERAM to enhance the flow of air traffic by allowing for more flexible routing of aircraft. Overall, FAA estimates that designing, acquiring, and deploying ERAM will cost $2.1 billion.

FAA has designated ERAM as one of the Agency's highest priority efforts because replacing the Host before it becomes obsolete and unsustainable is critical to maintaining safe, orderly, and efficient ATC operations. Host computers function as the central nervous system of the ATC environment. These computers process and integrate complex flight plan information and radar data to provide air traffic controllers with aircraft identification and position information to control air traffic 24 hours a day, 365 days a year. According to FAA, the Host, both its computer hardware and software, will reach the end of its useful life in the next 5 years (by 2010) and is increasingly difficult to maintain. FAA intends to replace the Host backup beginning in 2005.

Between 1998 and 2003, FAA conducted a significant amount of research and analysis to justify moving forward with the ERAM program. This analysis included the 2-year Eunomia project, which examined engineering approaches for replacing the Host. Subsequently, FAA's Investment Analysis Division conducted an investment analysis in 2001 and a follow-up analysis in 2002. The two analyses concluded that FAA would spend about $1 billion more over the life cycle of the system to try to sustain Host beyond 2010 than the Agency could expect to spend by moving forward with ERAM. In addition, the Mitre Corporation conducted a study that concluded that modernizing Host was a necessity to resolve hardware supportability and enhancement limitations.

To develop and field ERAM, FAA formally awarded Lockheed Martin a sole-source contract in February 2001. FAA's rationale justifying its sole-source

decision was that Lockheed Martin was the only contractor with the necessary expertise. However, Raytheon successfully challenged the contract award with FAA's Office of Dispute Resolution for Acquisition and the General Services Administration Board of Contract Appeals. In March 2002, FAA issued a competitive procurement solicitation for ERAM. Raytheon protested the revised solicitation on the basis that it still favored Lockheed Martin. FAA facilitated a compromise making Lockheed Martin the prime contractor and Raytheon a sub-contractor. This agreement cleared the way for the awarding of the ERAM prime contract to Lockheed Martin in December 2002.

ERAM Program Is Composed of Several Interrelated Elements

The ERAM effort is a composite of several interrelated elements. These include (1) the Enhanced Back Up Surveillance (EBUS) system to back up the Host until it is replaced by ERAM in 2009; (2) the En Route Information Display System, which provides electronically accessible aeronautical and controller operational information to the air traffic controllers; (3) ERAM Release #1, software that will begin fielding in 2009 to replace the Host and add certain capabilities; and (4) the Display System Replacement to provide modified controller workstations designed to work with Release #1. (A diagram of FAA's plan to transition from the Host to the ERAM architecture is included in Exhibit B.)

The major components of ERAM are:

- **The Enhanced Back Up Surveillance System** has replaced the existing Direct Access Radar Channel (DARC) as the backup to the Host computer as of April 2005.[10] EBUS is the least complex part of the ERAM program. EBUS is based on an existing FAA system called MicroEARTS that is deployed in Alaska, Hawaii, Puerto Rico, and Guam. In 2009, when ERAM begins replacing Host, EBUS will continue as the En Route backup system. FAA plans to remove EBUS when a second ERAM system (ERAM B) becomes operational at each site. ERAM B will provide a fully redundant backup to the primary ERAM system. The Agency estimates hardware and software costs for EBUS to be about $41 million for development, deployment, and testing.

  During this audit, we reviewed an allegation that a more cost-effective alternative to replacing DARC with EBUS would have been to upgrade DARC by adding EBUS-like capabilities. We reviewed the allegation and found that (1) three-fourths of the planned expenditures for EBUS had already occurred, and (2) the cost estimates and work definition to upgrade

[10] EBUS is necessary because the current backup for the Host does not have critical safety features, such as a conflict avoidance warning, mandated by the National Transportation Safety Board.

DARC were vague and had not been validated. FAA officials were clearly aware of this alternative but decided that because EBUS was an improvement to a certified ATC system (i.e., MicroEARTS) already in use at a number of locations, there was less technical risk in EBUS than in upgrading DARC.

- **The En Route Information Display System** provides controllers with electronically accessible aeronautical and operational information that was previously paper-based. FAA currently has three prototypes of this system deployed for testing with the Host computer, and deployment is scheduled to begin in the second quarter of FY 2006 and to complete by the second quarter of FY 2007. FAA estimates the total cost at $62 million. FAA expects this system, which will provide information electronically, to reduce controller workload by improving access to operational information.

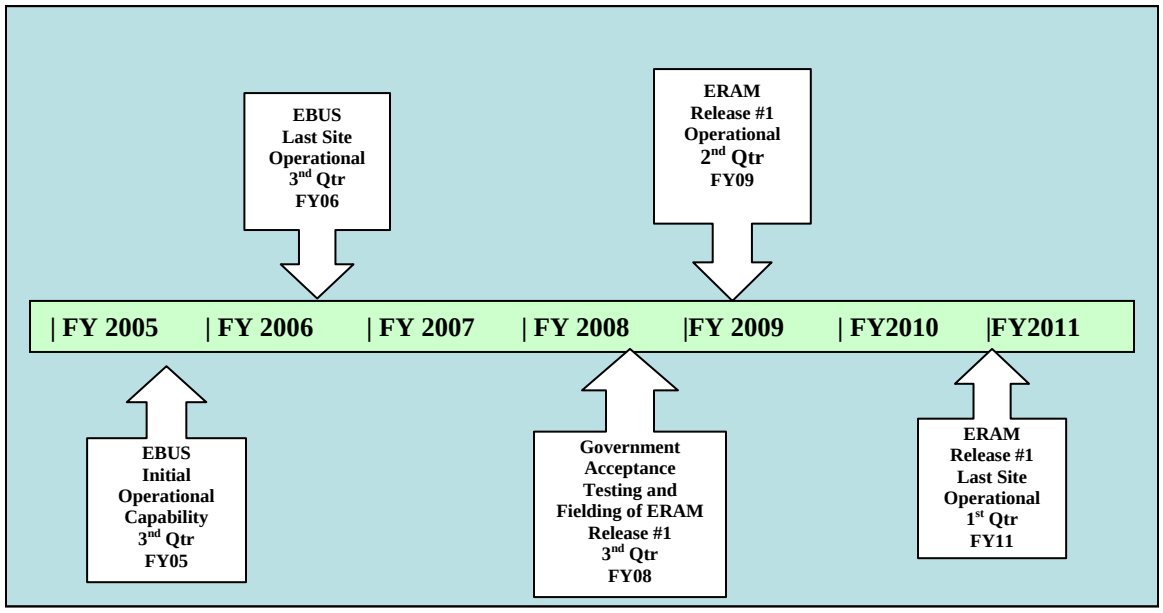
- **The ERAM Software Release #1** will consist of developing the initial ERAM software and upgrading computer workstations, with fielding of new computer hardware to the 20 En Route centers beginning in 2009. This is the most challenging and complex element of ERAM, with development (including workstations) estimated to cost approximately $797 million and deployment approximately $317 million. Release #1 will provide direct one-for-one hardware replacement of the existing Host Computer Systems and will provide some enhancements to existing Host capabilities. As part of Release #1, decision support systems such as the User Request Evaluation Tool (an automated strategic planning and decision-making support system for controllers) will be integrated with ERAM.

- **The Display System Replacement** is needed because computer processors within the Host computer workstations that display radar data to controllers are approaching the end of their useful life.[11] Display System Replacement includes the technical refresh of hardware and new software for the Radar Position Display to enable improvements in airspace capacity, efficiency, and safety. This technical refresh will provide the 800 existing computer workstations with modern hardware and software designed to work specifically with the ERAM Release #1 software and ERAM hardware. FAA recently completed price negotiations with the ERAM prime contractor for the workstations. The Agency expects the final cost will be about $205 million.

[11] Display System Replacement is the last remaining system with linkage directly traceable to AAS.

Figure 4 illustrates key ERAM schedule milestones for EBUS and ERAM Release #1. (The modified Display System Replacement workstations will be fielded with Release #1.)

Figure 4. ERAM Major Schedule Milestones



FAA Can Reduce Risk With ERAM by Maximizing Fixed-Price Agreements

One of the largest cost risks in the ERAM program is FAA's ability to control the cost of the prime contract. FAA is pursuing ERAM through a predominantly long-term cost-reimbursable contract that places most of the risk with the Government because the contractor is entitled to be reimbursed for all authorized costs, even if the contractor overruns estimates. (In contrast, the use of fixed-price contracting could reduce the cost and risk to the Government because the burden of cost overruns falls on the contractor.) Our work on a wide range of cost-reimbursable contracts for major FAA acquisitions shows FAA's historical inability to manage long-term, complex automation projects, leading to significant cost growth.[12]

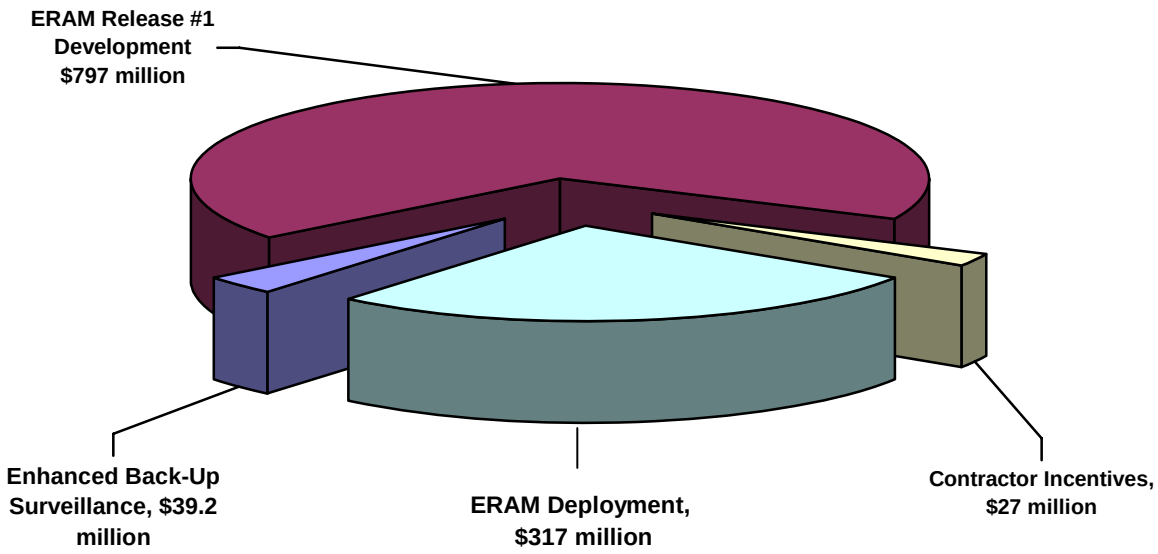
Specifically, we reported in 2002 that FAA has had a very difficult time controlling costs with this type of contract vehicle.[13] Last year, we again reported that FAA's management of cost-reimbursable contracts was deficient, lacked

[12] OIG Report Number AV-2003-045, "Status of FAA's Major Acquisitions," June 27, 2003.
[13] OIG Report Number FI-2002-092, "FAA's Oversight of Cost-Reimbursable Contracts," May 8, 2002.

accountability, and did not adequately protect against waste and abuse.[14] Other audits on cost-reimbursable contracts that we have conducted have found that FAA officials did not (1) obtain audits of billions of dollars in expenditures, (2) ensure reliable Government cost estimates were prepared and used in evaluating contracts, and (3) properly account for billing and expenditures to prevent overpayments.

Currently, the ERAM prime contract with Lockheed for ERAM Release #1 development and deployment and technical refresh of about 800 controller workstations is valued at about $1.2 billion. Figure 5 shows the cost breakdown of the principal elements of the contract.

Figure 5. ERAM Contract Is Currently Valued at About $1.2 Billion



While cost-reimbursable contracts may make sense when an agency faces a program with significant and complex development, FAA has historically had difficulty effectively managing these types of contracts. For instance, FAA's AAS and STARS contracts were both of the cost-reimbursable type, but due to a number of factors, including requirements changes and inadequate Government

[14] OIG testimony Number CC-2004-038 before the Senate Appropriations Subcommittee on Transportation, Treasury and General Government, "Key Issues for FAA's FY 2005 Budget," April 22, 2004.

cost estimates, the scope of the work and cost growth for both became unmanageable.

For ERAM, FAA has established defined requirements for software Release #1 and has implemented controls to manage requirements and cost growth. We note, however, that the scope of other planned ERAM work, such as the development of software Releases #2 and #3 to provide additional capabilities, has not been defined and negotiations have not yet begun. Additionally, there are a number of other contract elements that have not yet been defined or priced, such as hardware, logistics, and maintenance. Until contract negotiations are completed for all program elements, the Agency cannot quantify with any real precision whether the program's budget baseline of $2.1 billion can be achieved.

We believe that by focusing on the development and deployment of Release #1 and avoiding the uncertainty of less well-defined elements in software Releases #2 and #3, FAA will be in a better position to effectively manage the remaining elements of the ERAM cost-reimbursable contract. Moreover, in our opinion, the remaining elements that have not been negotiated (e.g., Releases #2 and #3, training, logistics and maintenance) are candidates for fixed-price agreements.

Table 1 illustrates key ERAM contract elements, with the value of those that have been negotiated. Table 1 also shows the key contract elements that have not yet been negotiated.

Table 1. Key ERAM Contract Elements, Target Price, and Types

Contract Element	Contract Target Price (in Millions)	Contract Type or Candidates
Enhanced Back Up Surveillance	$40.7	Cost Plus Incentive Fee with Schedule Incentive
ERAM Release #1: Design, Develop, Test (includes Radar Position Workstations)	$797.0	Cost Plus Incentive Fee
Release #1 Equipment & Installation	$317.3	Cost Plus Incentive Fee
Release #1 Incentives	$25.2	Fixed When/If Awarded
Release #1 Training	$2.0 + TBD*	Fixed-Price Candidate
General Information Processing Systems	TBD	Fixed-Price Candidate
Task Orders/Technical Directions	$0.4	Labor: Time and Materials, Other Direct Costs: Cost Plus Fixed Fee or Cost-Reimbursable
On-Site Maintenance Support	TBD	Fixed-Price Candidate
Contractor Depot Logistics Support	TBD	Fixed-Price Candidate
Second Level Engineering Support	TBD	Fixed-Price Candidate
System Extensibility and Enhancements (Releases #2 and #3)	TBD	After Requirements and Specification Definition, Fixed-Price Candidate
Optional Anchorage ERAM Capability	TBD	If site is added to ERAM scope, Fixed-Price Candidate
Anchorage Maintenance Support	TBD	Fixed-Price Candidate
Technology Refresh	TBD	Fixed-Price Candidate
Total of Currently Negotiated Elements	**$1,182.6**	

* TBD: To Be Determined

FAA Should Use Incentives To Effectively Control Contractor Performance

To encourage good performance on the ERAM contract, FAA has negotiated a plan to award Lockheed with variable fees for delivering contractual items below contract cost targets. This means Lockheed can earn higher fees by completing work under estimated cost. Conversely, should Lockheed exceed targeted cost, contract fees diminish. For instance, if the final cost of EBUS is under the target cost of $35.8 million, Lockheed's fee could be as high as $5 million, but should EBUS exceed the target cost, the fee decreases to a low of $2.1 million.

In addition to paying Lockheed a cost-based fee, FAA's contract with Lockheed rewards the contractor with incentives for achieving important schedule milestones on time. For example, if FAA accepts ERAM Release #1 at its Technical Center on schedule in October 2007, Lockheed could receive an incentive payment of up to $4.1 million (see Table 2). Also, FAA has included performance incentives in the ERAM contract to reward the contractor for achieving specified performance criteria by certain dates.[15] In contrast, the Agency can withhold incentive payments from the contractor if criteria are not met.

We are concerned, however, that historically FAA has accepted contractual items that did not meet its performance criteria or met criteria that were inadequately defined and so then required corrective action.

- The STARS system—new controller displays and computers for FAA's terminal facilities—was accepted by FAA even though numerous problems were identified during Government testing. Consequently, after FAA accepted STARS in Syracuse, NY, El Paso, TX, and Portland, OR, the Agency had to deal with serious radar tracker deficiencies that had been previously identified.

- Likewise, the ATOP system—new automated systems for facilities that manage travel over oceans—completed factory acceptance testing 12 months late, and numerous problems were identified. Nevertheless, FAA allowed the program to proceed to the next phase, site acceptance.[16] Subsequently, although FAA declared that ATOP was ready for initial operations at Oakland, CA, problems persisted. This resulted in the Agency adding $11 million to the value of the contract to resolve problems. Subsequently, FAA added another $20 million.

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[15] ERAM performance criteria are defined in FAA's (1) ERAM system specifications, (2) ERAM Statement of Work ("Shalls"), and (3) ERAM Test and Evaluation Master Plan.

[16] OIG Report Number AV-2004-037, "FAA's Advanced Technologies and Oceanic Procedures," March 31, 2004.

After acceptance in both cases, the systems required significant cost and development efforts to fix the problems.

To date, FAA has awarded Lockheed approximately $5.8 million in incentives, the maximum that could be earned so far. Included in this amount, for instance, was an incentive fee for submitting EBUS on time for testing by November 15, 2004. However, FAA (in accordance with the contract) awarded only two-thirds of the fee because of an unacceptable number of problems. According to FAA officials, the EBUS problems were corrected in December 2004, and FAA authorized payment for the remaining third of the fee.[17]

We note, however, that EBUS (with only 145,000 lines of code) is *far less complex* than the future work remaining on ERAM. Therefore, due to increasing complexity, future incentives may be more difficult to achieve and this may result in lower incentive awards. Table 2 provides a list of the incentives in the ERAM contract.

Table 2. ERAM Contract Incentives and Award Criteria

Incentive	Award Criteria	Amount in Millions	Date
EBUS Schedule Incentive	Award is divided into 3 pieces: (a) successful delivery of EBUS on schedule, (b) passing Tech Center testing, and (c) achieving key site Initial Operating Capability on or before specified date. (Note: First two awards have been paid.)	$1.5	Key Site Initial Operating Capability scheduled for 4/15/05
ERAM Release #1 Design Schedule Incentives	Completion of three design and engineering reviews by specified dates. (Note: FAA awarded full incentive after determining Lockheed had met requirements.)	$4.5	Completed prior to scheduled date of 12/15/04
ERAM Release #1 Software Completion Schedule Incentive	Completion of software development and critical early software integration.	$1.5	3/01/06

[17] We did not verify that Lockheed met FAA's criteria for receiving these awards.

Incentive	Award Criteria	Amount in Millions	Date
System Integration Milestones #1 and #2	An increased "Shall" (a mandatory requirement) pass rate at two checkpoints. The incentive is reduced for late completions and disappears 50 days after the incentive date if not complete.	$1.75	11/01/06 and 3/01/07
Development Test System Test	An increased "Shall" pass rate. The incentive is reduced for late completions and disappears 50 days after the incentive date if not complete.*	$3.45	9/14/07
Tech Center Government Acceptance Schedule	Completion of Government Acceptance no later than 5 days after specified date. A portion of the incentive will be held back pending successful resolution of identified deficiencies before a specified date. Failure to complete by the date results in loss of incentive.	$4.1	10/1/07; successful resolution of identified deficiencies no later than 90 days after specified Government Acceptance Date.
Site Deployment Government Acceptance Schedule	Completion of Government Acceptance no later than 5 days after specified date. A portion of the incentive will be held back pending successful resolution of identified deficiencies before a specified date. Failure to complete by the date results in loss of incentive.	$7.9	Government Acceptance Date specified for each site; successful resolution of identified deficiencies no later than 90 days after specified date.
Initial Operating Capability Schedule	Completion of site Initial Operating Capability no later than 5 days after the date specified in the contract. Failure to complete by the date results in loss of incentive.*	$2.0	Initial Operating Capability dates specified for each site; bonus if all sites reach this status within 45 days of specified dates.

* The Government, at its discretion, may award portions of this incentive even if the contractor does not meet incentive targets.

While the purpose of incentives is to encourage good contractor performance, FAA also can take other approaches to ensure that the Government gets what it is

paying for. For instance, using contractual language to establish controls is important. According to the ERAM contract, Lockheed is responsible for any corrective actions necessary to ensure full specification compliance. The contractor must complete repairs or rework before submission for regression testing.

During Government test activities, the contractor must ensure that all detected problems are promptly reported, corrective action is initiated; resolution is achieved; and status is tracked, reported, and maintained. The contract also states that all high-level problems must be corrected before FAA Technical Center acceptance. If the contractor does not correct the deficiencies, the FAA Contracting Officer has discretion to postpone further work until the problems are corrected. Using this discretion could be especially important before FAA certifies the system for Initial Operational Capability because it reduces the risk of having to make costly modifications later.

In addition, to avoid problems that have affected other modernization efforts, FAA must ensure that the system meets both functional and operational requirements and that the contractor successfully meets all performance criteria. The Agency should withhold performance-related incentives to ensure that ERAM meets the Government's performance criteria as demonstrated through testing. We note that in response to our draft report, the Agency has committed to withholding incentive or award payments to help ensure that hardware and software meet performance requirements.

In summary, to control ERAM costs and reduce risk to the Government, FAA should maximize the use of fixed-price agreements, rather than cost-reimbursable ones, for contract elements that have not yet been negotiated. Taking this step is consistent with FY 2005 congressional direction that encourages FAA to place more reliance on fixed-price contracting with ERAM.

FAA Can Reduce Risk With Complex Software Development by Limiting the Scope of Development

At this stage, FAA has obligated approximately $283 million for ERAM through December 2004. Most of the expenditures to date have been devoted to developing software Release #1, which FAA plans to field in FY 2008. FAA has also been working on EBUS, the enhanced backup system for the Host.

However, EBUS (with 145,000 lines of code) is the least complex element of the ERAM program, accounting for *less than $40 million* (or less than 2 percent) of the $2.1 billion total. It may not be indicative of future progress to view EBUS in FY 2005 as representative of future success for ERAM since the vast majority of

ERAM work and cost focuses on developing Software Release #1 to replace the Host beginning in 2009.

Successfully developing and deploying Software Release #1 is by far the most complex element of the ERAM program. This work involves developing, integrating, and testing 1.3 million lines of software code to replace the Host. Table 3 compares the functionality of the Host to that of ERAM Release #1.

Table 3. Functionality Comparison of Host and ERAM Release #1

Function	Host	ERAM Release #1
Radar Data Processing	X	X
Flight Data Processing	X	X
Safety Functions	X	X
Real-Time Status and Trajectory Data	X	X
Departure to Arrival Route Conversion	X	X
Providing Full International Flight Plan Processing		X*
Full Function Backup w/Safety Alerts		X*
Common User Interface for Primary and Backup (creates seamless transition from primary to backup system)		X*
Increased Surveillance Coverage (increases coverage from 1000 x 1000 nautical miles to 2000 x 2000 nautical miles)		X*
Increase number of surveillance sources (increases from 22 radar sources to ERAM's 64 radar and future satellite-based sources)		X*
Process New Types of Surveillance Data (ERAM will integrate radar and non-radar sources, such as satellite-based navigation data)		X*
Provide Increased Flight Track Accuracy and Decision Support Tools for Controllers		X*
Local Test and Training Capability		X*
Integrated User Request Evaluation Tools		X*
Integrated Weather Data on Controller Display		X*

* New or enhanced functions

Just for Release #1, over 1.3 million lines of computer code need to be developed, integrated, and tested by FY 2008. Specifically, the ERAM contractor has to develop about 577,000 lines of new or modified software code and integrate this

code with about 731,000 lines of reused code from other FAA programs, such as automated controller tools.[18] According to the contractor, about 252,000 lines of new code were written as of December 2004. To be considered complete, however, this code must be tested, first by the contractor and then by FAA. As a point of reference, FAA has spent 8 years developing and testing software for STARS, which includes more than 1.2 million lines of code.

While reusing code from other proven systems helps mitigate risk, FAA officials caution that there is considerable potential for unanticipated problems. This is a concern because the contractor is integrating software code written in different programming languages and relying on three different entities (i.e., Lockheed, CSC, and Raytheon) to develop and integrate the software. FAA officials point out that this places a considerable need for systems integration and engineering skills on both FAA and the contractors.

In November 2004, the ERAM prime contractor reported about 70,000 lines of additional software code will be needed to meet FAA requirements. The need for additional code is the result of problems with, among other things, integrating non-developmental software items, such as a flight tracker. FAA officials believe this growth in code is modest, representing less than 10 percent of the total code, and the cost can be accommodated within the management reserve of the current $2.1 billion baseline. However, further unexpected software growth could force FAA either to adjust the baseline or reduce capabilities.

Planned future software Releases #2 and #3, which are to add additional capabilities, currently have undefined requirements and undetermined costs. FAA needs to avoid these uncertainties and focus on its primary ERAM objective—replacing the Host. After ERAM Release #1, which is expected to cost $680 million to develop and deploy, is proven operationally and future requirements become better defined, FAA should then pursue developing software for new functionality candidates (see Table 4). This is consistent with the Fiscal Year 2005 Senate Appropriations Committee Report that calls for FAA to divide ERAM into more manageable pieces. Table 4 lists "Candidate Functions" being considered for Releases #2 and #3 and describes their potential benefit to the ERAM system. Candidate capabilities include, among other things, tools to better manage the flow of air traffic.

[18] FAA's primary automated controller tool is the User Request Evaluation Tool (URET), which is now being fielded to all 20 En Route centers. URET introduced automated management of flight data and conflict probe which allows controllers to calculate quickly whether a pilot's requested change to an approved flight plan will create a conflict with other approved flight plans.

Table 4. Functionality "Candidates" for ERAM Releases #2 and #3

Candidate Function	Description
Increased Simulation and Scenario Execution Capability	Additional tools to allow live data (e.g., about aircraft and weather) to be combined with generated (simulated) data for the development of worst-case workload training scenarios
Increase Flight Information Capability	Ability to provide additional information to the aircraft concerning altitude and desired routes of flight available to assist in aircraft hand-offs between controllers (less oral communication required)
Constraint and Restriction Processing	Additional controller tools that consider airspace congestion due to weather and/or airspace closure before aircraft rerouting
Special Activities Airspace/Temporary Flight Restrictions Status	Provides the controller real-time planning and scheduling of airspace for military aircraft exercises or other interests
Holding and Delay Information Processing	Provides additional information to the controller, such as how long the aircraft has been in the holding pattern or amount of delay to assign to an aircraft as a result of airspace congestion
Increased Information Exchange With Traffic Flow Management System	Automated data exchange of delay and aircraft flight reroute information between strategic and tactical systems

We believe a modest restructuring of the software effort is warranted for two reasons.

- First, FAA will face technical and programmatic risks in adding many new features to ERAM Release #1 that do not exist in the Host, and the Agency has yet to decide how many additional capabilities it can realistically expect to integrate to Releases #2 and #3. A decision will not be made until mid to late 2005.

- Second, current FAA projections show that inclusion of features to Releases #2 and #3 could be problematic within the $83 million the Agency presently is allotting for these features. For instance, according to ERAM program engineers, this allotment only allows for 70,000 lines of additional code for each release. Furthermore, at least half of this code is being reserved for required maintenance updates, leaving little new code available

for additional features. In our opinion, therefore, trying to add additional features could result in unanticipated software code growth and cost.

These factors argue for focusing the scope of ERAM work on Release #1 and deferring plans for additional ERAM features in Releases #2 and #3. By limiting ERAM's scope to what can be realistically delivered with the first ERAM software release, the Agency can attain a modern hardware and software replacement for Host as well as some new capabilities, such as increased surveillance coverage, within the cost and schedule baseline. FAA can and should pursue additional functions through a separate contract mechanism as they become better defined. This could allow FAA to put the $83 million that was allocated for Releases #2 and #3 to better use. This is also consistent with the FY 2005 Senate Appropriations Committee report that called for FAA to divide ERAM into more manageable pieces.

A Value-Engineering Analysis of ERAM Is Needed To Optimize System Design and Identify Potential Cost Savings

The purpose of value engineering is to analyze a series of design alternatives and consider appropriate trade-offs among system capabilities, schedules, costs, and other factors and recommend the most cost-beneficial technical solutions to a given problem.[19] According to FAA, value engineering is to be performed in the early stage of system development efforts. Although ERAM is well underway, FAA could still benefit from applying value-engineering principles to ERAM.

Beginning in 1998, FAA performed a number of analyses to decide how best to replace the Host computer system. The analyses explored three system design alternatives, but did not consider replacing the 20 Host computers on other than a one-for-one basis. FAA then selected the alternative of replacing each Host computer with an ERAM computer system using a phased approach. Subsequently, FAA selected Lockheed as the ERAM contractor but did not examine the long-term supportability of the Ada software language that Lockheed is using to develop ERAM.

We have identified these decisions—one-for-one computer replacement and Ada—as solutions that should be subject to a value-engineering analysis. Because FAA did not consider other alternatives and other software languages, the Agency cannot know if it has selected the most optimal and cost-effective ERAM system design for the long term (i.e., the estimated 18-plus years the system is expected to be used.) As a result, FAA needs to do these analyses now.

[19] FAA policy directs the following factors to be included in a value-engineering analysis: reliability, testability, supportability, survivability, compatibility, and producibility.

Consider Alternative Ways To Deploy ERAM To Support the 20 En Route Centers

To reduce technical risk, FAA plans to deploy 20 ERAM computer systems to its 20 En Route facilities, the Host configuration setup established in the 1960s. However, technological advances may allow FAA to deploy ERAM computers at fewer than 20 En Route centers while providing equally reliable surveillance, flight plan, and communications services. Furthermore, in recent years, FAA has invested in more reliable and less expensive telecommunications capabilities to connect its centers. Potentially, the Agency could also realize lower ERAM life-cycle costs. Although a value-engineering analysis is not synonymous with a consolidation study, FAA may find that deploying a full ERAM computer system at each En Route facility may not be the most cost-effective configuration to replace the Host.

The number of computer processing sites is one of the main drivers in determining system life-cycle costs. Generally speaking, the more processing sites used, the more computer and telecommunication equipment needs to be acquired. Centralizing computer processing can result in significant savings. For instance, the Office of Management and Budget estimates that by consolidating 22 payroll systems, the Federal Government will save $1.2 billion over the next decade.[20] Likewise, in a March 10, 1997 Department of Defense letter to the (then) General Accounting Office, Defense reported that consolidating 194 of its computer centers into 16 centers reduced cost by approximately $500 million annually. We believe that FAA could also potentially realize savings by centralizing ERAM computer processing and should analyze the opportunities to do so.

Table 5 shows FAA's ERAM life-cycle cost estimates under the current design approach—fielding 20 ERAM computers to the 20 En Route facilities and keeping the systems for 20 years.

[20] Office of Management and Budget News Release 2003-01, "New E-Payroll Program Estimated To Save More Than $1 Billion," January 15, 2003.

Table 5. FAA's ERAM Life-Cycle Cost Estimates and Potential Effects of Fielding ERAM at Fewer Than 20 Centers

ERAM Life-Cycle Category	Lifecycle Cost Estimate ($ in Millions)	Potential Effects of Fielding ERAM at Fewer Than 20 Centers
Program Management	$200	No likely impact
System Engineering, Design, and Coding	$690	Increased costs to rewrite software, and realign surveillance and telecommunication lines
Hardware Design, Development, and Procurement	$380	Lower hardware procurement costs
Test, Evaluation, and Implementation	$433	Lower implementation and higher testing costs
In-Service Management and Maintenance	$1,872	Lower operating costs from maintaining and upgrading fewer systems
Total Cost Estimate	**$3,575**	

A value-engineering analysis would help FAA make an informed decision based on cost-effectiveness over the entire ERAM life cycle. While it is preferable to do this analysis at an earlier stage, it is still not too late to complete this analysis because of the design approach adopted by the ERAM team. The ERAM design team is using an open, modular design approach to develop the software code, which allows a higher level of adaptability to changes. Therefore, FAA has the opportunity to adapt its ERAM hardware acquisition to a more cost-effective approach. FAA is planning to finalize the acquisition of its hardware in FY 2007.

We discussed the potential benefits of performing this value-engineering analysis with FAA officials. They agreed that a value-engineering study could be performed to determine the most cost-effective design alternative because there may be a more cost-effective way to deploy ERAM. FAA officials indicated that the current plan for a one-to-one replacement of systems at all En Route facilities was adopted because it presented a lower technical risk (i.e., it requires fewer hardware and software changes and no realignment of surveillance and communication lines). Considering the magnitude of potential cost effects, FAA should complete, within 12 months, a cost-benefit analysis to determine the most cost-effective alternative for deploying ERAM.

Examine the Long-Term Supportability of the Ada Software Language Used To Develop ERAM

FAA's prime contractor, Lockheed, is writing some new software code for ERAM using the Ada software programming language. Ada is considered technically suitable for developing systems like ERAM that require high integrity. Lockheed used Ada while programming software for FAA's AAS program, which was to have replaced Host during the 1990s. As shown in Table 6, Lockheed's current plan is to have about 50 percent of ERAM code programmed in Ada.

Table 6. Estimated ERAM Lines of Code

	Total Lines of Code Estimated	**Programmed in Ada**	**Percentage of Code in Ada**
Reused Codes	731,573	415,190	57%
New Codes	577,757	217,255	38%
Total	**1,309230**	**632,545**	**49%**

Since the mid-1990s, use of Ada has steadily decreased in the computer industry, which now favors the "C" and "C++" programming languages. As a result, the Department of Defense dropped the mandatory use of Ada in its major acquisition programs. In addition, the National Aeronautics and Space Administration has reduced its use of Ada for developing new systems. A number of schools, such as the University of Virginia, have also stopped offering Ada courses due to a lack of student interest. Consequently, FAA faces a shared risk that the number of personnel trained in Ada may be limited in the future. In that case, costs to maintain the ERAM software over its life cycle could increase significantly. This is an important issue because, on average, software maintenance accounts for about 80 percent of total life-cycle software costs.

Part of FAA's modernization strategy for the National Airspace System is to avoid use of proprietary or specialty software and take advantage of commercial development power. While Ada is not in danger of becoming obsolete, it is clearly in the specialty category. FAA has prior experience with a specialty software language. In fact, one of FAA's justifications for developing ERAM is the difficulties in finding experienced JOVIAL programmers to maintain the Host System. In late 1990s, FAA paid a high premium to make the JOVIAL-based software for the Host computer "Year 2000 Compliant" because of a shortage of JOVIAL programmers. To mitigate a similar risk with Ada, FAA needs to conduct a value-engineering analysis that examines the long-term supportability of

Ada and develop a contingency plan to reduce risk associated with migrating from Ada to another software language.

Significant Work on Developing Effective Computer Security Plans Needs To Be Done Sooner Rather Than Later

The critical importance of FAA's En Route system and the recent emphasis on addressing vulnerabilities to the nation's vital computer infrastructure underscores the need to address computer security in ERAM. FAA requires that computer security risks associated with acquisition projects be assessed early and that security plans and requirements be developed to ensure that the risks are properly mitigated during the system design phase. This is important because it is much less expensive to build good security into the system than it is to add security features later. The computer industry estimates that it costs 10 times more to add a feature to a system after it has been designed than to include the feature at the initial design phase.

Lockheed developed a preliminary risk assessment for ERAM in 2004. The ERAM product team used FAA's assessment methodology and assessed security risks associated with the ERAM preliminary system design. According to FAA officials, mitigation plans are under development based on the preliminary assessment in accordance with FAA guidance. However, the ERAM product team did not involve ATC staff with operational knowledge and experience while developing its preliminary assessment. The ERAM product team should review prior ERAM reports on En Route security management and controls to ensure that these findings are considered in developing risk assessments and security plans for ERAM.

In the preliminary assessment, FAA divided ERAM computer-related resources into components (assets) to assess the risk. The assessment identified those assets that would have a significant impact on overall ERAM operational integrity and availability, and we reported on them in 2004.[21] FAA security policies require mitigation plans be developed to protect these assets. According to FAA officials, mitigation plans are under development and are expected to be completed in early 2008. To improve the ERAM computer security design, FAA needs to continue assessing risk and develop effective mitigation plans by engaging personnel with operational and security experience, including field personnel, to assist in identifying threats posed to ERAM system security.

[21] Specific examples are considered Security Sensitive Information by FAA. OIG report "Security and Controls Over Technical Center Computer Systems," November 5, 2004.

CONCLUSIONS AND RECOMMENDATIONS

ERAM is in the early stages of a program that will span 7 years and completely replace the automation system for managing high-altitude traffic. FAA can take proactive steps to control costs, stay on track, and set expectations for this multi-billion dollar program that are consistent with the congressional direction provided in the FY 2005 Senate Appropriations Committee Conference Report. We recommend that the Federal Aviation Administrator:

1. Maximize the use of fixed-price agreements and ensure requirements are well defined to reduce cost risk for elements of ERAM, such as training and logistics support, that have not been negotiated.

2. Withhold award of performance-related incentives and not accept ERAM from the contractor until the contractor demonstrates the system meets the Government's performance criteria.

3. Focus the scope of ERAM software development and maintenance on Release #1 and defer developing additional capabilities until Release #1 passes developmental/factory acceptance testing. This could allow FAA to put to better use projected funding for Releases #2 and #3. After ERAM Release #1 is tested and additional capabilities and costs become better defined, FAA should pursue developing additional capabilities using fixed-price agreements.

4. Complete value-engineering analyses (a) in 12 months for the life-cycle cost benefits for fielding ERAM computers at fewer locations than planned; and (b) in 6 months for the long-term supportability of the Ada programming language while developing a contingency plan for migrating ERAM from Ada to another software language. Senior FAA and departmental management should be informed of the results as soon as is practical.

5. Engage personnel with En Route operational security experience to participate in developing the next release of the ERAM risk assessment. FAA should also develop mitigation plans to protect the system assets deemed critical to ERAM operations as part of the updated ERAM risk assessment.

EXHIBIT A. OBJECTIVES, SCOPE, AND METHODOLOGY

We conducted this review at the direction of the Senate Appropriations Committee, Subcommittee on Transportation, Treasury, and Independent Agencies. In reviewing ERAM, our objectives were to (1) determine whether FAA's ERAM acquisition plan is executable, (2) identify risks to the executability of the program, and (3) assure that computer security design issues are being addressed. To address our objectives, we first acquired ERAM planning data identifying cost, schedule, technical requirements, and computer security goals of the program. We also acquired historical and other data related to FAA's preliminary work to develop a technical and investment framework for ERAM, as well as a copy of FAA's contract with Lockheed Martin, the ERAM prime contractor.

To determine whether FAA's ERAM plan is executable within the broad scope of the program, we analyzed the cost, schedule, requirements, and technical data. We included in our analysis the results of interviews and briefings from FAA ERAM program office engineers and engineers and cost analysts from Lockheed. These interviews covered various aspects of the program ranging from the contract and the system capabilities of the Host to the proposed capabilities of the new system.

To identify ERAM technical risks, we reviewed each of the major elements of the ERAM program, including the planned interim backup replacement of the Host, EBUS; ERAM Software Release #1; and the Display System Replacement (i.e., Radar Position Work Stations). Additionally, to identify cost risks, we reviewed FAA's ERAM investment analysis, the elements of the ERAM cost-reimbursable contract with Lockheed, and other decision and planning documents to determine whether FAA cost estimates are realistic.

While conducting our review, FAA awarded incentive payments valued at $5.8 million to Lockheed for meeting performance goals. We did not verify that Lockheed did indeed meet FAA's criteria for receiving these awards.

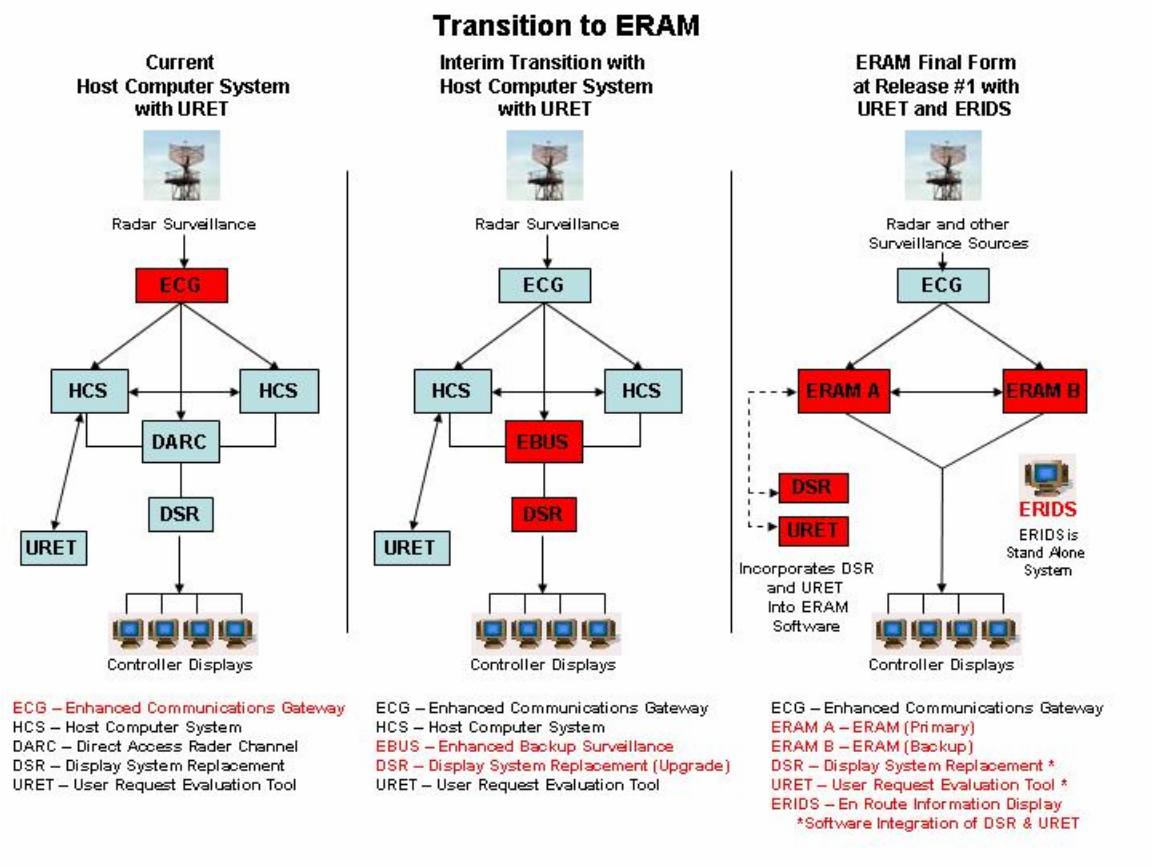
To determine whether FAA has assurance that computer security issues are being addressed, we worked with Office of Inspector General Information Technology Audit Staff who reviewed FAA's and Lockheed's proposed plans for ERAM computer security and Lockheed's Computer Security Risk Assessment. We also reviewed the ERAM high-level security and integration requirements and applicable Government and industry computer security standards and compared these with proposed ERAM security plans. We also considered FAA's plans to integrate ERAM with existing and future systems in the National Airspace System to ensure that ERAM is properly aligned with other Agency programs.

While conducting this review, we interviewed key FAA officials at the Agency's Headquarters in Washington, DC. We also interviewed prime contractor officials at the contractor's primary ERAM location in Rockville, Maryland. Additionally, we visited the FAA Air Route Traffic Control Center for the Washington Region in Leesburg, Virginia, and the FAA Technical Center in Atlantic City, New Jersey, and met with En Route program officials. We also met with FAA personnel responsible for conducting EBUS and ERAM testing and acceptance programs.

Outside of FAA, we met with technical and financial managers from the Defense Contract Audit Agency in Rockville, Maryland. To address a related Hotline Complaint, we interviewed a Hotline complainant and FAA Technical Center officials from the En Route support division concerning FAA's decision to field EBUS in lieu of upgrading the existing backup system.

We performed our survey and verification work from September 2003 through March 2005. We performed our work in accordance with Generally Accepted Government Auditing Standards as prescribed by the Comptroller General of the United States.

EXHIBIT B. FAA'S PLAN TO TRANSITION FROM HOST TO ERAM ARCHITECTURE, FY 2005 TO FY 2009



Subsystem Descriptions

HCS, or Host, is the existing air traffic control computer system for controlling high-altitude air traffic.

DARC is the existing Host Backup system.

ECG is the communications gateway through which data from the surveillance sources (e.g., radar) and telecommunications information are passed.

EBUS replaces DARC as the backup to the Host and will remain until ERAM fielding is complete.

DSR workstations display radar data to controllers.

Exhibit B. FAA's Plan to Transition From Host to ERAM Architecture, FY 2005 To FY 2009

ERAM Release #1 is the initial release of ERAM software. Release #1 will eventually be installed on two sets of identical hardware, referred to as ERAM A and ERAM B.

URET allows controllers to quickly calculate whether a pilot's requested change to an approved flight plan will create a conflict with other approved flight plans.

ERIDS provides electronically accessible aeronautical and controller operational information.

Exhibit B. FAA's Plan to Transition From Host to ERAM Architecture, FY 2005 To FY 2009

U.S. Department of Transportation
Federal Aviation Administration

Memorandum

Subject: **INFORMATION:** Federal Aviation Administration's (FAA) Response to the Draft Report on FAA Needs to Limit the En Route Modernization Program's Scope to Reduce Risk Project Number OIG-03A3017A000, April 18, 2005

Date: MAY 20 2005

From: Assistant Administrator for Financial Services and Chief Financial Officer

Reply to Attn. of:

To: Assistant Inspector General for Aviation Audits

As requested we have reviewed the subject report and concur with your recommendations. Provided per the attachment are specific actions taken or planned for each recommendation, accompanied with general comments.

If you have questions or need further information, please contact Anthony Williams, Budget Policy Division, ABU-100. He can be reached at (202) 267-9000.

For John F. Hennigan
Ramesh K. Punwani

Attachment

APPENDIX. MANAGEMENT COMMENTS

Federal Aviation Administration's (FAA)
Response to the Office of Inspector General's (OIG) Report
FAA Needs to Limit the En Route Modernization (ERAM)
Program's Scope to Reduce Risk

General Comments: The En Route & Oceanic Services, En Route Program Operations (ATO-E) office in its deliberative process prior to contract award, evaluated different pricing strategies in order to obtain the best value to the Government while minimizing overall development and deployment risks. The team determined the best value would be a cost-plus incentive-fee development and deployment pricing strategy. This pricing method provides the FAA the ability to penalize the contractor (i.e., reduce fee) for cost over-runs as well as to share in any costs under-runs. Additionally, the contract contains technical performance and schedule award incentives to ensure the contractor: (a) completes the effort under cost; (b) meets schedule milestones; and (c) satisfies performance criteria in order to maximize profit. To mitigate technical risks and affordability concerns associated with replacing the Host Computer System (HCS), the ERAM Program was segmented as follows:

- **Enhanced Backup Surveillance (EBUS)**
  - Replaces current Direct Access Radar Channel (the backup system for the HCS)
  - Improves availability and reliability of surveillance data service
  - Provides safety alerts and additional weather on backup system
  - Deployment occurs in FY 2005-2006
- **ERAM Release #1**
  - Core capabilities plus some additional capabilities for HCS replacement
  - Deployment occurs in FY 2009-2010

- **En Route Information Display System (ERIDS)**

  - Provides information access system for En Route controllers including Notices to Airmen. This provides an incremental step toward replacing HCS function.

  - Production system based on prototype capability currently operational at 3 sites

  - Deployment occurs in FY 2006-2008

- **ERAM Releases 2 and 3**

  - Software maintenance

  - Future capabilities for further benefits realization

  - Deployment occurs in FY 2009-2011

Recommendation #1: Maximize the use of fixed-price agreements and ensure requirements are well-defined to reduce cost risk for elements of ERAM, such as training and logistics support that have not been negotiated.

Response: Concur. Future ERAM work activities, such as On-Site Maintenance and Contractor Logistics Support, will be assessed to determine the appropriate contract pricing strategy, including fixed-price. The ERAM Program Office has determined that ERIDS National Deployment will be acquired using a fixed-price strategy. The estimated definitization of this contract line item is the first quarter of FY 2006. It has been and will continue to be the FAA's policy to structure and price a contract to provide the overall best-cost value to the Government. While fixed-price contracting does limit the Government's liability, it does not always provide the best value, especially for support services where the cost over-run risk is low.

The ERAM Program Office believes that some of the items listed in Table 1, Key ERAM Cost Elements, Target Price, and Types, are not well suited to firm-fixed-price contracting. There is considerable risk, based on our extensive en route automation experience that the Government may overpay for Second Level Engineering Support and System Extensibility/Enhancements when using firm-fixed pricing for these work activities.

Recommendation #2: Withhold award of performance-related incentives, and not accept ERAM from the contractor, until the contractor demonstrates the system meets the Government's performance criteria.

Response: Concur. The ERAM contract was formulated to include award incentives to motivate the contractor to meet the Government's cost, schedule and performance objectives and to maximize financial compensation. The performance-related incentives describe specific criteria prior to William J. Hughes Technical Center (WJHTC) Government Acceptance. The ERAM Program Office believes that these incentives will keep the contractor focused on performance quality throughout the development cycle and will ultimately result in a better product. The incentive criteria will also allow the Program Office to gauge software quality at various milestones as well as the ability to compare these results to past en route automation programs.

The FAA will not award incentives unless the contract criteria are appropriately satisfied. For example, the FAA withheld one-third payment of EBUS schedule incentive until a high open Problem Trouble Report (PTR) was corrected and verified. The PTR resolution effort took 4 months after which the remaining one-third incentive payment was made. With respect to WJHTC Government Acceptance, the contract contains specific thresholds for PTRs in order to achieve successful ERAM Development System Test Readiness Review and WJHTC Government Acceptance. ERAM system acceptance will not occur until the acceptance criteria specified in the contract is fully satisfied. The estimated completion date is the third quarter of FY 2008.

Recommendation #3: Focus the scope of ERAM software development and maintenance on Release #1 and defer developing additional capabilities until Release #1 passes developmental/factory acceptance testing. After ERAM Release #1 is tested and additional capabilities and costs become better defined, FAA should pursue developing additional capabilities using fixed-price agreements.

Response: Concur. The ERAM program will not begin developing additional capabilities beyond Release #1 until after developmental factory acceptance testing is completed and the requirements are better defined. The ERAM team will support the refinement of future requirements in an effort to effectively and accurately estimate their costs. The Release #1 factory acceptance is currently planned for completion in third quarter of FY 2007. While the FAA understands the Inspector General's reasoning behind suggesting the use of fix-priced agreements, the conditions by which fix-priced agreements should be used should vary with the type of work. As stated in our response to recommendation #1, all un-priced work will be assessed to determine the appropriate contract pricing strategy, including fixed-price. It has been and will continue to be the FAA's policy to structure and price a contract to provide the overall best-cost value to the Government.

Recommendation #4: Complete value engineering analyses for: (a) the life cycle cost-benefits for fielding ERAM computers at fewer locations than planned in 12 months; and (b) the long-term supportability of the Ada programming language in 6 months while developing a contingency plan for migrating ERAM from Ada to another software language. Senior FAA and departmental management should be informed of the results as soon as practical.

Response: Concur. As noted in the report, the ERAM Program's office decision to pursue a one-for-one replacement of existing systems with ERAM was to minimize technical risk. To better understand the potential cost savings, FAA System Engineering has begun initial studies to support a lifecycle benefit-cost analysis of alternate deployment scenarios. The lifecycle benefit-cost analysis is planned for completion in the second quarter of FY 2006. System Engineering will present the analysis results to senior FAA management and make any necessary changes to the Enterprise Architecture. The ERAM Program's technical decision to use the Ada software language for specific software components was based on its well-documented high-integrity, high performance, high security, and safety assurance characteristics. In addition, the use of Ada was judged to provide best value in cases where significant amounts of existing software could be reused and extended to meet ERAM needs. In an effort to better understand the long term lifecycle costs associated with that decision, the ERAM Program has commenced a long-term supportability analysis that will include a contingency plan to migrate from Ada in the future, if a lack of affordable support for the language makes it necessary. This analysis is planned for completion in the 4th quarter of FY 2005.

Recommendation #5: Engage personnel with En Route operational security experience to participate in developing the next release of the ERAM risk assessment. FAA should also develop mitigation plans to protect the system assets deemed critical to ERAM operations as part of the updated ERAM risk assessment.

Response: Concur. Both air traffic controllers and maintainers of the system throughout the requirement validation and design developmental phases reviewed the ERAM security requirements and design. Personnel with En Route operational security experience will continue to be involved in the validation of all security documents. Personnel with En Route operational security experience and the Information System Security Manager who supports the Designated Approving Authority will also review the security designs and documentation. The ERAM Security Risk Assessment Plan will be available in the first quarter of calendar year (CY) 2008.

The ERAM Security Risk Mitigation/Remediation Plan will provide recommendations to mitigate high and medium risk areas. This plan will discuss how all assets are protected by technical, operational, management, physical, and

personnel controls that are incorporated into the ERAM system design. The ERAM Security Risk Mitigation/Remediation Plan will be available in the first quarter of CY 2008.

Appendix. Management Comments