Office of Inspector General

Audit Report

WEAKNESSES IN PROGRAM AND CONTRACT MANAGEMENT CONTRIBUTE TO ERAM DELAYS AND PUT OTHER NEXTGEN INITIATIVES AT RISK

Federal Aviation Administration

Report Number: AV-2012-179
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Memorandum

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

Subject: ACTION: Weaknesses in Program and Contract Management Contribute to ERAM Delays and Put Other NextGen Initiatives at Risk
Federal Aviation Administration
Report No. AV-2012-179

Date: September 13, 2012

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Reply to Attn. of: JA-10, JA-60

To: Acting Federal Aviation Administrator

Since 2002, the Federal Aviation Administration (FAA) has been developing the $2.1 billion En Route Automation Modernization (ERAM) program to replace and significantly enhance the existing hardware and software at facilities that manage high-altitude air traffic. ERAM is a foundational component of FAA's Next Generation Air Transportation System (NextGen) and is critical to meeting FAA's goals for increasing airspace capacity and reducing flight delays. We have testified on several occasions before Congress that delays in implementing ERAM could significantly impact the cost and pace of NextGen[1] implementation. FAA planned to deploy ERAM to the Nation's 20 en route facilities by the end of 2010. However, due to software problems that were identified early on at its two key test sites in Salt Lake City, UT, and Seattle, WA, FAA has delayed ERAM's schedule beyond original completion dates.

[1] OIG Testimony Numbers CC-2010-048, "Challenges in Meeting FAA's Long-Term Goals for the Next Generation Air Transportation System," April 21, 2010, CC-2011-016, "Actions Needed To Meet FAA's Long-Term Goals for NextGen," February 16, 2011, and CC-2011-036, "Progress and Challenges in Developing and Transitioning to the Next Generation Air Transportation System," October 5, 2011. OIG reports and testimonies are available on our Web site: http://www.oig.dot.gov.

Given the importance of ERAM for transforming the National Airspace System (NAS), the Chairman and Ranking Member of the House Committee on Appropriations, Subcommittee on Transportation, Housing, and Urban Development and Related Agencies, requested that we assess FAA's progress with implementing ERAM. Accordingly, our audit objectives were to (1) evaluate FAA's progress in correcting ERAM's persistent software problems; (2) evaluate whether the ERAM contract is designed and administered effectively to manage costs and achieve desired outcomes; and (3) identify the risks that ERAM's delays pose to FAA's plans to implement critical NextGen initiatives.

We conducted this audit in accordance with generally accepted Government auditing standards. Exhibit A details our scope and methodology. Exhibit B lists the entities we visited or contacted.

RESULTS IN BRIEF

FAA's multibillion dollar ERAM program has experienced software problems that have impacted the system's ability to safely manage and separate aircraft. As a result of the delays at the key sites, FAA now projects that ERAM will be almost 4 years behind schedule, with an uncertain final completion date. If problems persist, cost increases could reach in excess of $500 million and interfere with program execution. FAA's problems in advancing ERAM are attributable to a number of fundamental program management weaknesses that have impeded the Agency's ability to effectively implement ERAM and effectively manage other major acquisitions. These weaknesses include (1) setting an unrealistic schedule, (2) allowing ERAM to successfully pass Government Acceptance[2] even though testing at the Agency's Technical Center was limited and could not replicate actual field conditions, (3) ignoring early warning signs of trouble, such as an unexpectedly high number of problem reports, and (4) a lack of attention to identify, communicate, and fix ERAM's problems. This was compounded by a management culture that was slow to fully acknowledge the extent of ERAM's problems or communicate them to senior FAA management.

ERAM's problems are also traceable to weaknesses in its contract, which is not structured or administered to effectively manage costs and achieve desired program outcomes. Due to insufficient acquisition planning, FAA did not fully adopt best practices that would have permitted more effective contract management when designing the ERAM contract structure. For example, FAA structured ERAM as a traditional, large-scale contract with enormous contract

[2] Government acceptance of ERAM by the FAA Technical Center requires meeting specific established criteria. These criteria include successfully completing developmental testing activities per the Statement of Work, listing all problem trouble reports, demonstrating that all contractual requirements are satisfied, and completing both functional and physical configuration audits. After Government Acceptance is reached, FAA assumes all costs, including fixing any additional problems discovered.

tasks that span several years instead of using modular contracting, which would divide the contract into manageable segments for better control. In addition, FAA has still not fully finalized the costs for 16 of 57 contract tasks,[3] yet the Agency authorized the contractor to begin work on them—a practice that gives the contractor little incentive to control costs. Additionally, FAA has awarded the contractor over $150 million in cost incentives despite cost overruns, delays, and software problems. Problems with the ERAM contract were further compounded by weaknesses in FAA's acquisition workforce and poor contract management practices. These include (1) high contracting officer (CO) turnover and heavy reliance on support service contractors, (2) poorly organized and incomplete contract files, and (3) limited reviews of vendor invoices that failed to detect unallowable charges, including nearly $69,000 in fraudulent travel expenses.

ERAM's delays pose significant risks to FAA's plans to implement critical NextGen initiatives because of complex interdependencies between ERAM and other key systems needed to advance NextGen. Continued problems will affect the pace of critical efforts such as Data Communications (DataComm), System Wide Information Management (SWIM), and Automatic Dependent Surveillance - Broadcast (ADS-B). ERAM delays will also impact FAA's ability to develop other NextGen-related software enhancements and other improvements, such as trajectory-based operations[4] and the development and transition to a common automation platform for FAA air traffic facilities. In addition, ERAM's schedule delays and corresponding cost growth have forced FAA to reallocate millions in funds from other capital NextGen programs. Despite the significant program risks and unresolved issues—and that FAA plans to allocate more than $500 million to align and integrate NextGen-critical initiatives with ERAM—FAA has not fully assessed the impact of these delays on other programs' costs and schedules.

We are making a series of recommendations to improve ERAM's contract structure and oversight and reduce the associated risks to future NextGen related programs.

BACKGROUND

ERAM is a key NextGen enabling program for processing high-altitude air traffic[5] flight information across the NAS. It replaces HOST, the legacy en route automation system, which consists of a 40-year-old computer hardware and

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[3] As of January 17, 2012.

[4] Trajectory-based operations focus on more precisely managing aircraft from departure to arrival with the benefits of reduced fuel consumption, lower operating costs, and reduced emissions.

[5] En route airspace is high-altitude traffic typically above 10,000 feet, where aircraft reach their cruising altitudes and fly as direct a route as possible between their departure and destination points.

software system, plus a backup, and more than 800 computer display workstations (see figure 1) at 20 of FAA's Air Route Traffic Control Centers (ARTCCs).[6]

Figure 1. ERAM Air Traffic Controller Workstation

Source: FAA

In 2002, FAA awarded ERAM as a sole source contract to Lockheed Martin. The ERAM contract is a hybrid of multiple contract types, including fixed-price incentive, cost-plus-fixed-fee, cost-plus-incentive-fee, and time-and-materials. However, its software development portion relies primarily on a cost-plus-incentive-fee (CPIF) contract type, which requires the Government to shoulder much of the program's cost risk. The ERAM contract offers several types of fees to motivate the contractor to effectively manage costs, schedule, and performance. These fees include: (1) cost incentive fees for delivering contractual items below pre-defined cost targets, (2) schedule incentive fees for achieving important schedule milestones, and (3) performance incentive fees for meeting specific performance criteria.

Initially, FAA planned to implement both ERAM hardware and software (release 1) beginning in fiscal year 2009 at all centers nationwide and reach operational use by December 2010. Software release 1 was intended to replicate the functionality of the current HOST system and add a few new capabilities. Software releases 2 and 3, which would provide additional capabilities, were to become available to operational sites in September 2009 and September 2010, respectively, concurrent with release 1. FAA plans to develop a series of additional software releases through 2020 to enhance ERAM capabilities and support planned NextGen initiatives.

In June 2005, we reported on the risks facing the ERAM program and made a number of recommendations, including that FAA maximize the use of fixed price agreements, withhold incentive payments to the contractor until it met Government criteria, and defer work on software development for future capabilities that had yet to be defined or priced.[7]

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[6] ARTCCs, also referred to as en route centers or centers, control high-altitude air traffic nationwide.

[7] OIG Report Number AV-2005-066, "FAA's En Route Modernization Program Is On Schedule but Steps Can Be Taken to Reduce Future Risks," June 29, 2005.

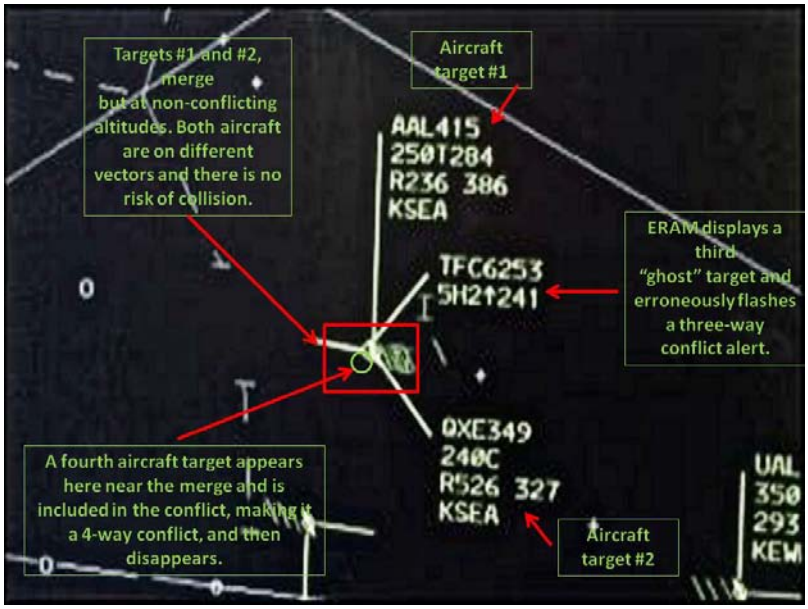
FAA HAS NOT FULLY RESOLVED CRITICAL ERAM SOFTWARE ISSUES, CAUSING SIGNIFICANT COST OVERRUNS AND DELAYS AND EXPOSING FUNDAMENTAL PROGRAM MANAGEMENT WEAKNESSES

FAA has yet to fully resolve critical software-related issues that impact ERAM's ability to separate and control aircraft. These continuing problems raise concerns about elements of ERAM's design, as well as the system's backup architecture. As a result, ERAM's nationwide implementation has been significantly delayed, resulting in increased costs. FAA now projects that ERAM will be almost 4 years behind schedule, with an uncertain final completion date. If problems persist, cost increases could reach in excess of $500 million. ERAM's problems are directly traceable to a number of underlying program management deficiencies that impede the Agency's ability to implement ERAM and effectively manage other large-scale acquisitions.

Software Problems With ERAM's Core Capability for Managing Traffic Persist

FAA has been using ERAM to continuously control live traffic at Salt Lake City since October 2010 and at Seattle since December 2010. More recently, Denver, Minneapolis, and Albuquerque centers have also begun using ERAM on a full-time basis. However, FAA has continued to identify significant software problems related to functions that are critical to safely separating and managing air traffic. These include errors that tag flight data to the wrong aircraft, incorrect display of flight information to controllers, and problems with aircraft hand-offs between controllers within a facility and between facilities with adjacent airspace. (See figure 2 for a data error example.)

Figure 2. Example of Incorrect Data on ERAM Controller Screen



Source: FAA (textboxes added by OIG)

Event Description: Two aircraft (tagged as **AAL415** & **QXE349**) merge on the screen at different altitudes and vectors. ERAM then produces a "ghost" target **TFC6253** (a false target). This series of non-conflicting events activates a conflict alert for the controller's attention.

Controller's Concern: There is no reason for ERAM to cause an active conflict alert in any one of these scenarios; consequently, this is a significant distraction to the controller.

Because of these problems, controllers at these two key test sites have been forced to rely on a large number of workarounds,[8] temporary fixes that increase their workload and distract their attention away from controlling traffic. For example, if a data block—aircraft and flight plan information displayed to the controller—is paired to the wrong aircraft, a controller must manually re-enter the flight information for one or more aircraft. This cumbersome process increases the risk for data entry errors and, more importantly, takes the controller's focus away from the primary task of managing and separating aircraft. FAA continues to work on these problems and to limit the number of workarounds.

To address these persistent problems with ERAM, FAA developed a series of corrective action plans, revised schedules, and milestones. The Agency also responded with numerous ERAM software builds to correct the problems and spent an average of nearly $16 million per month from January through June 2011 on these efforts. However, the total cost to complete ERAM remains uncertain. Table 1 chronicles ERAM's progress and setbacks since March 2010.

[8] A workaround is a method or series of steps to correct or manage an ERAM software deficiency or faulty capability. It must be executed each time the problem occurs.

Table 1. Chronology of Significant ERAM Events, March 2010–January 2012

Timeframe	Significant ERAM events
Mar–Dec 2010	• FAA places moratorium on new ERAM software builds to focus on fixing the numerous problems affecting air traffic management and system stability. • ERAM achieves continuous operations at Salt Lake City, beginning on October 19. • FAA achieves continuous operations at key test sites and conducts preliminary Independent Operational Assessment (IOA), a prerequisite for continuing deployment at additional sites. • Between October and December, Salt Lake City and Seattle both experience critical ERAM system failures caused by software problems. Seattle falls back to the legacy system, pending an emergency ERAM software build.
Jan–Aug 2011	• FAA's IOA team finds that ERAM is "not operationally ready for national deployment." The team determines that there are 17 hazards that must be fixed or mitigated before ERAM is ready for deployment to additional sites. • Despite the team's warning, FAA declares prematurely that ERAM is ready for further deployment. FAA develops an action plan to fix or mitigate the identified hazards and complete initial operations at three new sites. However, FAA again postpones using ERAM at the new sites—even on a limited basis—due to delays delivering new software. • FAA and the National Air Traffic Controllers Association (NATCA) establish working groups to improve ERAM problem analysis, prioritization, and implementation. The workgroups call for a halt to FAA's plans to deploy ERAM at new sites due to concerns about ERAM's ability to maintain key test site operations. FAA cancels plans to begin operations at three new sites planned for April 2011. • NATCA and FAA program officials agree on a definition of ERAM's "core functionality" and develop a plan to address 117 issues before restarting limited operations and deploying at new sites. FAA and Lockheed Martin develop and begin implementing software builds to address the problems.
Sept–Nov 2011	• FAA revises the implementation schedule again and plans to begin operational use of ERAM at 6 new sites in December 2011—with a total of 11 planned for FY12. • On November 21, Salt Lake City suffers another critical software failure and falls back to the legacy backup system for several hours. FAA suspends an ongoing IOA, and transitions key test sites to an earlier ERAM software version, pending fixes. • Testing of an emergency software build reveals a previously undiscovered, critical problem, present in the software for at least 1 year. This problem could have caused critical failures in one or more new sites preparing to use ERAM.
Dec 2011 – Jan 2012	• On December 22, FAA completes IOA re-assessment, which allowed Denver, Albuquerque, and Minneapolis to begin using ERAM on a limited basis in late December. The additional three sites planned for December were rescheduled for January 2012.

Source: OIG analysis

Between December 2011 and April 2012, after continuing to fix ongoing software problems, ERAM began limited operations[9] at seven additional sites—Denver, Minneapolis, Albuquerque, Chicago, Oakland, Los Angeles, and Houston. FAA program officials decided that the Agency should "pause" to assess the new sites' progress toward continuous operations for the remainder of fiscal year 2012 before continuing deployment to other sites. This has proven to be a prudent decision in that Seattle experienced two new critical system failures in late March and early April 2012. FAA has now shifted the deployment dates for the four remaining fiscal year 2012 sites—New York, Indianapolis, Kansas City, and Miami—to fiscal year 2013.

ERAM's persistent problems raise questions about whether elements of the system's overall design—particularly functions related to tracking aircraft and displaying information to controllers—could be contributing to these problems. Our work on FAA's Standard Terminal Automation Replacement System (STARS),[10] which uses the same aircraft tracking software (tracker)[11] as ERAM, found similar problems, such as data tags detaching and not connecting with the correct aircraft. After we discussed these similarities with Lockheed Martin and FAA program officials, the Agency tasked MITRE[12] to examine the current ERAM tracker's performance parameters and accuracy. MITRE's interim report has identified additional potential issues and plans to complete its initial assessment in the summer of 2012. Lockheed Martin reports that it has made nine changes to the tracker. These tracker issues could impact FAA's ability to integrate new satellite-based surveillance systems, such as ADS-B, with radar information for use by controllers. The performance of the ERAM tracker—and its integration with satellite based systems—is an important watch item for NextGen.

ERAM's repeated software failures and the recent discovery of a previously unidentified serious hidden software defect—one that could have caused a critical failure at one or more of the new operational sites—calls into question FAA's plans to remove the legacy backup system. ERAM's primary and backup channels[13] suffered multiple failures during live operations—such as both channels going down simultaneously and one channel taking down the other. Each

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[9] Limited operations are the initial operational use of ERAM to control live air traffic. It begins with 4- to 8-hour runs during weekday mid-shifts, progresses to 48-hour runs on weekends, and then transitions to weekdays and longer periods. Limited operations end after continuous operations are achieved, with no intent to fall back to legacy systems.

[10] FAA and Department of Defense air traffic controllers use STARS to control terminal traffic. The terminal environment controls aircraft taxiing, including departures and arrivals, up to 50 miles within an airport's vicinity.

[11] The tracker is a complex software algorithm that uses surveillance sources, such as radar or ADS-B, to display information on an air traffic automation system display.

[12] MITRE Corporation manages a Federally Funded Research and Development Center (FFRDC) for the FAA known as the Center for Advanced Aviation System Development (CAASD). CAASD is a unique organization that assists FAA with scientific research and analysis.

[13] The ERAM system operates with two identical and interlinked data paths, or channels, for processing and distributing flight and radar data used by the air traffic controllers. Each path provides full functionality. However, one is designated as primary for facilities' general use, and the other is used as a backup for the primary.

failure resulted in a brief loss of air traffic control. While transitioning from the legacy system to ERAM, the Agency relied on a separate, dissimilar hardware and software system, known as the Enhanced Backup Surveillance (EBUS) system. However, once ERAM is fully operational, FAA planned to remove EBUS, thereby leaving ERAM with a single backup channel. Given ERAM's history of repeated system failures, many controllers, technical operations personnel, and testing personnel have argued that FAA should modify and retain EBUS as an additional backup mechanism, at least until ERAM is more mature. FAA's December 2011 Independent Operational Assessment (IOA)[14] report also highlighted the need for a dissimilar backup system. In response, FAA's ERAM program office assessed requirements, made changes, and has deployed modifications needed to retain EBUS after the legacy system is decommissioned. FAA has stated that it is continuing to assess long-term alternatives for a dissimilar backup system.

ERAM's Problems Have Caused Schedule Delays and Cost Overruns

ERAM's continued problems and FAA's difficulty in resolving them have resulted in significant schedule delays and cost overruns. In June 2011, FAA senior management decided to continue the program and rebaselined ERAM, estimating that the cost to complete the program would increase by an additional $330 million. FAA is now planning to declare the system fully functional and operationally ready at the national level in 2014—a slip of almost 4 years (44 months) from the original schedule. However, FAA's plans remain fluid and continue to change.

Since rebaselining ERAM, FAA continued to identify significant software-related problems. Our work and MITRE's ERAM assessment suggest that if delays continue, cost growth could be in excess of $500 million with completion delayed until 2016. ERAM will continue to face substantial risk for cost growth, schedule delays, and performance shortfalls as FAA fully deploys the system, especially to more complex sites. In particular, Initial Operating Capability (IOC) only marks the milestone where controllers begin to use the system on a limited basis to manage traffic; therefore, significant risk and work still lie ahead before full deployment. The ERAM Director of Program Operations stated that significant additional software problems are likely as more sites begin to use the system. In its report, MITRE also cautioned that additional time and resources could be required when implementation moves to larger sites.

For example, ERAM's performance at sites such as those in Chicago and Los Angeles will be a driving factor for potential future delays and cost overruns.

[14] FAA Office of Independent Safety Assessment conducted an IOA for the ERAM system, which was conducted at Salt Lake City Air Route Traffic Control Center (ARTCC) (ZLC) and Seattle ARTCC (ZSE) and issued its final report on March 18, 2011.

These facilities manage airspace that is divided into smaller and more heavily congested sectors, which could exacerbate existing problems and make workarounds more complicated.

FAA's decision to continue concurrent software development and introduce new capabilities, while attempting to fix problems, has further compounded difficulties in implementing ERAM. In 2005, we proposed that FAA focus on its primary objective of providing a replacement for the HOST legacy system, and wait to pursue additional capabilities in future developments.[15] However, FAA and Lockheed Martin have continued to add new capabilities—such as those to support more advanced NextGen requirements—while simultaneously fixing core functionality issues. This overlapping software development and deployment increases the likelihood of introducing problems into subsequent software builds or of re-introducing previous problems. To mitigate these problems, FAA is implementing plans to more thoroughly evaluate software releases before deploying them.

ERAM's delays will also result in sustaining the HOST legacy system longer than planned, forcing FAA to incur additional costs to maintain two different automation systems (HOST and ERAM). HOST was originally envisioned to be decommissioned in December 2010, but FAA will need to maintain the system until at least 2014. According to FAA, costs for maintaining the HOST system averaged $1.4 million per month during the period of December 2010 to May 2011. In addition, as a result of retirements and normal personnel turnover, many facilities face challenges in staffing maintenance technicians for HOST. As a result, FAA extended legacy system training at the FAA Training Academy beyond its original plan. FAA Training Academy officials stated that experienced maintenance technicians are retiring and they are having difficulty finding qualified instructors. Recent progress at the two key sites, Salt Lake City and Seattle, has allowed FAA to decommission both legacy systems at these sites.

ERAM's Problems Are Attributable to Fundamental Breakdowns in Program Management

FAA's cost, schedule, and performance problems with ERAM are attributable to breakdowns in its program management, execution, and oversight. Up until December 2009, and well after Government Acceptance, FAA reported that ERAM was on track, or ahead of schedule, even though there were already serious problems with the program. Our work shows that FAA did not establish effective controls or useful milestones during ERAM's planning and deployment stages to address problems and ignored early warning signs such as a higher than expected incidence of problem reports. As a result, when significant problems occurred,

[15] OIG Report Number AV-2005-066, "FAA's En Route Modernization Program Is On Schedule But Steps Can Be Taken To Reduce Future Risks," June 29, 2005.

FAA was not well positioned to address them. The ERAM experience represents important lessons learned for FAA as it develops and implements even more complex software intensive systems for NextGen that are expected to fundamentally change the way air traffic is managed. For example:

- **FAA underestimated the complexity of implementing ERAM and ignored early warning signs of trouble.** FAA and its contractor significantly underestimated the difficulty in fielding ERAM and were overly optimistic that they could fully field all 20 sites in just over 1 year. Specifically, FAA and Lockheed Martin falsely assumed that fielding ERAM as a one-to-one replacement for HOST—a system that has evolved over the 40 years of its operational life—would be manageable. FAA also dismissed or ignored early warning signs of trouble during site deployment, working instead towards the goal of reaching milestones early. For example, ERAM achieved the Site Acceptance milestone at the Salt Lake City site in April 2008—8 months early, but with a higher than expected number of problem reports. As a result, FAA has stopped implementing monthly software builds twice in order to fix specific problems with the system, which has delayed implementation.

- **FAA did not adequately test ERAM at the Technical Center prior to accepting the system for the Government and releasing the software to the key test sites.** FAA allowed ERAM to successfully pass Government Acceptance even though testing at the Agency's Technical Center was limited and did not replicate actual field conditions. Government Acceptance is critically important because it is the point where the Government assumes full responsibility for paying for and fixing any new problems that are discovered. FAA management did not account for testing limitations at the Technical Center, and as a result, the Agency lacked a full understanding of the maturity and stability of the software after testing.[16] Further, FAA did not sufficiently test the tracker, which could be a contributing factor to ERAM's problems to date. Also, robust testing with live traffic and active controllers at one or more of FAA's facilities was not a prerequisite for Government Acceptance. As a result, the software left the Technical Center and was released to the key test sites with a significant, and undetermined, series of defects. FAA recognizes this problem, and among other things, is planning to improve the quality of testing by introducing a new test model and adjusting times to implement the test process.

- **FAA did not set realistic expectations regarding what would be required to implement ERAM.** The ERAM program office did not clearly communicate that the initial software would be relatively immature and was

[16] For example, FAA tested and simulated the basic ERAM operating software but did not fully test the interface requirements for linking and processing radars, different automation platforms, or multiple airspace sectors.

not ready for operational use, and that site personnel and controllers would be expected to further test, identify problems, and evaluate fixes to the software. FAA's failure to set realistic expectations for facility management and staff at the key sites negatively impacted user confidence in the system. Further, the use of operational runs at key test sites for additional problem identification and resolution was extremely labor intensive and adversely affected the site's confidence in the maturity, stability, and operational suitability of the system. Moreover, FAA failed to convey the fact that ERAM would differ significantly in both appearance and function from HOST. As a result, controllers expected a system that would look and act like the legacy system, rather than a completely new system with a wide range of new capabilities. This failure to set clear expectations contributed to the problems the key test sites experienced when operational testing began, and also contributed to an unexpectedly high number of software problem trouble reports.

- **FAA used ineffective milestones for measuring progress with ERAM.** FAA's key milestones for measuring progress with ERAM, such as Initial Operating Capability (IOC), do not accurately portray the current progress of the program. For example, FAA identified IOC at the two key sites as an important program milestone and the pivot point for further deployment. However, this benchmark has not proven an effective indicator of progress because the key sites experienced multiple failures after the milestone was achieved. IOC meant that the system was only ready for very limited control of live air traffic. Moreover, after achieving this status, the key sites began a measured transition from limited operations (running for a period of 4–48 hours during off-peak times), to extended operations (running for 48 hours for 1 to 2 weeks, 24 hours a day), and eventually to continuous operations. Yet, the success of this transition was site specific, as it depended on individual site requirements and the resolution of site-specific software problems before the system became fully operational. Moreover, the process of successfully achieving continuous operations is also site specific and requires a significant amount of time to achieve. Therefore, the use of IOC for tracking progress with ERAM gave FAA decision makers a false sense of confidence in the maturity of the system when in reality, much work and time still remained at the key sites and beyond.

  For example, on April 14, 2012, FAA declared IOC at Houston center on the first ERAM software release that enabled controllers to use ADS-B. However, software problems identified in testing have prevented the use of ERAM during daytime and peak operation periods and will likely result in delays in using ERAM for full-time operations. The problems may also delay the opportunity for more robust testing of ADS-B with ERAM. Houston center is currently using the legacy system to control air traffic that are ADS-B equipped and operate in the Gulf of Mexico servicing oil platforms.

FAA's use of vague, confusing, and ineffective milestones could become a larger concern as FAA begins tracking the progress and implementation of multiple interdependent programs. These include SWIM and DataComm, which are necessary to achieve NextGen-related capabilities.

- **FAA's Acquisition Management System (AMS) does not adequately establish criteria for Government Acceptance.** FAA's AMS does not provide specific guidance to assist program managers in accepting large software-intensive programs such as ERAM from a contractor. Our discussions with FAA officials found that Government Acceptance is defined not by AMS but rather by the individual program manager for each acquisition and its corresponding contract. As a result, one FAA program's definition of Government Acceptance can likely be inconsistent with another program's definition. In the case of ERAM, Government Acceptance was declared before the system was adequately tested with other air traffic systems and in an operational environment. As a result, FAA had little understanding of what it would take to deploy this complex new system.

- **Problems with FAA's management culture contributed to ERAM delays.** ERAM's problems indicate a management culture that did not fully acknowledge the extent of ERAM's problems or effectively communicate problems to senior FAA management. Our discussions with FAA officials and staff at air traffic facilities revealed that staff and managers routinely did not share bad news about ERAM with FAA senior management and that senior program officials at the headquarters level actively withheld and suppressed bad news from being reported to higher levels. Further, site personnel stated that they felt pressure from the program office to maintain schedules and were uncertain of the program office's commitments to fix discovered problems. These concerns were exacerbated by poor communication with the field regarding new software releases, discovery of new problems, and the recurrence of old problems that had already been fixed. Consequently, trust between program management and the sites deteriorated during critical periods of ERAM's deployment. In response, FAA took actions to address many of these problems by appointing a new Director of Program Operations and ERAM Program Manager. Our discussions with FAA staff at several facilities found a consensus that the program office's efforts have improved the effectiveness of decision making authority, oversight, and communications.

ERAM'S CONTRACT IS NOT STRUCTURED OR ADMINISTERED TO EFFECTIVELY MANAGE COSTS AND ACHIEVE DESIRED OUTCOMES

ERAM's problems are also attributable to weaknesses with the ERAM contract, which is not structured or administered to effectively manage costs and achieve desired program outcomes. Due to insufficient acquisition planning, FAA did not fully adopt best practices when designing ERAM's contract structure that would have permitted more effective contract management. In addition, weaknesses in FAA's acquisition workforce and poor contract management practices have led to insufficient oversight of the multibillion-dollar ERAM contract.

ERAM's Contract Structure Reduced FAA's Ability To Effectively Manage the Contract

FAA did not manage ERAM's cost, schedule, or performance effectively because it did not fully adopt best practices for information technology (IT) acquisitions when designing ERAM's contract structure (see table 2).

Table 2. Weaknesses in ERAM's Contract Structure

Best practices for structuring contracts	Weaknesses in ERAM's contract structure
Modular contracting should be used to divide major systems acquisitions into manageable contract tasks completed every 6–12 months.	FAA did not divide ERAM into manageable contract segments, and it develops software releases concurrently, which increases interface and inoperability risks.
Contract Line Item Numbers (CLINs) and Contract Subline Item Numbers (SubCLINs)—with clear cost, schedule, and performance objectives—should be used to fund separate deliverables and integral parts of deliverables for major acquisitions.[17]	ERAM's CLINs were too large, covered too long a time span, and were not divided sufficiently into SubCLINs to manage costs, schedule, and performance.
Scope, costs, and contract terms should be ***definitized*** (or finalized) in a timely manner.	FAA has not always definitized scope and costs in a timely manner.
Incentives should be designed to motivate the contractor to achieve schedule, cost and performance goals. These incentives should be awarded regularly to offer continuous motivation to the contractor.	FAA paid the contractor over $150M in cost incentives, despite software problems, delays, and cost overruns. Incentive fees were not tied to predetermined goals that are evaluated at regular intervals.

Source: OIG analysis

[17] A CLIN is a specific unit of work to be performed by the contractor as a pay item. SubCLINs are used to facilitate payment, delivery tracking, contract funds accounting, or other management purposes. Each SubCLIN has its own delivery schedule, period of performance or delivery date, and unit or total single price.

FAA Did Not Design the ERAM Contract Using Manageable Contract Segments

FAA did not divide ERAM into manageable contract segments—an approach known as modular contracting—when designing the program. However, modular contracting has been recommended by Federal guidance for over a decade[18] and is an industry best practice to reduce operational risks and better control costs. This approach involves dividing the work for large IT contracts into discrete, contractual segments with firm, short-term performance, cost, and schedule objectives.

While FAA partially applied modular concepts to ERAM's software development, it did not design a modular contract structure with which to manage it. Specifically, ERAM software is built using spiral development, a "build a little, test a little" approach that involves incremental phases of code design. However, the ERAM contract does not include these incremental contract objectives and related cost targets or incentives, so it is difficult for the ERAM program office and the contractor to understand when deliverables are due and at what agreed-upon cost. The lack of a modular approach can also create interface and interoperability risks and require more oversight of the contractor. For example, FAA is developing multiple software releases at once to reduce development time, rather than completing, implementing, and troubleshooting one software release before it initiates another.

FAA acquisition officials stated that the ERAM contract was not structured in a more modular fashion because the task of replacing the existing HOST system was too monumental and complex to be delivered in the short increments required by modular contracting (release cycles of 6 to 12 months). FAA also said that the modular contracting concepts strongly recommended in 2010[19] by the former U.S. Chief Information Officer (CIO) for all agencies could not have applied to the ERAM contract because it was awarded in 2002, prior to the CIO's recommendation.

Although FAA has independent procurement authority to develop its own acquisition process,[20] modular contracting has been recommended for Federal agencies for over 14 years. There are a number of Federal requirements and best practices intended to help Federal agencies manage their IT investments more effectively. Many of these contain modular contracting concepts that are useful in managing aspects of IT acquisitions structured like ERAM, such as:

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[18] The Clinger-Cohen Act of 1996 states Federal agencies should use modular contracting for IT acquisitions to the maximum extent possible.

[19] Office of Management and Budget (OMB) plan by Vivek Kundra, former U.S. Chief Information Officer, "25 Point Implementation Plan to Reform Federal Information Technology Management," December 9, 2010.

[20] In DOT's Fiscal Year 1996 Appropriations Act, Congress provided FAA with broad authority to develop its own acquisition process which relieved the Agency from Federal acquisition laws or regulations. FAA established its AMS, a set of policies and guidance designed to address the unique needs of the Agency.

- The Clinger-Cohen Act of 1996 required Federal agencies to use modular contracting for IT acquisitions to the maximum extent possible.

- The Raines Rules, guidance enacted by OMB in 1996 under the Clinger-Cohen Act, specify that major information systems investments should be implemented in phased, successive segments.

- The Federal Acquisition Regulations (FAR) was amended in 1998 to require that Federal agencies other than FAA use modular contracting to the maximum extent possible.

- The General Services Administration implemented a "Guide for Modular Contracting" in 1998, which the Department of Defense has incorporated into its IT acquisition guidance.

More recently, in 2010 the former U.S. CIO issued a 25-point plan for reforming Federal IT program management. The plan recommends that agencies only approve funding for major IT programs that use a modular approach since it has been shown to increase success and reduce risk. With regard to the development process, the plan also recommends that agencies lock down current software releases and push noncritical functionality to future releases rather than developing multiple releases at once.

FAA's Contract Structure Prevented Effective Cost Tracking for ERAM Deliverables

FAA's large-scale contract structure makes it difficult to account for the individual factors that have driven cost overruns at ERAM test sites. FAA divided ERAM into CLINs that span several years. For example, FAA designed a single, large CLIN that now contains almost 9 years and over $1 billion of work related to ERAM's software release 1. FAA included all design, development, testing, and implementation work in the same CLIN, rather than establishing separate CLINs and SubCLINs for each of these phases. FAA also did not establish separate CLINs for individual en route sites, along with applicable cost targets, milestones, and incentives. Consequently, when FAA began implementing ERAM software release 1 at its test site at Salt Lake City in 2008, the program began to experience problems that the Agency had difficulty managing because "implementation" was all covered under the single, large CLIN. This CLIN structure exacerbated the problems that led to an almost 4-year slip to the original ERAM schedule and a cost overrun that could exceed $500 million.

FAA has since notified OMB that it will manage future ERAM software releases by breaking out periodic cost goals and frequent milestones (i.e., use smaller CLINs and SubCLINs). According to FAA's ERAM Program Manager, future software builds can be much smaller than release 1 because the program has

significantly improved its software core capabilities. This will allow FAA to track costs and manage the program more effectively.

If FAA restructures the ERAM contract using smaller CLINs and sufficient SubCLINs beginning with release 4, we estimate that at least $157 million in funds could be put to better use by allowing FAA to track costs and manage the program's schedule and performance more effectively.[21]

FAA Does Not Finalize ERAM's Scope, Cost, and Performance Periods for CLINs in a Timely Manner

FAA awarded ERAM as a letter contract in December 2002, which allows the contractor to start work before FAA finalizes the project costs, schedule, scope of work, and contract terms (known as contract definitization). However, this contract practice increases risks and gives the contractor little incentive to control costs until work is definitized. FAA's AMS does not require a specific timeframe for definitization. However, the ERAM contract established a timeframe for definitizing initial CLINs and establishing terms, such as scope and cost. In comparison, the FAR, which FAA does not follow, allows no more than 180 days for letter contract definitization.[22] FAA did not meet its own contract terms or the FAR benchmark of 180 days for definitizing ERAM. FAA is still working to definitize 16 out of 57 CLINs for the contract,[23] even though the contractor has been authorized to work on them. For example, FAA initially definitized one of these CLINs 25 days after the date required in the contract and 48 days after FAR's 180-day benchmark. However, FAA has since modified this CLIN 45 times—increasing target costs by $328 million.

The ERAM Contract's Cost Incentives Were Ineffective at Controlling Costs

After Government Acceptance at the key site, FAA continued to pay the contractor incentives, including over $150 million in cost incentives for meeting target costs, even though ERAM began to experience software problems, schedule slips, and a cost overrun of as much as $500 million. FAA's practice of continually increasing target costs as ERAM's work requirements grew and software problems increased negated the contractor's incentive to manage contract costs.

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[21] Software release 4 is a follow-on to release 3, which focuses on adding NextGen functionality such as DataComm and will be funded by various NextGen programs. Funds could be used more efficiently if management took actions to implement and complete the recommendations. Our estimate of $157 million in funds put to better use is the lower end of FAA's estimated cost range for release 4 ($157 million). We obtained these figures from FAA's current ERAM CO.

[22] FAR 16.603-2(c), "Letter Contracts."

[23] As of January 17, 2012.

In addition, FAA does not finalize incentive fees until the end of a CLIN's performance period, which could span many years. This practice does not offer the contractor an immediate or continuous incentive. Instead, smaller incentives could be awarded at shorter intervals, such as bi-annually, to effectively motivate the contractor.

Since FAA has had difficulty establishing cost targets due to ERAM's changing requirements and software problems, award fees might provide a more effective cost management incentive. Award fees could be tied to meeting and exceeding performance goals that contribute to program success, such as achieving operational readiness at remaining facilities within a target date.[24] OMB guidance states that agencies should consider using an award fee with performance measures designed to encourage effective cost management when it is not feasible to determine objective incentive fee cost targets.[25]

Weaknesses in ERAM's Acquisition Workforce and Poor Contract Management Practices Have Led to Insufficient Contract Oversight

Weaknesses in FAA's acquisition workforce and poor contract management practices have led to insufficient oversight of the multibillion-dollar ERAM contract (see table 3).

[24] According to FAA's AMS, award fees should be designed to motivate the contractor by offering additional profit for excellent performance in key areas that support the Government's desired acquisition outcomes.

[25] OMB guidance requires that agencies consider an incentive for performance-based acquisitions that is most likely to motivate efficient and economical performance and that this incentive fee should be used when a cost target can be pre-determined and a formula can be used to adjust the negotiated fee over an established cost range. OMB guidance also stipulates that an award fee with performance measures designed to encourage economical performance should be considered when it is not feasible to determine objective cost targets to motivate the contractor through incentive fees.

Table 3. Weaknesses in ERAM's Contracting Staff and Management Practices

Requirement or best practice for contract management	Weaknesses in ERAM's contract management
Contracting office staff should be consistent and have institutional knowledge of the contract.	ERAM has experienced high CO turnover. Contracting staff rely heavily on support contractors.
Contract file should contain an organized record of all contractual actions.	ERAM's contract files are disorganized, incomplete, and not centrally located.
When ***reviewing invoices***, the contracting officer's technical representative (COTR) should require supporting documentation to prevent unallowable costs.	The COTR only performs basic checks of invoices and does not require supporting documentation for expenses. As a result, FAA did not detect nearly $69,000 in unallowable travel costs.
Program operations field managers (POFM), regional staff who oversee contractor performance at facilities nationwide, should be trained on monitoring contractor performance and be given guidance on the contract.	ERAM's POFMs lacked training and guidance, increasing the risk that they could assign tasks that exceed contract scope and fail to detect performance problems.

Source: OIG analysis

High Acquisition Workforce Turnover Has Resulted in a Lack of Institutional Knowledge Needed for Effective Contract Oversight

ERAM has had eight COs in the past 9 years. FAA explained that it is not unusual for contracts as lengthy as ERAM to experience high turnover in contracting staff. However, because of this high turnover, ERAM's COs lack the institutional knowledge needed to successfully administer the complex contract. The Government Accountability Office (GAO) reported in October 2011 that a consistent and stable contracting staff is a critical factor for successful major systems acquisitions.[26] The effects of high turnover are exacerbated by incomplete and poorly organized contract files. At the time of our review, ERAM's contract files did not contain a complete history of all contractual actions, as required by AMS guidance.[27] For example, FAA could not provide sufficient support for about $28 million in performance incentive fees paid to the contractor. The file also existed in three separate locations—one physical file and two virtual files. This makes it difficult for newer staff to readily access and understand the contract's complete history. A well-maintained contract file also provides a trail of supporting documentation in the event of litigation, audits, or congressional inquiries.

[26] GAO Report Number GAO-12-7, "Critical Factors Underlying Successful Major Acquisitions," October 21, 2011.

[27] AMS states basic contract files containing records of all contractual actions should be maintained by the organization or person administering the contract. In 2006—about 4 years after FAA awarded its ERAM contract—the Agency required that COs use a contract file checklist of essential contracting documents and clearances intended to support the complete history of an acquisition from pre-award through contract closeout.

In addition, COs rely heavily on contract support staff. For example, during our review, COs could neither answer our questions about the contract nor provide all requested contract documents. Instead, they either referred us back to former COs or to FAA's support service contractors to provide documentation. We also found that these support contractors write contract modifications and assist in contract administration—tasks which are closely associated with inherently governmental functions.

The program's COTR also heavily relies on FAA's support service contractors for contract administration. For example, the COTR delegated the task of maintaining the contract correspondence file to the support service contractors, even though the COTR's official designation letter indicates that the task cannot be delegated. In addition, the COTR said that, because of the size of the ERAM contract, he is not able to perform full reviews of contractor invoices or validate whether the contractor actually performs the work billed. FAA's new ERAM Program Manager stated that the COTR—rather than performing full reviews—currently "spot checks" all invoices to ensure that hours, charges, and details reflect actual work performed. The COTR also assesses whether the work billed seems reasonable. However, even though the ERAM contract allows FAA to request supporting documentation, the Agency still does not require the contractor to routinely provide supporting documentation for expenses, such as travel vouchers or receipts. Consequently, FAA's invoice review procedures were not sufficient to identify some unallowable charges.

Prior audits have detected weaknesses in Lockheed Martin's travel expense policies and identified instances of unallowable ERAM travel costs. For example, a 2006 internal audit found that a Lockheed Martin employee working on ERAM had been paid lodging expenses for 2 days he stayed at home.[28] In addition, Lockheed Martin recently self-reported that a former software engineer submitted almost $69,000 in fraudulent travel expenses between February 2008 and December 2010.[29] Despite these findings, FAA still does not require supporting documentation for all expenses. ERAM's ongoing history of unallowable travel costs and FAA's insufficient invoice review procedures creates the potential that FAA may have unknowingly paid other unallowable expenses.

FAA also relied on POFMs, who are primarily systems engineers, to oversee the contractor's performance at the Agency's 20 nationwide en route centers where ERAM software is being implemented. Yet, the majority of POFMs we spoke to had not been given training as technical officer's representatives (TOR) or guidance on the contract. For example, at one facility, the POFM had reported

[28] In response, FAA's then-CO began requiring the contractor to submit supporting documentation to verify billed costs. However, Lockheed Martin did not comply with the CO's request, as FAA did not enforce it. The following ERAM CO decided to retract this supporting documentation requirement in 2008—around the time FAA began incurring what became nearly $69,000 in fraudulent travel expenses.

[29] The sum includes only direct costs and excludes indirect costs.

problems with contractor performance, but he did not properly document them, so FAA did not take action. Many POFMs we spoke to also reported that they had not seen the ERAM contract's Statement of Work nor been given guidance on what they are allowed to assign the contractor, creating the potential that POFMs could assign tasks that exceed the contract's scope and budget.

FAA has taken actions to address some of these acquisition weaknesses. For example, in response to OIG audit findings on FAA's acquisition workforce,[30] FAA recently required all TORs—a term that also applies to POFMs—to train and certify as COTRs.[31] In addition, FAA has appointed a new Acquisition Executive to oversee the Agency's Office of Acquisition and Business.

FAA Has Not Used Contract Management Tools Effectively

We also found that FAA has not correctly implemented management tools for ERAM, which are intended to improve the management of costs, schedule, performance, and risk (see table 4).

Table 4. Ineffective Use of Management Tools

Effective use of management tools	Ineffective use of ERAM's management tools
Earned Value Management (EVM) systems must include all work to completion for accurate forecasts of schedule and cost trends.	ERAM's EVM system does not include all work, so forecasts are inaccurate and do not help detect problems with the program.
Integrated Baseline Reviews (IBRs) should be performed early to ensure adequate planning.	FAA did not complete IBRs for four of its five largest contract modifications—each exceeding $100M.
Risk management process should provide early detection of risks.	Problems were discovered at key sites in June 2009, yet ERAM's risk management process did not detect significant risks until almost 2 years later.

Source: OIG analysis

- **EVM.** FAA incorrectly implemented ERAM's EVM system,[32] a management tool intended to forecast performance trends and help managers identify cost

[30] OIG Report Number ZA-2011-148, "FAA's Policies and Plans Are Insufficient to Ensure an Adequate and Effective Acquisition Workforce," August 3, 2011.

[31] In April 2011, FAA eliminated the terms "Task Order Representative" from its AMS. All persons appointed by the CO to support contract administration are now designated COTRs.

[32] To set up an EVM system, an integrated cost and schedule baseline is developed by time-phasing budget resources for defined work. As work is performed and measured against the baseline, the corresponding budget value is "earned." Using this earned value metric, cost and schedule variances are identified and analyzed to forecast whether the program will meet desired budget and schedule goals at completion.

and schedule problems early. According to national EVM standards,[33] EVM systems should compare performance against a baseline, which should include all authorized work for the program. FAA program officials stated that the EVM baseline for ERAM was based on the contract's baseline and work breakdown structure,[34] rather than those for the overall program, as required by EVM standards. Despite incorrect implementation, FAA maintains that EVM was an accurate management tool for ERAM until the program began experiencing significant software problems after Government Acceptance at the initial key test site. However, these software problems required significant additional work, which FAA never accounted for in the EVM baseline. Without an accurate baseline that includes all required work, ERAM's EVM system has not identified significant problems with the program. For example, although ERAM is almost 4 years behind and may be as much as $500 million over budget, FAA's March 2011 EVM report stated that "all ERAM milestones to date have been achieved on or ahead of schedule, while meeting cost targets." Three months after this EVM report, FAA rebaselined ERAM due to cost overruns and delays. FAA stated that it is planning to revise ERAM's EVM baseline to incorporate all of the program's work requirements.

- **IBRs.** FAA did not complete timely IBRs for ERAM. Both OMB and AMS require IBRs, which are contract management tools intended to improve program performance. Specifically, an IBR is an evaluation of a program's baseline plan to determine whether all program requirements have been addressed, risks have been identified, mitigation plans are in place, and resources are sufficient to complete the work. However, we found that FAA did not conduct its initial IBR for ERAM until 337 days after contract award. Although AMS includes some high-level policy on IBRs, it does not specify a timeframe for conducting IBRs. FAA also lacked guidance at the time of ERAM's contract award on how to implement AMS IBR policy. In contrast, guidance from other agencies, such as DOD, requires IBRs within 180 days of contract award. We also found that FAA did not complete IBRs—and thus did not complete adequate planning and risk assessments—for four out of five of its largest contract modifications, each exceeding $100 million. DOD's acquisition regulations,[35] on the other hand, require IBRs within 180 days of major modifications. In 2008, FAA developed a "Program Level Integrated Baseline Review Guide," and its 2010 update requires program offices to conduct IBRs for sole source contracts, such as ERAM, prior to definitization.

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[33] OMB and AMS require major programs like ERAM to base their EVM systems on American National Standard Institute (ANSI)/Electronic Industries Alliance (EIA) Standard-748-A. The ANSI/EIA-748 guidelines describe the attributes of an effectively integrated cost, schedule, and technical performance management system.

[34] A work breakdown structure (WBS) is a hierarchically structured grouping of project elements that organizes and defines the total scope of the project. Each descending level is an increasingly detailed definition of a project component. Project components may be projects (a product-oriented WBS) or tasks (a task-oriented WBS).

[35] Defense Federal Acquisition Regulation Supplement (DFARS) is DOD's implementation and supplementation of the FAR.

However, the guidance does not specify a timeframe to submit IBRs for major contract modifications, so FAA can still approve major contract modifications without sufficient planning.

- **Risk Management Process.** FAA did not sufficiently identify ERAM's risks early in the program, even though FAA developed comprehensive risk management process guidance in 2002 that would have applied to ERAM. In addition, DOD's risk guidance states that risk management should start as early as possible to avoid the greatly increased costs of addressing risks later. Significant problems were discovered at key test sites in June 2009,[36] yet FAA's risk management process for ERAM did not detect significant risks until January 2011—almost 2 years later. Additionally, FAA had initially identified only four "medium" risks and one "low" risk, despite ERAM's considerable cost overruns, schedule delays, and software problems. FAA's new project manager developed a June 2011 risk assessment that provided a more accurate portrayal of ERAM risks; it identified 28 active risk areas including 12 "high" risks. FAA reports indicate that it has addressed some of these risks. Specifically, FAA has reduced the number of ERAM's risks from 28 to 16, as of October 2011.

ERAM's risks contributed to significant cost and schedule problems that required the FAA Administrator to consider whether to terminate ERAM, in accordance with Public Law.[37] Ultimately, FAA decided not to terminate, in part because the Agency had already planned to rebaseline the program.[38] In June 2011, FAA's Joint Resources Council (JRC)—a body responsible for making authorization and funding decisions—approved rebaselining the ERAM program. As a result, the program's cost variance now exceeds its original baseline by more than 15 percent, and the schedule is delayed by 48.9 percent. However, further implementation delays could place the Agency in the position of once again having to make a determination about program termination. Specifically, the law requires the FAA Administrator to terminate programs funded from Facilities and Equipment appropriations with cost or schedule variances of 50 percent or more, unless the Administrator decides to continue the program and submits the basis for its decision to the House and Senate. ERAM's continuing delays may soon increase the program's schedule variance above this 50 percent threshold.

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[36] FAA had received even earlier warnings that it would need to carefully monitor risks for ERAM, as GAO highlighted FAA's air traffic control modernization programs as high-risk for 14 years, from 1995 to 2009.

[37] Public Law 104-264, "Federal Aviation Reauthorization Act of 1996," October 9, 1996—Requires the FAA Administrator to consider terminating any major acquisition—specifically, those funded from Facilities and Equipment appropriations—that has cost or schedule variances of over 10 percent or fails to achieve at least 90 percent of the performance goals established for the program. It also requires the FAA Administrator to terminate programs that have cost or schedule variances of over 50 percent or fails to achieve at least 50 percent of the performance goals established for the program, unless the Agency decides to continue the program and submits the basis for its decision to the House and Senate to continue the program.

[38] JRC Meeting Minutes, dated March 16, 2011.

CONTINUED PROBLEMS WITH ERAM POSE RISKS TO NEXTGEN INITIATIVES

Continued problems with ERAM will have a cascading effect on FAA's NextGen efforts and the Agency's capital account now and well into the foreseeable future. ERAM is a critical step on the path to NextGen and is the bridge for future NextGen automation capabilities for controllers. ERAM has complex interdependencies with key NextGen initiatives that are required for fundamentally changing the way air traffic is managed in the United States. Problems with ERAM will impact many aspects of NextGen, including FAA's ability to deliver new Performance-Based Navigation routes and transition to the common automation platform envisioned for future NextGen capabilities.

Despite the significant program risks and unresolved issues, FAA has not conducted a detailed assessment of ERAM's interdependencies or impact on other programs' costs and schedules. Our analysis shows, however, that three of the largest and most complex NextGen transformational programs are dependent on the successful implementation of ERAM to meet their performance parameters. These programs—ADS-B, DataComm, and SWIM—are allocating more than $500 million specifically to integrate with ERAM. The following table details individual program interdependencies to ERAM:

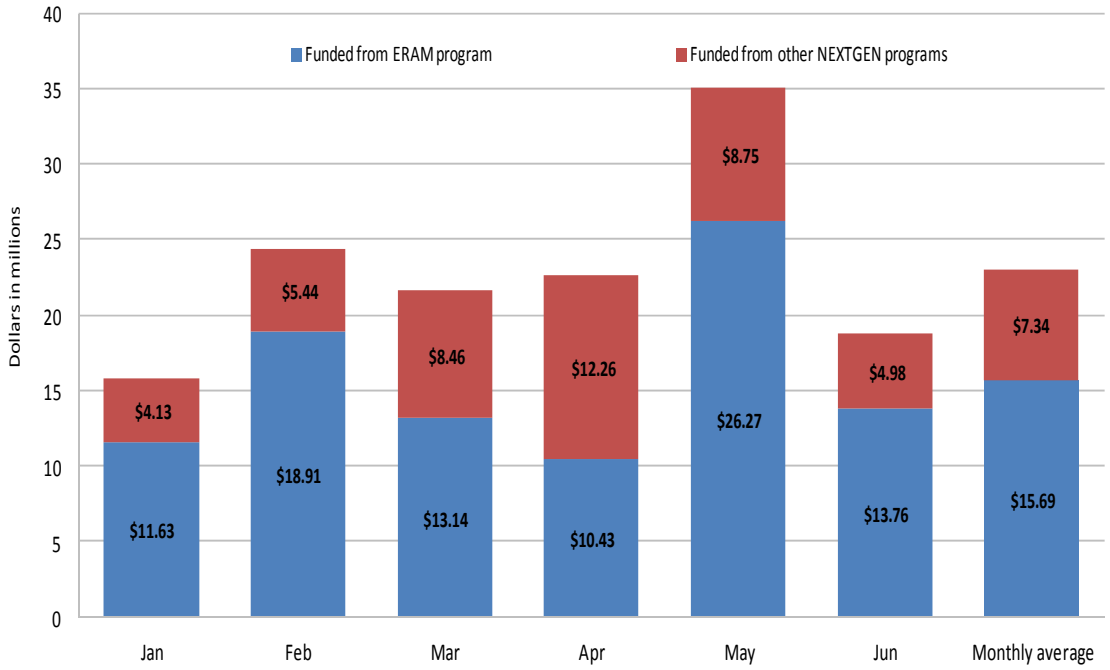
Table 5. ERAM Interdependencies With Key NextGen Programs

Program Description	ERAM Interdependencies
Automatic Dependent Surveillance-Broadcast (ADS-B)	
Uses aircraft avionics and ground-based systems to provide information on aircraft location to pilots and traffic controllers.	FAA plans to provide the ERAM program $74M to display ADS-B data for use by controllers in the high-altitude environment.
Data Communications (DataComm)	
Provides two-way data communication between controllers, automation platforms, and flight crews. DataComm is intended to supplement rather than replace voice communications in all phases of flight.	FAA plans to provide the ERAM program with as much as $400M to develop an interface that provides controller-pilot message processing and displays information to controllers in the en route centers.
System-Wide Information Management (SWIM)	
Provides a more agile exchange of information through a secure, NAS-wide information web that will connect FAA systems and improve interaction with other agencies, air navigation service providers, and airspace users.	FAA planned to provide the ERAM program with as much as $117.7M (for SWIM Segment 1 only) to modernize and enhance its flight data processing and external interfaces with terminal air traffic control and the Traffic Flow Management systems. *However, the SWIM Program Office terminated Segment 1 early and has only provided $41 million to ERAM.*

Source: OIG analysis of FAA documents

The importance of ERAM to NextGen execution is illustrated by the fact that FAA is investing hundreds of millions of dollars on ERAM to interface with other systems that are critical to achieve new NextGen capabilities. For example, a key component for realizing benefits from ADS-B is displaying satellite-based information on air traffic controller displays. Between January and June 2011, the ERAM Program Office spent about $7 million a month in addition to ERAM program costs for work to integrate other systems, such as ADS-B, SWIM, and DataComm, into ERAM. The following figure shows monthly expenditures on ERAM and the work to integrate the transformational systems with the new system for managing high-altitude air traffic.

Figure 3. ERAM Monthly Expenditures Funded by ERAM and Other NextGen Programs for the First Half of 2011



Source: FAA ERAM program office

In addition to these three transformational programs, delays with ERAM will impede other NextGen efforts, including:

- The implementation of FAA's new Performance-Based Navigation routes and procedures that allow aircraft to fly more flexible routes, based on aircraft avionics and satellite-based navigation. New performance-based navigation routes are an important stepping stone for near-term NextGen initiatives and boosting capacity at already congested airports. New automated systems for controllers, such as ERAM, are key to maximizing the benefits of new routes.

- Trajectory-based operations, an important NextGen capability, focus on the management of aircraft through all phases of flight. This capability is expected to predict the path of each aircraft in time and space to facilitate the transition from today's ground-based radar to more accurate satellite-based systems that will result in better strategic management of the entire NAS and reduce fuel consumption by the airlines and aircraft emissions. Progress with ERAM is important with trajectory-based operations because FAA plans to begin to implementation of this capability in the high-altitude environment.

- Future software enhancements for new NextGen capabilities estimated to cost close to $1 billion through fiscal year 2017, including a flexible and dynamic airspace that will allow controllers to shift airspace segments to other controllers, based on weather and traffic pattern changes. However, FAA must fix core capabilities for managing aircraft before the new capabilities can be implemented.

- Common automation platform, which will combine both terminal and en route operations into a common automation system. Currently, FAA operates and maintains a diverse system of automation systems with unique displays, software, and hardware. FAA believes that a common automation platform will reduce costs, improve air traffic and airspace management, and allow the Agency to consolidate and realign its facilities. The problems with ERAM are one reason why FAA cannot determine when it can begin to develop and transition to a common automation platform.

Schedule delays and corresponding cost growth with ERAM have forced FAA to reprogram funds from other FAA capital programs. According to Agency officials responsible for capital planning and budgeting, FAA thus far has reallocated funds from the NextGen solution sets (development efforts for NextGen capabilities and procedures), tower replacement, electrical power systems for air traffic control facilities, and planned technical improvements to communications and oceanic automation systems. As we have noted in our previous work, continuing cost growth with ERAM, especially in the current budget environment, will crowd out other capital programs.

CONCLUSION

ERAM is a critical component of FAA's efforts to modernize the National Airspace System and transition to NextGen. While FAA has taken steps to improve program management, significant challenges and risks remain to successfully complete the program. In addition, FAA's problems with ERAM have revealed weaknesses with the contract vehicle, highlighting the need to improve the management of the contract as the program moves forward. Sustained comprehensive actions will be required to manage ERAM and its contract, achieve

full implementation of ERAM at all facilities, and gain user confidence in the system. Ultimately, achieving NextGen's goal of more efficient airspace for the future will depend on FAA's ability to effectively manage within cost and schedule large-scale acquisitions such as ERAM to support its NextGen portfolio. Until FAA improves its acquisition, program, and contract management practices, the Agency will likely find itself repeating its past and current missteps in future large-scale software-intensive NextGen acquisitions, putting the future of NextGen at risk.

RECOMMENDATIONS

To reduce risk with further implementation of ERAM and to address programmatic management weaknesses, we recommend that the ERAM program office:

1. Develop a mitigation plan to address ERAM's core capabilities problems at all 20 ERAM sites before deploying new capabilities.

2. Evaluate available options and take action to deploy an additional backup for ERAM until the system has become significantly more mature.

To improve ERAM's contract structure and oversight, we recommend that FAA's Acquisition Executive:

3. Revise the Contract Line Item Number (CLIN) structure to more effectively track ERAM costs. This should include establishing subordinate CLINs, cost targets, and incentives to better achieve program objectives, beginning with software release 4.

4. Include a requirement in the Acquisition Management System (AMS) to definitize CLINs in a reasonable time period, such as FAR's 180-day benchmark. Ensure that future ERAM CLINs are definitized according to the new requirement.

5. Design incentives to better achieve desired program outcomes. For example, offer incentives over shorter intervals, such as bi-annually, to effectively motivate the contractor.

6. Review AMS requirements for a contracts file list and contract maintenance procedures to verify that they are adequate. In addition, develop a process to verify that major contract files are reviewed by FAA's National Acquisition Evaluation Program for compliance with AMS policy and best practices for contract management.

7. Develop a formal process for ERAM invoice reviews that requires supporting documentation, such as travel vouchers and hotel receipts.

8. Update the performance measurement baseline for ERAM's earned value management system to include all remaining work on the ERAM contract, including planned work that has not yet been priced and work performed by the Government.

9. Develop procedures in FAA's "Program Level Integrated Baseline Review Guide" to verify that integrated baseline reviews meet the requirements and to establish a time frame for conducting integrated baseline reviews after executing major contract modifications.

10. Complete the comprehensive risk management guidance that FAA is currently developing, to more effectively manage acquisition risks.

To reduce risk to future NextGen related programs, we recommend that FAA:

11. Assess current testing capabilities and limitations at FAA's Technical Center and develop corrective action plans to more robustly test future complex software-intense air traffic systems.

12. Require complex software-intensive systems (that are interdependent on other systems, such as ERAM) to be successfully tested in a live, operational environment, at one or more FAA air traffic facilities, prior to Government Acceptance.

13. Revise AMS to better define key milestones, such as Government Acceptance and initial operating capability, so that milestones are clear measures of progress for managing major acquisitions.

AGENCY COMMENTS AND OFFICE OF INSPECTOR GENERAL RESPONSE

We provided FAA with our draft report on June 13, 2012, and received its formal response on July 24, 2012. FAA's response is included in its entirety as an appendix to this report. In its response, FAA states that it has made substantial progress with ERAM, and Agency management is confident that the program can stay within the revised cost and schedule baseline. We agree that ERAM is on stronger footing now than when we began our review. We attribute this to sustained management attention by FAA leadership as well as focused risk management and close work with controllers. Throughout our review, we communicated our views to FAA officials on actions needed to reduce risk and strengthen contract oversight, and the Agency took steps to address our concerns.

Our draft report acknowledged that FAA has made strides toward improving the way it tracks ERAM deliverable costs. For example, we reported that FAA indicated that it will manage future software releases by breaking out periodic cost goals into more discrete contractual segments and establishing frequent milestones. In May 2012, in response to our concerns, FAA modified the ERAM contract to begin definitizing its software implementation effort and to break large software development efforts into smaller contract segments. This will allow FAA to better manage its software releases.

Notwithstanding FAA's risk mitigation efforts and the use of the system at more facilities, considerable risk still lies ahead for completing ERAM within the revised baseline. For example, as we have stated previously, when FAA fields ERAM at large sites, such as New York and Washington—which are more complex than any of the previous locations—it will likely identify new problems, raising the risk that program costs will grow. Therefore, it is uncertain how much ERAM will ultimately cost, how long it will take, what capabilities will be delivered, and what trade-offs will be needed to complete deployment. The ERAM experience represents important lessons learned for FAA as it develops and implements even more complex software-intensive systems envisioned for NextGen.

In responding to our recommendations, FAA concurred with 12 of our 13 recommendations and partially concurred with 1. Based on FAA's response, we believe the Agency met the intent of nine recommendations, but we are requesting additional information, revised responses, and/or targeted completion dates for recommendations 1, 7, 8, and 12, as detailed below. All recommendations will remain open pending completion of planned actions.

FAA concurred with recommendation 1, to develop a mitigation plan addressing ERAM's core capabilities problems at the 20 sites, and asked that we close the

recommendation. However, FAA continues to add new capabilities while fixing problems identified at the sites. As we noted in our report, this has compounded problems with ERAM's implementation—an issue that FAA recently experienced at Houston center, which hindered efforts to use the system on a full-time basis. Therefore, we request that FAA provide us with its plans to mitigate risks and related milestones for deploying ERAM to the remaining sites, such as New York.

FAA concurred with recommendation 7, stating that controls are in place to ensure that its "spot-checking" approach for reviewing invoices meets the criteria for balancing the effort of the reviews with the risks for potentially fraudulent charges. However, the intent of our recommendation was to ensure that FAA's invoice "spot checking" reviews include reviewing supporting documentation for travel costs, such as travel vouchers and hotel receipts. To mitigate the incidence of additional fraudulent travel charges billed to the ERAM contract, we are requesting that FAA clarify whether its "spot-checking" approach will include a review of supporting documentation for billed travel costs, such as travel vouchers and hotel receipts.

FAA partially concurred with recommendation 8. By September 30, 2012, FAA plans to restructure its EVM measurement baseline to adopt a product oriented approach that is aligned to program milestones, such as achieving IOC at a specific en route site. This will improve the reliability of measurements of cost and schedule variances impacting the program. In addition, although FAA agrees that planned future work should be included in the EVM measurement baseline, as required by FAA's acquisition guidance, it has not yet determined whether or how it plans to implement this requirement for ERAM. For example, FAA is unsure whether to include planned work in the EVM system for ERAM when programmatic work is unstable or programmatic requirements and milestones are not mature. OMB guidance incorporates national EVM standards that state EVM systems should compare performance against a baseline that includes all authorized work for the program. Accordingly, the recommendation is unresolved pending FAA's determination of whether it intends to include all planned authorized work in the EVM measurement baseline.

FAA concurred with recommendation 12, but its response does not meet the intent of the recommendation. FAA states that AMS prescribes an approach that supports the "notion" that complex capabilities must be successfully tested in a live, operational environment at one or more facilities before Government Acceptance. However, as we note, live operational testing did not occur with ERAM before the Government accepted the system and assumed the responsibility to fix ERAM's problems. This was partly due to the fact that the Government Acceptance milestone is inconsistently defined and interpreted by individual program managers, as we reported. Therefore, we are asking FAA to reconsider its response and provide more specific information on its planned actions and target

completion dates to not only require, but also ensure that complex software-intensive systems are tested in a live operational environment at one or more FAA air traffic facilities prior to Government Acceptance.

ACTIONS REQUIRED

We consider recommendations 2, 3, 4, 5, 6, 9, 10, 11, and 13 resolved but open pending the completion of planned actions. For recommendations 1, 7, 8, and 12, we request that FAA provide target milestones, additional information, and/or reconsider its response, as specifically detailed above. In accordance with Department of Transportation Order 8000.1C, we request that FAA provide us this additional information within 30 days of this report.

We appreciate the courtesies and cooperation of Department of Transportation representatives during this audit. If you have any questions concerning this report, please call Jeff Guzzetti, Assistant Inspector General for Aviation and Special Programs, at (202) 366-0500, or Mary Kay Langan-Feirson, Assistant Inspector General for Acquisition and Procurement Audits, at (202) 366-5225.

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cc: FAA Audit Liaison, AAE-100
OST Audit Liaison, M-1

EXHIBIT A. SCOPE AND METHODOLOGY

We conducted this performance audit between September 2010 and June 2012 in accordance with generally accepted Government auditing standards as prescribed by the Comptroller General of the United States. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

We conducted onsite interviews with management officials, technical operations personnel, air traffic controllers, contract oversight staff, and contractor staff at FAA's two key test sites, as well as at five selected en route centers that were planned to begin initial operations in fiscal year 2011. We visited the FAA Technical Center in Atlantic City, NJ, to examine software testing, discuss the Center's testing limitations, and interviewed the manager of ERAM's contract oversight staff. We interviewed FAA program officials at FAA Headquarters, National Air Traffic Controllers Association (NATCA) union officials, Professional Aviation Safety Specialists (PASS) union officials, and officials from Lockheed Martin and Raytheon to discuss FAA's implementation of ERAM. We interviewed ERAM contracting staff and support contractors to discuss contract oversight. We met with training officials at FAA Headquarters and FAA Training Academy in Oklahoma City, OK. We interviewed FAA's senior officials, Air Traffic Organization officials, Joint Planning and Development Office officials, and NextGen Integration and Implementation officials to discuss the impact of ERAM delays on NextGen initiatives. We spoke with the Air Traffic Organization's Office of Safety about its ERAM assessment. Finally, we met with MITRE officials to discuss its ERAM assessment and determine how FAA should align its future investments as its move forward with NextGen. Exhibit B lists all organizations we contacted during this audit.

In addition to conducting interviews, we also reviewed relevant policies and guidance from the Office of Management and Budget, the Government Accountability Office, FAA's Acquisition Management System, and the Department of Defense, as well as other applicable laws and regulations. We collected and analyzed program data, FAA's National Airspace System and NextGen Enterprise Architecture documents, cost and schedule projections for ERAM and other NextGen programs, problem trouble reports, the ERAM contract, and other pertinent documents and records. Our assessment of the ERAM contract included reviews of contract terms, contract modifications, contract costs, incentive fees, and pre-award contract documents. We also reviewed FAA's use of program management tools, such as earned value management and integrated baseline reviews. Further, we reviewed all 81 bi-weekly invoices for onsite

maintenance support to determine if FAA required enough supporting documentation to detect unallowable costs.

EXHIBIT B. ORGANIZATIONS VISITED OR CONTACTED

FAA Facilities

FAA Headquarters

Denver Air Route Traffic Control Center

Salt Lake City Air Route Traffic Control Center

Seattle Air Route Traffic Control Center

Minneapolis Air Route Traffic Control Center

Albuquerque Air Route Traffic Control Center

Houston Air Route Traffic Control Center

Los Angeles Air Route Traffic Control Center

Chicago Air Route Traffic Control Center

Oakland Air Route Traffic Control Center

FAA Training Academy at the Mike Monroney Aeronautical Center

FAA Accounts Payable Office at the Mike Monroney Aeronautical Center

FAA William J. Hughes Technical Center

Other Organizations

Lockheed Martin Information Systems & Global Solutions

Raytheon Network Centric Systems

MITRE Corporation

National Air Traffic Controllers Association (NATCA)

Professional Aviation Safety Specialists (PASS)

CEXEC, Inc.

TASC, Inc.

Evans Incorporated

EXHIBIT C. MAJOR CONTRIBUTORS TO THIS REPORT

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APPENDIX. AGENCY COMMENTS

Federal Aviation Administration

Memorandum

Date: July 24, 2012

To: Jeffrey B. Guzzetti, Director, Assistant Inspector General for Aviation and Special Program Audits

From: H. Clayton Foushee, Director, Office of Audit and Evaluation, AAE-1

Subject: FAA's Response to the Office of Inspector General Draft Report on En Route Automation Modernization (ERAM) program

The Federal Aviation Administration (FAA) has made substantial progress on the ERAM program beyond that conveyed in the Office of Inspector General (OIG) draft report. The FAA has already implemented several of the OIG's recommendations, and the FAA disagrees with the draft report's statements that the program is likely to incur over $150M in costs above its new baseline and delays into 2016. Moreover, the FAA finds it disconcerting that the OIG draft report failed to recognize or acknowledge the substantial recent progress made by the agency to place the ERAM program back on a strong footing, and some of the OIG's findings are based upon out of date information.

The original ERAM program baseline has been modified to include a $330M cost variance and a three-year, eight-month schedule variance. However, the program was re-baselined in June 2011 and is currently operating within that new baseline. The last site Operational Readiness Date (ORD) milestone shifted from December 2010 to August 2014.

Although the agency will continue to adjust deployment dates for individual sites within the approved baseline, there is a high degree of confidence in the program's final completion date. As anticipated, since re-baselining the FAA has also continued to identify software related issues that affect ERAM performance, particularly as new capabilities are implemented, and more sites are brought on-line. The FAA anticipates, however, that software fixes will be implemented within the boundaries of the current approved baseline.

The OIG report should recognize a number of major deployment milestones that have now been accomplished, including:

- Achieving Initial Operating Capability (IOC) at seven more sites, bringing the current total to nine sites.
- Achieving ORD at two of those nine sites, and achieving continuous operations at another three (meaning they are operating on ERAM with no planned fall-back to the legacy HOST system), while the remainder continue to work through the progression of longer and longer operational runs toward continuous operations.
- Declaring IOC on the first ERAM software release enabled with Automatic Dependent Surveillance Broadcast (ADS-B), allowing for operational use of both ERAM and a key NextGen program in Houston.
- Decommissioning of the legacy HOST system at Seattle and Salt Lake Centers.

The growing level of ERAM-enabled operations has led to multiple instances where nearly one half of the nation's air traffic was being served by ERAM-based air traffic control procedures. Since December of 2011, the system has accumulated over 2,600 hours of operations for newly IOC'd sites other than Seattle and Salt Lake, across a range of varying airspace needs and traffic volumes. The program is well positioned to continue to activate sites within the current budget and schedule as planned into FY13.

The ERAM acquisition team now maintains firm oversight and control of the program. Through key management changes of personnel overseeing the project, including the appointment of a new Contracting Officer in October 2011, FAA has reinforced its ability to oversee and administer all contract activities. Over the last six months, the team has negotiated and definitized a number of significant undefinitized contract actions valued at over $374M. Portions of the negotiations included establishing a more modular contract structure while incentivizing performance. Contract provisions have been established to track performance and formally measure the results. The associated performance incentives are detailed in the contractually established release plan. This plan delineates all of the activities required to meet the contract schedule and program requirements.

The shared obligations of such activities force both the FAA and the contractor to track progress and limit change, and all changes now have a directly traceable impact on the software release plan and ability to achieve each milestone. The milestones are directly tied to the contract incentives and the ability of the contractor to earn the negotiated fee for performance. These activities have occurred in conjunction with the planning and developing of acquisitions and documents in support of future software releases and various Contractor Depot Level Support (CDLS) activities.

Beginning in early 2011, the Program Office has undertaken a series of management initiatives that are also helping to get the program back on track. This includes addressing strategic, structural, process, personnel, and incentive aspects of the program’s overall approach. Specific examples in each of these areas are highlighted below, and have been implemented in the past 18 months. These improvements are reinforced here

to emphasize the differences between where the program currently stands and many of the challenges highlighted in the report:

- **Strategy**: The program has addressed strategic changes that create a formula for success. This new strategic direction is driven by the following program artifacts: the In-Service Decision (ISD) Action Plan, the ERAM Process Improvement Plan, the updated Office of Management and Budget Improvement plan, and the artifacts used in conjunction with the re-baselining of ERAM by the Joint Resources Council. In an effort to enhance the focus on operational needs and improve organizational integration with 2nd Level Support, the work to transition Program Office ownership to 2nd Level has been accelerated (began in October 2011). Furthermore, a revised waterfall schedule was developed to allow the time and attention necessary to efficiently and effectively address facility needs. Based on the outcomes highlighted earlier in this document (i.e. accumulation of IOC and ORD milestones), the FAA feels confident this strategic direction is the correct one.

- **Structure**: The Program Office redefined the specific program structure with a re-baseline of funding and schedule. New program governance was put in place in early 2011 which included the labor unions (Article 48 working group), a steering committee and regular Program Management Reviews that include a cross-section of key program stakeholders. There were also several process improvements made within the program's communications and management. For example, there was a realignment of personnel for a more streamlined approach and new communication channels established to clarify decision authority across organizational boundaries. In addition, the Program Office and Article 48 working group standardized procedures for how sites transition from IOC to continuous operations on ERAM.

- **Process**: ERAM has implemented a series of process improvements across all aspects of the system lifecycle, including in the areas of release management, software build packaging, test, deployment, and issues management. This work has improved the quality defect rate of software coming out of test, the effective collaboration with Union partners, the flow of information to the field facilities, and the ability to integrate complex data needed for planning. Specific examples of these changes include:
    - The use of the National User Team to provide Air Traffic (AT) perspective and collaboration on the design of software fixes.
    - The use of AT Subject Matter Experts to support site software activation activities, training, and comparable local planning processes.
    - Improved communications evidenced by revised briefing packages and increased presence of support personnel at the site, to more effectively manage the release of software to the facilities.

- **People**: The program has optimized its resourcing strategy to align with both ERAM's strategic goals as well as with the operational vision of the FAA. This began in early 2011, with the appointment of a new Director of Program Operations. Since then, the FAA has institutionalized its new Program Management Office,

created this fiscal year. Additional personnel changes in the past year include the assignment of a new program manager, a new manager of Air Traffic Manager Programs, and a new Director of Air Traffic Systems. New working relationships with the National Air Traffic Controllers Association and the Professional Airway Systems Specialists (via collaborative work groups initiated in 2011), as well as with Lockheed Martin (who has also introduced new resources in key positions in the past 18 months) have improved coordination and integration of the team.

- **Rewards**: New rewards on the program include a range of opportunities. In working with Lockheed Martin, the new contract provides new incentives based on the successful achievement of future milestones (described in more detail below). More informally, communications in response to achievement of milestones, all-hands workforce meetings (where milestones are highlighted and hard-work acknowledged), and leadership recognition of positive achievements all incentivize program stakeholders.

RECOMMENDATIONS AND RESPONSES

Recommendation 1: Develop a mitigation plan to address ERAM's core capabilities problems at all 20 ERAM sites before deploying new capabilities.

FAA Response: Concur. The ERAM program has already completed this plan. Release 2 software builds--EAB0300 (July 15, 2011), EAB1100 (August 18, 2011), EAB1200 (December 5, 2011) and EAB1300 (April 24, 2012)--have been deployed to address identified core functionality issues. Since the time that "core functionality" issues were identified in spring of 2011, the program has achieved the following milestones that demonstrate core functionality has been substantially addressed within the system:

- The two program key sites, ZSE (Seattle, WA) and ZLC (Salt Lake City, UT), have achieved their ORD, and the legacy HOST system, has been decommissioned.
- Seven new sites after the key sites have achieved IOC.
- ZDV (Denver, CO), ZMP (Minneapolis, MN), and ZAB (Albuquerque, NM) have begun use of ERAM for continuous operations.
- ZHU (Houston, TX) has successfully demonstrated the operational use of ADS-B capability in ERAM through limited operational runs.

Depending upon the definition of "new capabilities," many planned ERAM software release 3 functions augment and strengthen core functions (i.e. ADS-B integration should improve surveillance and radar processing accuracy, among other examples). More specifically, with release 3, the program has already implemented new functionality to include ADS-B and System Wide Information Management and has begun development on release 4 to support other core programs. As such, adding "new capabilities" to future software builds will in many cases act to strengthen ERAM core functionality capabilities. While this approach may introduce software complexities, the agency does not believe that these complexities constrain its ability to address core functionality in ERAM. Evidence of this can be seen in the following examples:

- Since activating the release 3 software baseline for software development, test, and deployment activities, an additional three sites have entered continuous operations and two sites have entered ORD (as noted above). This was achieved in conjunction with the pursuit of additional NextGen capability.

- In addition, the instances of problems identified as a part of site testing on a "pre-build" basis has dropped significantly through release 3. The number of problems found[1] during site test processes for the last three software builds appear below, spanning both release 2 and release 3:
  - EAB1300 (made operationally available April 24, 2012) - 61 total (34 Critical, 27 highs of interest)
  - EAC1003 (made operationally available June 7, 2012) - 42 total (16 Critical, 26 highs of interest)
  - EAC1100 (planned to be made operationally available June 9, 2012) - 29 total (15 Critical, 14 High of interest)

Accordingly, the FAA requests that this recommendation be closed.

Recommendation 2: Evaluate available options and take action to deploy an additional backup for ERAM until the system has become significantly more mature.

FAA Response: Concur. As of May 2012, modifications to the Enhanced Back Up System (EBUS) have been deployed and EBUS will remain operational until ERAM's operational stability (validated and measured through quantitative data on system availability, failure rates of system components, and the like) validates that the system is sufficiently stable[2]. The ERAM Program Office and 2nd Level Engineering organizations are currently assessing the costs and benefits of operating EBUS beyond FY12 and will make a decision on the need for sustainment of EBUS, or alternatives and associated costs, by the end of FY12.

Recommendation 3: Revise the Contract Line Item Number (CLIN) structure to more effectively track ERAM costs. This should include establishing subordinate CLINs, cost targets, and incentives to better achieve program objectives, beginning with software release 4.

FAA Response: Concur. The recent negotiation/definitization of the "ERAM FY12/13 Site Waterfall Proposal," completed in May 2012, included the establishment of a contract structure that designates efforts under the software development CLIN into Sub-CLINs segmented by software releases. Subsequent releases will be assigned sequentially by Sub-CLIN. Cost targets and incentives are accordingly established and tracked at the Sub-CLIN and individual software release level, as are the associated cost

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[1] Note these are issues found and resolved during the test phase of each build. They do not represent a count of issues found during operational use of ERAM.

[2] EBUS was originally deployed between 2004 and 2006 as a back-up to ERAM. More recent modifications allow for continued maintenance of EBUS beyond the decommissioning of the legacy HOST system.

accounts. This recommendation is now fully implemented, and the FAA requests that it be closed.

Recommendation 4: Include a requirement in AMS to definitize CLINs in a reasonable time period, such as FAR's 180-day benchmark. Ensure that future ERAM CLINs are definitized according to the new requirement.

FAA Response: Concur**.** The FAA will review current Acquisition Management System (AMS) language regarding definitizing changes, and revise accordingly to ensure it requires action within a reasonable time period. This review will be completed by September 30, 2012.

Since December of 2011, the ERAM acquisition team has completed negotiations, definitized, or is in the process of definitizing, all undefinitized contract actions, with the exception of datacom S1P1 proposal preparation (which is in progress) and approximately $70K of legacy miscellaneous efforts falling under three CLINs. Specifically, En-Route Information Display System (ERIDS) Option 3 (definitized February 15, 2012), ERIDS Option 4, Legacy Display System Replacement (DSR) CDLS (definitized June 7, 2012) and the FY12/13 Site Waterfall efforts (definitized May 23, 2012), having a combined value in excess of $374M, spanning over 25 CLINs/sub-CLINs, are now definitized. Acquisition schedules not exceeding 180 days are in development for future work including release 4 activities (R.4.1 Air Borne Re-Route / Ground Interval Management and R.4.2 Data COMM S1P1).

Recommendation 5: Design incentives to better achieve desired program outcomes. For example, offer incentives over shorter intervals, such as bi-annually, to effectively motivate the contractor.

FAA Response: Concur. The contract CLIN structure was revised as of the completion of the contract renegotiation in May 2012, to incentivize performance based upon milestones specific to operational software releases. The work on redesigning these incentives began in March of 2011 and was resolved with the negotiation of the new contract. A significant portion of what was previously a one-time fee incentive has been allocated to five performance targets for each operational release (starting with software release EAC1200). Each of these five performance targets has mandatory and challenge success criteria that must be achieved for the partial or complete award of an incentive fee. The performance-based incentive milestones for each operational software release are assigned a specific contract designation by Sub-CLIN. This more segmented and modular approach will facilitate specific tracking and verification of the milestones by the Technical Officer, Contracting Office (CO) and the Quality Reliability Officer. The specific measures are tied to a contractually established release plan that identifies the milestone dates as well as the supporting detailed activities and their requisite schedule dates. FAA requests that this recommendation be closed.

Recommendation 6: Review AMS requirements for a contracts file list and contract maintenance procedures to verify that they are adequate. In addition, develop a process

to verify that major contract files are reviewed by FAA's National Acquisition Evaluation Program for compliance with AMS policy and best practices for contract management.

FAA Response: Concur. The FAA will review published AMS contract file checklists and maintenance procedures for adequacy and applicability. This review will be completed by September 30, 2012. Additionally, the FAA's National Acquisition Evaluation Program will continue to include major contract files in its annual sampling for onsite reviews.

The FAA AMS required checklists have been included and completed for all ERAM files and contract modifications since the issuance of Modification 90 in December 2010. Assurance that procedures are being followed is being facilitated by review of all modifications to the contract. Such reviews include, but are not limited to, the ERAM CO's, Contracting Officer Technical Representative, Contracts Manager and FAA legal counsel. The FAA has also initiated a Contract Administrative Review process in which major contracts are briefed by the CO in detail to a FAA contract management panel, including the Director of Contracts. ERAM Contract number DTFA01-03-C-00015 was the first briefing under this FAA initiative. The briefing was successfully accomplished on February 24, 2012. This approach will be repeated for future contract ERAM contract modifications as well. Based upon actions already taken, the FAA requests that this recommendation be closed.

Recommendation 7: Develop a formal process for ERAM invoice reviews that requires supporting document documentation such as travel vouchers and hotel receipts.

FAA Response: Concur. Controls continue to be in place ensuring the "spot-checking" approach meets the requisite criteria for balancing a reasonable effort of detailed invoice reviews with the risks these reviews mitigate – potentially incorrect or fraudulent charges to the FAA. FAA's best-practices include a combination of training and lessons-learned activities to help educate contracting staff about the nature of invoice reviews. In addition to adhering to and imposing compliance with FAA Cost Principles and AMS clause 3.2.4-5 "Allowable Cost and Payment," the ERAM team retains financial spreadsheets and follows practices for processing vouchers/invoices consistent with FAA procurement guidance section T3.10.1, appendix D.7. Based upon the availability of this guidance, and in following these two standards, the FAA believes that the OIG recommended formal process is in place and is being followed. Thus, the FAA requests that this recommendation be closed.

Recommendation 8: Update the performance measurement baseline for ERAM's earned value management system to include all remaining work on the ERAM contract, including planned work that has not yet been priced and work performed by the Government.

FAA Response: Partially Concur. The ERAM program is expanding its existing Earned Value Management (EVM) approach to be a program-wide performance reporting tool rather than solely focusing on the prime vendor activities. Non-Prime Cost Performance

Reports (CPR) have been generated starting in April 2012. These CPR will be integrated with the prime vendor reports which have been restructured to follow a product oriented Work Breakdown Structure better aligning to program milestones. This approach provides a range of benefits including more holistic reporting of progress against milestones and more accurate insight into anticipated cost or schedule risk against those milestones. In some cases, the FAA agrees that adding planned, future work that has not yet been fully priced would benefit from inclusion in the baseline. However, the business rules for addressing this should include considerations such as the maturity of the associated requirements, maturity of milestones and commitments made within and outside the agency, and the stability of the work program itself so as to not introduce unnecessary variability or volatility in the EVM reporting. Because the longer-range future requirements are not fully developed, the FAA is reluctant to fully concur with regard to the inclusion of all ERAM-related contract work into the baseline. The FAA will develop the initial implementation of this performance measurement baseline and an associated proposal for how to include planned future work into this EVM system by September 30, 2012.

Recommendation 9: Develop procedures in FAA's "Program Level Integrated Baseline Review Guide" to verify that integrated baseline reviews meet the requirements and to establish a time frame for conducting integrated baseline reviews after executing major contract modifications.

FAA Response: Concur**.** The FAA EVM Focal Point began an initiative in October 2011 to track and ensure Integrated Baseline Reviews (IBR) are conducted on major programs in accordance with the AMS Policy and the IBR Guide. The AMS Policy Section 4.16 EVM requires the conduct of IBR. The FAA's Program Level IBR Guide contains the procedures in section 2.0 used to verify that integrated baseline reviews meet the requirements as stated in AMS Section 4.16 EVM. Section 2.0 Program Level IBR Process provides the necessary steps for IBRs, they include the preparation of an IBR Plan, the approval of the IBR Plan, IBR preparation and conduct, the preparation of findings, the development and approval of an action plan, and the closure of the actions contained in the plan. Each step identifies the responsible office and the process step description. The IBR Guide also provides the time frame for conducting the IBR for major contracts, and if it is not conducted prior to contract award, it must be conducted within 90 to 180 days of contract award or program baseline establishment. Currently, the Guide does not specifically state that an IBR is required after executing major contract modifications. The IBR Guide will be revised to make conducting an IBR after the execution of a major contract modification a requirement by September 30, 2012.

Recommendation 10: Complete the comprehensive risk management guidance that FAA is currently developing, to more effectively manage acquisition risks.

FAA Response: Concur. While the FAA agrees that comprehensive risk management guidance is needed to effectively manage acquisition risks, the risk management toolkit referenced in this recommendation was completed in 2006. The risk management toolkit was based on the Risk Management section of the Systems Engineering Manual

completed in 2002. In a recent update to FAA Acquisition System Toolset, the link published inadvertently directed users to a track changes version of the toolkit rather than the final version. If the OIG used this previous link, it may have appeared that the guidance was not completed. Accordingly, the FAA requests that this recommendation be closed.

Recommendation 11: Assess current testing capabilities and limitations at FAA's Technical Center and develop corrective action plans to more robustly test future complex software-intense air traffic systems.

FAA Response: Concur. The FAA shares OIG's perspective that it is prudent to continually assess capabilities and limitations and develop corrective actions to improve upon our processes and capabilities for all aspects of testing. This is accomplished through the engagement of cross organizational teams to identify test and laboratory requirements and new processes to support program objectives. As issues arise, laboratory managers work with the laboratory users to determine how to improve current testing capabilities and take corrective action as needed.

As part of the current ERAM regression testing conducted at the William J. Hughes Technical Center, ERAM is regularly connected with the following live interfaces: En Route, Oceanic, Terminal, Surveillance, Weather, and Traffic Management. This testing is conducted prior to deployment of an ERAM software release. Additionally, in support of the International Civil Aviation Organization 2012 program, the International Upgrade to Flight Plan Processing, ERAM has established live connections to both Canada and Mexico. These live connections were established in 2010 to support the testing which commenced in late 2011 and continues through 2012.

In addition to the increased use of live interfaces, the Technical Center has improved its simulation capabilities. Starting in early 2011 and continuing through 2012, simulation hardware has been upgraded to allow the simulation of any or all surveillance capabilities (i.e., radars, ADS-B, etc.) used at air traffic control sites. The number and complexity of the simulation scenarios have been improved to allow two ERAM systems and three Terminal systems to be interfaced and run simultaneously. Another example of improved testing capabilities is the incorporation of a shadow mode capability which has been established with several field sites. This effort started in late 2009 and the Standard Terminal Automation Replacement System test team continued to enhance the capability in 2010 to support deployment of a software system release to Philadelphia (PHL). This capability enables the sites' live radar and flight data information to be utilized at the Technical Center over FAA Telecommunications Infrastructure / Bandwidth Manager (currently used for the Terminal Automation Modernization Replacement test program).

As a result of the increased simulation capabilities, the number of lab runs has increased for ERAM testing. The increased demand for lab resources has necessitated the installation of a fifth ERAM testbed to support current ERAM and future NextGen testing needs (i.e., DataComm). This new ERAM laboratory is expected to be available in January 2013 and will have the same capabilities as the other ERAM labs with

connections to the various National Airspace System (NAS) laboratories and live interfaces throughout the Technical Center.

The Technical Center continues to enhance its network infrastructure and connectivity to other laboratory capabilities and assets internally and externally, using a Live Virtual Constructive Environment for distributed simulation and testing activities to support NextGen. A recent example of this capability expansion includes network connectivity to the Florida Test Bed, National Aeronautics and Space Administration North Texas Facility, Department of Defense (DoD) Research and Engineering Network (DREN), and Boeing.

The Technical Center is also exploring tools that could provide the basis for a System of Systems Assessment Platform (SoSAP) for NextGen. SoSAP is a simulation architecture similar to those used by the DOD for concept exploration, requirements definition, and testing complex software-intensive systems. A robust SoSAP would support large scale system testing by using software agents and emulated systems with the system under test to evaluate system behaviors and interactions inherent within complex systems. SoSAP could support multiple phases of the AMS and Ideas to In-Service Process. A demonstration of an early SoSAP prototype, leveraging DOD experience, was provided to the Technical Center Director in May 2012.

The Technical Center has also improved their testing processes, with all of the NextGen Organization's (ANG) Technical Center test organizations and the Laboratory Services Division certified to the International Organization for Standardization (ISO) 9001:2008 quality management standard. The ISO certification provides consistent best practices, standards, and procedures across the ANG test and laboratory organizations. As an example of process improvement, the Technical Center has increased the use of FAA field specialists in the design and execution of system tests.

Additionally, the Air Traffic Systems (ATS) organization, within the Program Management Office (AJM), has begun an assessment of the test capabilities currently at its disposal. This assessment is envisioned to include a review of test assets and processes, gaps in capabilities needed to support known future NextGen programs, and best-practices from other programs that could be expanded or institutionalized. Stakeholders for this assessment would include personnel from AJM, ANG, and various aspects of the operation that currently support test (including facility and operational service unit personnel). This work is planned to produce a cost-benefit analysis (i.e. business case), requirements, and associated work plan, to close the gaps and implement an enhanced, future-state test capability. ATS plans to deliver this business case, requirements, and work plan by the end of FY13.

Recommendation 12: Require complex software-intensive systems (that are interdependent on other systems, such as ERAM) to be successfully tested in a live, operational environment, at one or more FAA air traffic facilities, prior to Government Acceptance.

Appendix. Agency Comments

FAA Response: Concur. The approach prescribed within the AMS currently meets this recommendation and fully supports the notion that complex capabilities must be successfully tested in a live, operational environment at one or more FAA facilities prior to full Government Acceptance (GA). Completion and full closure of GA is an iterative process over the lifecycle of a program. Some level of GA is required in the program's initial implementation to enable the use of the system or service in a live, operational environment (i.e. before it can enter the NAS). GA of any system or service is driven by the ability of that system or service to meet the required specifications developed as part of the contract between the government and the vendor.

Controls exist within the AMS to address the OIG's recommendation at incremental stages. These include the following:

1. Factory Acceptance Testing Milestone - the hardware and software acceptance of the functional specification requirements from the prime contractor;

2. Interface Acceptance Milestone - integration and testing utilizing live interfaces; and

3. Site/System Acceptance Test Milestone - testing required at the site to meet the IOC program milestone.

Beyond ERAM, this approach to GA has and will continue to guide the implementation of the FAA's other systems. This is prescribed in the AMS and is aligned to the OIG's recommendation. The FAA requests that this recommendation be closed.

Recommendation 13: Revise the Acquisition Management System to better define key milestones, such as Government Acceptance and initial operating capability, so that milestones are clear measures of progress for managing major acquisitions.

FAA Response: Concur. Each of the key milestones noted (GA, IOC, and in-service decision) are defined by the current AMS. In their current form, the definition of GA, IOC, and in-service decision represent critical and specific milestones each program must proceed through. However, the FAA recognizes that, in light of the practices on programs such as ERAM, the agency can review the definitions in the AMS to further establish clear criteria for entrance and exit at the referenced key milestones. The FAA has started this review and anticipates that it will be completed by October 30, 2012.