



Major IT Acquisition Audit Steps – FAA’s En Route Automation Modernization (ERAM) Program

U.S. Department of Transportation
Office of Inspector General



Introduction

- ▶ In September 2012, we reported on FAA's En Route Automation Modernization (ERAM) program—a multibillion dollar program that is intended to replace and significantly enhance the hardware and software at FAA's en route facilities that manage high-altitude air traffic.
- ▶ We made a series of recommendations to FAA to improve ERAM's program management, testing, contract structure, and oversight to reduce the associated risks to completing ERAM and to future NextGen-related programs. FAA has been responsive to our recommendations.



Background

- ▶ FAA's goals for NextGen—increasing airspace capacity and reducing flight delays—depend on the success of its efforts to deploy ERAM—a \$2.1 billion system for processing flight data. Without ERAM, the key benefits from new NextGen systems—such as satellite-based surveillance systems and data communications for controllers and pilots—cannot be realized.
- ▶ FAA originally planned to complete fielding ERAM to 20 sites by the end of 2010. However, significant software problems identified early on at the key sites impacted the system's ability to safely manage and separate aircraft and raised questions as to what capabilities ERAM will ultimately deliver.
- ▶ In June 2011, FAA rebaselined ERAM, pushing its expected completion to 2014 and increasing costs by an additional \$330 million.

Background – Definitions

- ▶ **Systems Acquisition**

The sequence of acquisition activities starting with the agency's reconciliation of its mission needs with its capabilities, priorities, resources, and extending through the introduction of a system into operational use.

- ▶ **Traditional Procurement Model**

Requires that agencies solve the entire problem in during pre-award source selection or acquisition planning. Offerors are asked to propose and price the design, development, test, and implementation of a software system that may not be fully defined or understood.

Background – Definitions

▶ Modular Contracting

Offers an alternative acquisition process that allows agencies to incrementally acquire a system. This provides for *design, delivery, implementation, and testing* of a workable system in discrete increments or modules.

The event horizons are much closer, have much less complexity, and are easier to estimate plan, and manage.

- Allows for:
 - Competition
 - Multiple awards
 - Just in time pricing
 - IDIQ Task orders
 - Reduces risks

Background – Modular Contracting

- ▶ U.S. Chief Information Officer issued **“25 Point Implementation Plan to Reform Federal Information Technology Management”** on December 9, 2010
- ▶ Requires:
 - Agencies only approve funding of major IT programs that use a modular approach with usable functionality delivered every six months.
 - Develop flexible budget modules that align with modular development.

Background



25 POINT IMPLEMENTATION PLAN TO REFORM FEDERAL INFORMATION TECHNOLOGY MANAGEMENT

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U.S. Chief Information Officer

DECEMBER 9, 2010



QUESTIONS?

IT Acquisition Jeopardy

What contract type is best for a large-scale major IT System?

- a. Fixed Price
- b. Hybrid
- c. Cost Plus / Cost Plus Award Fee
- d. IDIQ

IT Acquisition Jeopardy

b. What is a hybrid contract.

Example of pricing flexibility a hybrid contract allows.

Contract Line Item Number	Pricing Strategies
System Design	CPFF, CPAF, T&M, or LH
System Requirements Analysis	CPFF or CPAF
Software Coding/ <i>Development</i>	Fixed-price or CPIF
Software Testing	Fixed-price or CPIF
<i>Implementation</i>	<i>Fixed-price or CPIF</i>

Prior Review



- ▶ In 2002, FAA awarded ERAM as a sole source contract. ERAM is a hybrid of multiple-contract types, including Fixed-price incentive, Cost-Plus-Incentive-Fee, and T&M. **The software development and implementation piece was CPIF (largest part).**
- ▶ Incentive fees include: (cost incentives – for delivering below a fixed cost target; schedule incentives for meeting milestones; and performance incentives for meeting performance criteria.
- ▶ **The acquisition plan called for implementing ERAM software beginning in FY 2009 at all (20) centers nationwide and to reach operational use by December 2010. Software Release 1 was intended to replicate the functionality of the current host system and add a few capabilities. Software releases 2 and 3 would add capabilities and would become available to operational sites in September 2009 and September 2010, respectively—concurrently with release 1.**
- ▶ In June 2005 we reported on risks and recommended that **FAA use fixed-price agreements, withhold incentive payments until it met Government criteria (acceptance), and defer work on software development for future capabilities.**

QUESTION?

IT Acquisition Jeopardy

Does modular contracting concepts recommend concurrent development of major software releases?

- a. Yes – delivers system sooner
- b. Yes – saves money
- c. No – push out added functionality and requirements into future releases

IT Acquisition Jeopardy

c. No – push out added functionality and requirements into future releases

Parallel development can significantly reduce development time and allow faster implementation. However, this strategy increases *interface and interoperability risks* and places greater demands on the systems integrator.

Modular contracting can be viewed as a **serial process** in which one module is completed and implemented before subsequent developmental efforts are initiated. (DOD Guide to Modular Contracting)

Current Conditions – September 2011–June 201



- ▶ FAA had been using ERAM to continuously control live traffic at Salt Lake City since October 2010 and at Seattle since December 2010. Other centers were added during our review. 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.
- ▶ **To address these problems**, FAA developed a series of corrective actions, revised schedules –added almost 4 years, and obtained funding (currently up to \$374 million to address the cost overrun/funding shortfall.) For example, FAA spent an average of almost \$16 million a month from January through June 2011 for software builds to correct the problems.
- ▶ FAA plans for all 20 sites to achieve full operational capability and to decommission and remove the legacy HOST system by August 2014.

What Happened? Fundamental Breakdowns in Project Management



- ▶ Up until December 2009, and well after Government Acceptance, FAA reported that ERAM was on track, or ahead of schedule, even through there was already serious problems with the program. *Higher than expected incidence of error reports were ignored.* As a result, when significant problems occurred FAA was not well positioned to address them.
- ▶ FAA underestimated the complexity of implementing ERAM and ignored early warning signs of trouble.
- ▶ FAA did not adequately test ERAM prior to accepting the software for the Government and releasing the software to test sites. Testing at the Technical Center was limited and did not replicate actual field conditions. Government Acceptance is the critical point where the Government assumes full responsibility for paying for and fixing any new problems. However, FAA lacked full understanding of the stability and maturity of the software due to inadequate testing before it accepted the software.

Fundamental Breakdowns in Project Management



- ▶ **FAA did not test the tracker** which may have contributed to ERAM's problems to date.
- ▶ Robust testing with live traffic and active controllers at one or more facilities was not a prerequisite for Government Acceptance. As a result the software was released to test sites with significant and undetermined defects.
- ▶ **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.

QUESTION?

IT Acquisition Jeopardy

Using modular concepts, when should testing occur?

- a. After coding/development (before implementation) – to show that software meets specifications
- b. Before Government acceptance of the software
- c. All of above – During all stages of the life cycle

IT Acquisition Jeopardy

- c. **Integration Testing.** Because of intricacies of integrating separate modules into the overall systems, it is important to establish a testing system that considers the systems at all stages of the life cycle. (DOD Modular Guide)
Other systems and patches unique to each operational site and differences in architecture require site testing when replacing legacy systems.

Fundamental Breakdowns in Project Management

- ▶ **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.
- ▶ **FAA did not set realistic expectations regarding what would be required to implement ERAM.**
 - ▶ The program office did not clearly communicate that the initial software would be relatively immature and was 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. This negatively impacted user confidence in the system.

Fundamental Breakdowns in Project Management



- FAA did not involve the users in the design of the software and did not communicate that ERAM would differ significantly in appearance and function from the HOST. This contributed to a high number of problem trouble reports.

Significant ERAM Events

- ▶ **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.
- ▶ 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.

Significant ERAM Events

- ▶ 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.

QUESTION?

IT Acquisition Jeopardy

Should users be part of the acquisition planning team or project implementation team?

- a. Yes
- b. No – the union would not permit this
- c. No – slows down the process

IT Acquisition Jeopardy

- a. Thousands of AMES reports, a preliminary report to determine whether a software change was needed or error occurred) were issued merely because what the controllers were seeing on the screen wasn't what they were used to and for other reasons. The software didn't act the same or real safety issues were involved. Because the screen results differed many controllers wanted something that looked like the "Host".

As a result tens of thousands of lines of code had to be written to change things that could have been avoided by including the users sooner and communicating in advance about the need for differences.

Contract Structure Reduced Ability to Manage the Contract



- ▶ Due to **insufficient acquisition planning**, FAA did not fully adopt best practices when designing ERAM's contract structure. In addition, weaknesses in acquisition workforce and poor contract management led to insufficient oversight.
- ▶ FAA's large scale contract structure made it difficult to account for individual factors that were driving cost overruns. For example, FAA designed a single, large CLIN that contains over 9 years (as modified) and over \$1 billion of work related to release 1. FAA included *all design, development, testing, and implementation in the same CLIN, rather than Sub-CLINS* and did not establish separate CLINS for individual implementation sites.
 - ▶ Tracking and identifying the extent and sources of cost overruns was almost impossible.
 - ▶ Advantages of using different contract types, incentivizing, and controlling costs with targets was difficult.

QUESTION?

IT Acquisition Jeopardy

What is the best time period to use for measuring a cost target/incentive?

- a. After periods of 6 months to 12 months based on the deliverable period for the module.
- b. After completing the CLIN for a traditional IT system acquisition.
- c. After 6 months intervals or builds for any IT system acquisition.
- d. A and C, depending on whether a modular or traditional acquisition occurs.

IT Acquisition Jeopardy

What is a and c. The cost incentives were ineffective because they periods went on for years and FAA continued to pay the base incentive fee for each CLIN as worked progressed. CLINS ranged from 3 to 9 years. Cost target were modified when initial targets were exceeded because requirements were not well defined. **Modular practices would allow for shorter intervals and closer horizons to better control costs. For traditional acquisitions a spiral “build a little/test a little” approach could be used with incentive dates set every six months or at the end of a build.**

Weaknesses in ERAM's Contract Structure



Best practices for structuring contracts	Weaknesses in ERAM's contract structure
<p>Modular contracting should be used to divide major systems acquisitions into manageable contract tasks completed every 6–12 months.</p>	<p>FAA did not divide ERAM into manageable contract segments, and it develops software releases concurrently, which increases interface and inoperability risks.</p>
<p>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.</p>	<p>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.</p>
<p>Scope, costs, and contract terms should be definitized (or finalized) in a timely manner.</p>	<p>FAA has not always definitized scope and costs in a timely manner.</p>
<p>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.</p>	<p>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.</p>

Contract Structure issues



- ▶ **Requirements Issue Impacted Cost and Schedule.** Systems architecture was not adequately addressed during acquisition planning—or clearly addressed in the solicitation or statement of work. Each stand alone Host at the 20 en route sites was greatly modified to adapt to different systems that existed at each location. Host software was also patched to adjust for differences in climate, winds, geography, etc. More code was required for implementation than expected. **It took 9 years before a common system architecture was identified.**
- ▶ **Core Functionality was never addressed or agreed upon until 2011.** The users (air traffic controllers) and their Union was excluded from planning and design considerations. When ERAM was introduced at initial Test Sites it did not look the same as HOST. Numerous problem reports were issued and thousands of lines of code were written to get it to look more like HOST. Training had to be reintroduced because ERAM was taken down to correct software defects.

QUESTION?

IT Acquisition Jeopardy

When should a common architecture best be established for an IT acquisition?

- a. Before Government acceptance of software design
- b. During acquisition planning
- c. Before reaching Initial Operating Capability as test sites.

IT Acquisition Jeopardy

- b. What is acquisition planning? The budget baseline can be exceeded if workarounds or added coding is required to successfully interface with systems at each site. At one point 80 percent of all code written was to adjust for interface problems. Waterfall delays occurred. The contractor lacks a solid basis to bid until the system architecture is agreed upon.

For **modular contracting** when the Government takes a large requirement and breaks it down into successive acquisitions of interoperable increments, it must address the integration process. Contractor support may be needed. The best way to mitigate the modular risk is the formulation and enforcement of systems architecture.

Contract Structure Issues

- ▶ **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. FAR, which FAA does not follow, allows no more than 180 days for letter contract definitization. FAA did not meet its own contract terms or the FAR benchmark of 180 days for definitizing ERAM.
 - FAA was still working to definitize 16 out of 57 CLINs for the contract, even though the contractor has been authorized to work on them.
 - FAA initially definitized one of these CLINs 48 days after FAR's 180 day benchmark. However, FAA has since modified this CLIN 45 times—increasing target costs by \$328 million. (Cost target increased 45 times.)

Weaknesses in ERAM's Contracting Staff and Management



Requirement or best practice for contract management	Weaknesses in ERAM's Contract Management
<p><i>Contracting office staff</i> should be consistent and have institutional knowledge of the contract.</p>	<p>ERAM has experienced high CO turnover. Contracting staff rely heavily on support contractors. (8 COs in 9 years.)</p>
<p><i>Contract file</i> should contain an organized record of all contractual actions.</p>	<p>ERAM's contract files are disorganized, incomplete, and not centrally located.</p>
<p>When <i>reviewing invoices</i>, the contracting officer's technical representative (COTR) should require supporting documentation to prevent unallowable costs.</p>	<p>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.</p>
<p><i>Program operations field managers (POFM)</i>, regional staff who oversee contractor performance at facilities nationwide, should be trained on monitoring contractor performance and be given guidance on the contract.</p>	<p>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.</p>

Contract Management Issues

- ▶ **GAO reported that a consistent and stable contracting staff is a critical factor for successful major systems acquisitions. The effects of high turnover are exacerbated by incomplete and poorly organized contract files.**
 - ERAM's contract files did not contain a complete history of all contractual actions, for example, FAA could not support 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.
 - COs relied 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.

Ineffective Use of Management Tools

Effective use of management tools	Ineffective use of ERAM's management tools
<p><i>Earned Value Management (EVM)</i> systems must include all work to completion for accurate forecasts of schedule and cost trends.</p>	<p>ERAM's EVM system does not include all work, so forecasts are inaccurate and <i>do not help detect problems</i> with the program.</p>
<p><i>Integrated Baseline Reviews (IBRs)</i> should be performed early to ensure adequate planning.</p>	<p>FAA did not complete IBRs for four of its five largest contract modifications—each exceeding \$100M.</p>
<p><i>Risk management process</i> should provide early detection of risks.</p>	<p>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.</p>

Contract/Program Tools Issues

- ▶ **EVM.** FAA incorrectly implemented ERAM's EVM system, a management tool intended to forecast performance trends and help managers identify cost and schedule problems early. EVM systems should compare performance against a baseline, which should include all authorized work for the program. The EVM baseline for ERAM was based on the contract's baseline and WBS, rather than those for the overall program.
- ▶ **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, adding 4 years and \$330 million.

Contract/Program Tools Issues

- ▶ **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.
- ▶ FAA did not conduct its initial IBR for ERAM until 337 days after contract award. 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.

Contract/Program Tools Issues

- ▶ **Risk Management Process.** FAA did not sufficiently identify ERAM's risks early in the program. 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, yet FAA's risk management process for ERAM did not detect significant risks until January 2011—almost 2 years later.**
 - 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.

Steps to “Do”

1. Look for early warning signs of trouble with software. Ask why?
2. Review the test procedures. Did they fully replicate field conditions? (Was the lab or contractor able to do this?)
3. Find out whether live testing at a site was a prerequisite for Government Acceptance.
4. Review the GA rationale.
5. Review the acquisition planning. Were users part of the plan and design team?
6. Ensure core functionality was agreed to early.
7. Determine whether system architecture (different lining systems at sites and conditions) was described in solicitation, RFP, and statement of work.
8. Determine whether milestones were reasonable for measuring progress and keeping management informed.
9. Determine whether software releases were locked down before introducing new functionality. Concurrent releases increase risks when software is unstable or immature.
10. Evaluate interface and interoperability risks. (Concurrent releases, different systems at sites, different architecture and site conditions.)
11. Determine whether Modular Contracting was used, short-term contract segments with deliverables in 6–12 months.
12. Determine whether multiple CLINS or Sub-CLINS are used for cost-reimbursement contracts to better measure, and control cost, schedule, and performance.

Steps to “Do”

13. Determine whether CLIN’s scope and costs are “definitized” within 180 days.
14. Determine whether program and contract staff is stable and that documentation is available in the contract files to support key decisions.
15. Review the reasonableness of incentive award decisions, award fee criteria (if used).
16. Ensure that cost targets for incentives are based on reasonably short periods and that cost targets are stable and not changed without sufficient justification.
17. Determine whether the invoice review process is reasonable.
18. Ensure that CORS are trained and supporting progress and properly documenting progress and aware fee evaluation criteria.
19. Program office, field site staff, and contractor are communicating.
20. Determine whether EVM is properly designed and that the baseline includes all milestones and authorized work and that it is based on the progress completed.
21. Determine whether IBR are completed timely and for major modifications. Review the risks reported and mitigation steps.
22. Determine whether a risk assessment team identifies major risks and is working with the contractors to mitigate the risks.