Office of Inspector General
Audit Report

FAA'S ACQUISITION STRATEGY FOR TERMINAL MODERNIZATION IS AT RISK FOR COST INCREASES, SCHEDULE DELAYS, AND PERFORMANCE SHORTFALLS

Federal Aviation Administration

Report Number: AV-2013-097
Date Issued: May 29, 2013

Memorandum

**U.S. Department of
Transportation**

Office of the Secretary
of Transportation

Office of Inspector General

Subject: <u>ACTION</u>: FAA's Acquisition Strategy for Terminal Modernization Is at Risk for Cost Increases, Schedule Delays, and Performance Shortfalls
Federal Aviation Administration
Report Number AV-2013-097

Date: May 29, 2013

From: Jeffrey B. Guzzetti
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   for Aviation Audits

Reply to
Attn. of: JA-10

To: Federal Aviation Administrator

The Federal Aviation Administration (FAA) operates more than 200 terminal radar approach control (TRACON) air traffic control facilities. In 1996, FAA began a plan to modernize and standardize the terminal automation systems that controllers rely on to manage traffic within a 50-mile radius of airports by implementing the Standard Terminal Automation Replacement System (STARS) throughout the National Airspace System (NAS). However, FAA has experienced significant cost growth and schedule delays with STARS and needed an interim solution to satisfy immediate modernization needs. From 1998 to 2003, FAA updated existing software and hardware for automation systems at sites yet to be converted to STARS. These systems were referred to as the Common Automated Radar Terminal System (CARTS).

By 2004, FAA was operating two distinct systems at different TRACONs—either CARTS or STARS. In the same year, FAA decided to revise its terminal automation approach through a three-phased acquisition strategy designed to reduce costs by reevaluating alternatives and incorporating lessons learned from earlier phases. Renamed the Terminal Automation Modernization/Replacement (TAMR) program, this effort is now necessary both to replace aging equipment and achieve FAA's goals to enhance capacity and reduce delays through the Next Generation Air Transportation System (NextGen).

Since 2003, we have reported on FAA's progress and challenges with terminal modernization and have noted that changing requirements significantly contribute
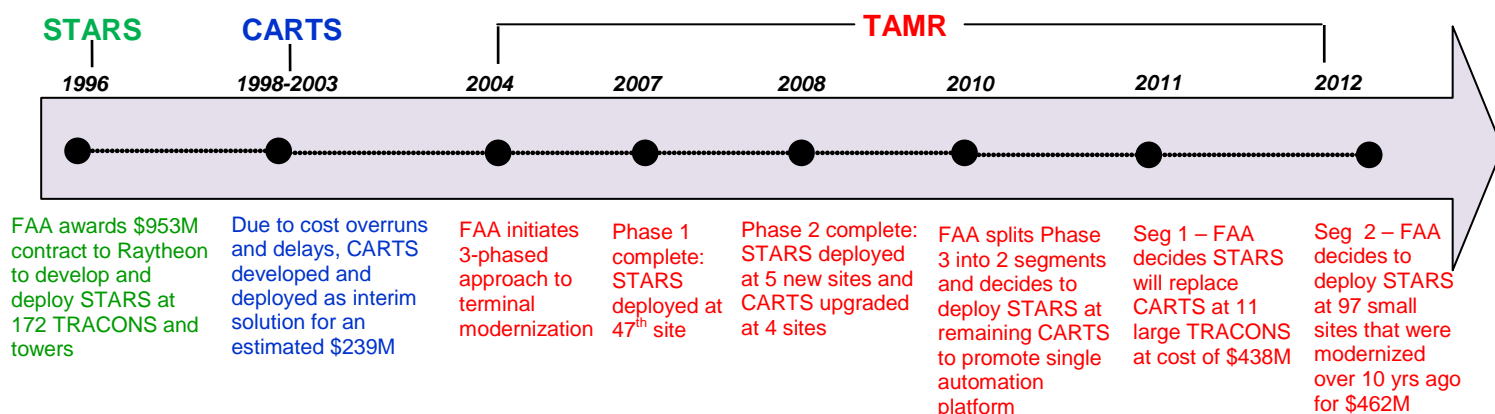
to schedule delays and cost growth.[1] Given FAA's past issues with terminal modernization and the importance of FAA's TAMR program in meeting the Agency's NextGen goals, we initiated this audit to evaluate FAA's current terminal modernization effort. Specifically, our audit focuses on the current phase of TAMR—TAMR Phase 3, Segment 1—which aims to replace CARTS with an updated version of STARS at 11 sites, some of which are the largest and most important TRACONs in the NAS. Our audit objectives were to assess (1) risks related to developing and implementing software and hardware requirements for Phase 3, Segment 1 and (2) whether FAA's final investment decision resulted in a reliable cost and schedule baseline.

We conducted this audit in accordance with generally accepted Government auditing standards. Exhibit A details our scope and methodology, and exhibit B provides a list of the organizations we visited or contacted.

BACKGROUND

In the 1970s and 1980s, FAA implemented its first Automated Radar Terminal systems (ARTS) at TRACONs, which displayed radar feeds to help controllers control takeoffs and landings, the most critical phases of flights. FAA's efforts to modernize these systems since 1996 are illustrated in the following timeline (figure 1).

Figure 1. Timeline of FAA's Terminal Modernization Efforts

STARS | **CARTS** | | | **TAMR** | | |
1996 | **1998-2003** | **2004** | **2007** | **2008** | **2010** | **2011** | **2012**

FAA awards $953M contract to Raytheon to develop and deploy STARS at 172 TRACONS and towers | Due to cost overruns and delays, CARTS developed and deployed as interim solution for an estimated $239M | FAA initiates 3-phased approach to terminal modernization | Phase 1 complete: STARS deployed at 47th site | Phase 2 complete: STARS deployed at 5 new sites and CARTS upgraded at 4 sites | FAA splits Phase 3 into 2 segments and decides to deploy STARS at remaining CARTS to promote single automation platform | Seg 1 – FAA decides STARS will replace CARTS at 11 large TRACONS at cost of $438M | Seg 2 – FAA decides to deploy STARS at 97 small sites that were modernized over 10 yrs ago for $462M

FAA's TAMR effort is designed to modernize air traffic control facilities to handle increased traffic and will support NextGen initiatives, such as the use of a satellite-based air traffic surveillance program, Automatic Dependent

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[1] OIG Report Number AV-2003-058, "FAA Needs To Reevaluate STARS Costs and Consider Other Alternatives," September 9, 2003; OIG Report Number AV-2005-016, "Report on Terminal Modernization: FAA Needs To Address Its Small, Medium, and Large Sites Based on Cost, Time, and Capability," November 23, 2004; OIG Report Number AV-2005-061, "Status of FAA`s Major Acquisitions: Cost Growth and Schedule Delays Continue to Stall Air Traffic Modernization," May 26, 2005. OIG reports are available on our Web site at http://www.oig.dot.gov.

Surveillance-Broadcast (ADS-B). FAA is currently in Phase 3 of TAMR. For this phase, FAA originally planned to replace all 108 of the remaining CARTS systems, but in April 2010 the Agency broke up the phase into 2 segments. The first segment focused on short-term (11 TRACONs with large traffic volumes) planning objectives, while the second segment focused on mid-term (97 TRACONs with small traffic volumes) planning objectives. In September 2010, FAA decided to deploy STARS as the terminal automation system to best promote FAA's goal for a single terminal automation platform. On December 21, 2011, FAA completed its final investment decision for Segment 1, pushing estimated completion to 2017. On September 19, 2012, FAA completed its final investment decision for Segment 2.

FAA's capital investment programs, such as TAMR, generally follow the acquisition lifecycle set forth in the Agency's Acquisition Management System (AMS), which establishes policy and guidance for all aspects of FAA's acquisition process. Programs are generally baselined at the final investment decision milestone when the Joint Resources Council (JRC)[2] approves the cost and schedule parameters, the specific performance requirements, and expected benefits for a program. Prior to the final investment decision, AMS requires the program office to manage the investment by developing a business case along with supporting documentation (e.g., implementation strategy and planning document, program requirements document) to support the baseline decision. FAA's Investment Planning and Analysis office must validate the supporting information to ensure the business case provides a credible picture of the investment and its impact on the NAS. The office also evaluates and assesses the cost, benefits, risks, schedule, and economics of a particular initiative. FAA considers this effort crucial for reducing the risks of a program's investment decision.

RESULTS IN BRIEF

FAA faces significant risks in developing and implementing the technical requirements for its current terminal modernization effort. Specifically, FAA has yet to identify and finalize all the software and hardware requirements needed to successfully replace CARTS with STARS at the 11 large TRACONs. FAA must first modernize STARS hardware to meet the current capabilities of CARTS, but has encountered problems such as keyboard failures that have resulted in delays. Furthermore, while FAA anticipated the need for developing 94 software and hardware requirements (referred to as "gaps") that are critical for successfully replacing CARTS with STARS, at least 5 more gaps have been identified that will require extensive software development and testing. FAA anticipates identifying more gaps once it begins transitioning to STARS at the highest-volume

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[2] The JRC is FAA's investment review board. It makes corporate-level resource decisions, including authorization and funding for new investment programs.

TRACONs, which could further delay implementation. At the same time, because full STARS capability at the 11 sites is still years away, FAA is continuing to add new capabilities to CARTS at select facilities to support air traffic operations. The longer FAA must maintain and update CARTS at these sites, the greater the implementation risk because FAA will have to add the same new capabilities to STARS to maintain functionality at the 11 sites.

FAA's final investment decision did not result in a reliable schedule and cost baseline for implementing STARS at the 11 large TRACONs, putting TAMR at risk of further schedule delays and cost growth. For example, FAA's approved schedule to deploy STARS by 2017 lacks key deployment milestones and completion dates and was not evaluated for risk per AMS requirements. Moreover, in July 2012, 6 months after its final investment decision, TAMR program officials approved a different schedule with the STARS contractor that requires the contractor to deploy STARS systems more than a year *earlier* than the baseline schedule. This timeframe ignores repeated concerns that FAA's software development and testing efforts would likely require additional time. As a result, it remains unclear how and when FAA will accomplish all the tasks necessary to implement STARS at the 11 sites. FAA's current cost estimates are similarly unreliable because FAA omitted major program cost elements from the cost baseline approved during its final investment decision. For example, even though the TAMR schedule extends through 2017, FAA's approved cost baseline of $438 million only covers the effort through 2015, and it remains unclear how the additional 2 years will be funded. The Agency also excluded anticipated technical refresh and modernization costs, estimated at $270 million, as well as longer-term, undetermined costs to continue maintaining and upgrading CARTS longer than originally planned. Finally, we found that the work products used to support the TAMR business case contained inconsistent information or lacked key details, further undermining FAA's ability to know the true costs and timeline of TAMR and its impact to the NAS.

We are making recommendations to FAA to address challenges and risks to its terminal modernization efforts.

FAA FACES CONSIDERABLE RISKS IN DEVELOPING AND IMPLEMENTING SOFTWARE AND HARDWARE REQUIREMENTS

FAA faces significant risks with its current terminal modernization effort because it has not yet finalized the technical requirements for the complex transition from CARTS to STARS. According to FAA, to successfully execute its acquisition strategy and implement STARS at the 11 large sites, the Agency must develop, test, and deploy upgrades to STARS hardware and software before it can fully replace the current CARTS systems. In the meantime, FAA must also continue to

maintain and sustain CARTS at the 11 facilities until the STARS replacement is accomplished. Without finalized requirements for these efforts, the Agency is at risk of increased software development costs and implementation delays.

FAA Must Address Problems With STARS Modernization Before It Can Meet the Existing CARTS Functionality

FAA has yet to identify and finalize all the software and hardware requirements needed to successfully replace CARTS with STARS at the 11 TRACONs. This lack of firm requirements is a particular concern given the complex and simultaneous efforts needed for this transition. First, FAA must modernize STARS hardware (i.e., computer processors, monitors, operating systems, and the dual display architecture), which will involve extensive testing to determine whether the hardware is fit for use.

At the same time, FAA must update STARS software to obtain the enhanced functionality required to support the 11 large TRACONs. For example, one enhancement would enable STARS to support more than 8 remote towers—an important upgrade given that 6 of the 11 sites have more than 8 remote towers. Another enhancement would reduce STARS recovery time from power failures from 6 minutes to 60 seconds. In accordance with its NextGen plans, FAA is also planning to deploy new ADS-B functionality at all STARS sites, which will require further operational testing and evaluation activities.

FAA considers the greatest risks to STARS development to be software development and acceptance. In particular, after upgrading STARS hardware and software, FAA will then need to incorporate at least 100 new functions, referred to as "gaps," into STARS to mirror the capabilities that CARTS currently provides. In modernizing and upgrading STARS for use at the 11 TRACONs, FAA initially identified the need to develop and implement 94 gaps in order for STARS to perform the same functionality as CARTS. These gaps equate to about 80,000 lines of software code and require extensive development and testing before they can be accepted by FAA. However, according to an FAA analysis of past STARS software development, it takes on average 16 months for a software build with about 13,000 lines of code to be developed, tested, and accepted by FAA. Consequently, FAA's plan to deliver the 80,000 lines of software code at the first key site by September 2014—only 33 months after the program was baselined—is a high-risk endeavor. These risks will be further exacerbated if FAA follows through with its contract plans to achieve operational capability at the first key site by February 2013.

Some of the needed gaps in STARS are critical for safely managing aircraft (see table 1). For example, automatic proximity alerts will help controllers maintain safe separation distances between aircraft in the terminal environment. However,

the proximity alerts will require extensive software development that will be time-consuming to install because of their impact on STARS operational software that supports existing capabilities.

Table 1. Key Gaps (Requirements) Needed To Upgrade STARS

Gap Item	Operational/Technical Impact
Automatic Proximity Alerts	Added software will improve situational awareness by automating a function to alert controllers of loss of separation.
Automatic Update of Altimeter Settings	Added software will allow controllers to determine proper altitude of aircraft.
Modernized Computer Data Recovery	Added hardware and software will allow continuous recording of data without manual intervention.
Number of Remote Towers	Added hardware will allow the use of STARS at TRACONs with more than eight remote towers.
Airspace Violator Alert	Added software will allow controllers to identify potential airspace violators.

Source: FAA.

Furthermore, FAA has not yet determined all the site-specific requirements needed to provide STARS with the necessary capabilities and anticipates discovering additional gaps as site surveys and deployment continue. For example, FAA identified 5 new gaps in July 2011 after it submitted the original 94 gaps to the contractor for cost proposal development. The five new gaps were generated during site surveys conducted at the Segment 1 sites. While FAA officials do not consider these gaps as having a significant impact on STARS performance, the Agency has yet to complete site surveys that may uncover more gaps. Until FAA determines whether new gaps exist and how they will be implemented, the Agency will not know the extent of the cost and schedule risks that the resulting requirements may present to successfully implementing STARS.

In addition, MITRE[3] has reported that the more traffic volume that exists at a site, the more complex the transition to STARS will likely be, increasing the chance for additional requirements that will take added time to complete. This is a particular concern because 7 of the 11 Segment 1 TRACONs are the largest in traffic volume for 2011, as shown in table 2.

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[3] MITRE Corporation manages FAA's federally funded research and development center.

Table 2. Traffic Volume for CARTS Facilities Slated for STARS in Segment 1

Facility	Traffic Volume (2011)	Rank
Southern California TRACON	1,985,000	1
New York TRACON	1,894,000	2
Potomac TRACON	1,492,000	3
Northern California TRACON	1,464,000	4
Chicago TRACON	1,243,000	5
Atlanta TRACON	1,223,000	6
Dallas Fort-Worth TRACON	1,120,000	7
Denver TRACON	886,000	10
Minneapolis TRACON	552,000	18
St. Louis TRACON	319,000	26
Louisville TRACON	212,000	50

Source: FAA Operations Network.

FAA's risks related to its still-evolving requirements are highlighted in several unanticipated technical issues that FAA has already reported, which may impact milestones. For example, in the midst of hardware and software modernization activities, keyboards for STARS equipment have been failing at higher than normal rates, and the Agency is reviewing various options if the STARS contractor cannot identify a fix. This has resulted in delays in installing the dual display architecture for aiding the transition from CARTS to STARS at the initial key site. In addition, a key software build that incorporates needed STARS enhancements has required more updates, and FAA has expanded the number of operational test sites initially planned, resulting in more delays. FAA is actively addressing these challenges; however, the potential exists for more unanticipated delays associated with the program's still-evolving requirements.

FAA Is Adding New Capabilities to CARTS, Which May Further Impact the STARS Transition

As FAA works to upgrade STARS, the Agency is also managing CARTS systems with differing capabilities across the NAS, further complicating terminal modernization efforts. Because STARS implementation at the 11 sites is still years away, FAA is continuing to add new functionality to CARTS at select facilities to support air traffic operations. For example, FAA is currently upgrading CARTS hardware at the New York TRACON to support ADS-B. The Agency has also added proximity alert technology at Minneapolis and St. Louis TRACONs and is

planning to implement this technology at the other sites that will be replaced with STARS, with the exception of Dallas-Fort Worth.

These simultaneous upgrades to CARTS pose several challenges to FAA. In a September 2011 report, MITRE stated—and we agree—that the more operational enhancements FAA continues to add to the CARTS system, the more difficult it will be to gain user support for the transition from CARTS to STARS, because CARTS will already be providing all the capabilities that controllers need. In addition, the longer FAA is forced to maintain and update CARTS at these sites, the greater the risk for new STARS requirements, as more software development will likely be required to ensure STARS systems meet the functionality for the 11 sites that the CARTS systems already provide.

FAA'S FINAL INVESTMENT DECISION DID NOT RESULT IN A RELIABLE COST AND SCHEDULE FOR IMPLEMENTING STARS

FAA held a final investment decision for the 11 sites in December 2011—after postponing it four times since March 2010—and approved a schedule baseline through 2017 and a cost baseline of $438 million. However, several factors limit the reliability of this baseline. First, the approved baseline schedule lacks completion dates such as detailed milestones for software development and deployment activities and a complete risk assessment per AMS guidelines. In addition, the approved schedule is in conflict with the deployment schedule negotiated with the contractor. Second, cost elements for developing STARS hardware and software and sustaining CARTS were omitted from FAA's TAMR business case. In addition, program funding approved in the cost baseline was only budgeted through 2015, even though the schedule baseline has a 2017 completion date. FAA also used incomplete work products that did not comply with AMS as its basis for approving the program. Because FAA approved the TAMR program with unreliable schedule and cost data and incomplete supporting work products, considerable risks and uncertainty exists regarding when the Agency will complete this effort and at what cost.

FAA's Approved Baseline Schedule Lacks Completion Dates and Milestones and Conflicts With the Contract Schedule, Which Introduces High-Level Risk

FAA's approved baseline schedule lacks detailed milestones, limiting its reliability as an indicator of the true timeline for successfully implementing STARS at the 11 large TRACONs. Originally slated to proceed until 2015, the approved TAMR schedule was revised on the date of the final investment decision meeting (December 21, 2011), to extend completion time of the 11 sites initial operating

capability (IOC)[4] to 2016, and full operational capability to 2017. This was done because major concerns were raised within FAA after several independent evaluations of TAMR's detailed working schedules highlighted major risks with the contractor's ability to complete IOC for all 11 sites by 2015. For example, MITRE reported in September 2011 that FAA's software development efforts would likely require additional time for operational testing and acceptance. The same report also identified that FAA officials in the TAMR program office and FAA Technical Center anticipated significant risk regarding implementation of new hardware elements for STARS. MITRE also recommended in December 2011 that FAA address software deployment risks by allotting more time to specific deployment milestones in the approved baseline schedule.[5]

However, the new schedule that FAA senior management both proposed and approved at the final investment decision meeting did not undergo a risk assessment, as required by AMS, to ensure it was feasible, and lacked completion dates for 8 sites as well as key milestones for hardware and software development, testing, and deployment activities at all 11 sites (see exhibit C). Establishing these milestones is important because 129 remote air traffic control facilities are associated with these 11 TRACONs, and STARS must be deployed to those sites as well.

Moreover, despite the concerns raised by MITRE and other FAA officials, TAMR program officials approved a new schedule with the STARS contractor in July 2012 that conflicts with the baseline schedule FAA senior management approved at the December 2011 final investment decision. FAA's actions raise major concerns about its schedule's reliability, particularly regarding the dates for achieving IOC for all 11 sites. For example, FAA directed the contractor to complete IOC a year and a half earlier for the first site than approved in the final investment decision baseline. This re-introduces the high level of risk FAA originally identified during its independent evaluations of TAMR's detailed working schedules, because it does not allow the time for software development and testing that FAA senior managers previously allocated.

According to AMS, schedule risks result from the likelihood that program actions may not be accomplished in the amount of time planned. However, a detailed program schedule that identifies each milestone and the critical steps to achieving it are necessary to identify and mitigate schedule risks. FAA officials state they performed sufficient risk assessment activities and met the intent of AMS by adding the 2 years to its approved schedule. However, FAA's actions to direct the

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[4] Initial Operating Capability (IOC) is the milestone where controllers begin to use the system on a limited basis to manage traffic.
[5] MITRE Briefing: "TAMR Program Phase 3 Interview Report," dated September 2011, and MITRE Briefing: "TAMR Program Phase 3 Segment 1 Schedule Analysis," dated December 2011.

contractor to complete IOC a year and a half earlier than the approved schedule raises concerns about whether FAA sufficiently addressed the schedule risks (see table 3).

Table 3. FAA's Approved Baseline Schedule Conflicts With the Contract Schedule for Implementing the 11 Sites

Facility		IOC Baselined December 2011	IOC Contract July 2012
1.	Dallas Fort-Worth TRACON	September 2014	February 2013
2.	Northern California TRACON	TBD	October 2013
3.	Atlanta TRACON	TBD	February 2014
4.	Southern California TRACON	TBD	June 2014
5.	Minneapolis TRACON	October 2015	August 2014
6.	Potomac TRACON	TBD	October 2014
7.	Denver TRACON	TBD	February 2015
8.	St. Louis TRACON	TBD	April 2015
9.	Louisville TRACON	TBD	June 2015
10.	Chicago TRACON	TBD	June 2015
11.	New York TRACON	October 2016	October 2015

Source: FAA's Acquisition Program Schedule Baseline for TAMR Phase 3, Segment 1, and STARS Contract Mod 79.
IOC - Initial Operating Capability is defined as site using TAMR Phase 3 hardware and software components operationally to control air traffic over a 2-4 hour period, typically on a mid-shift.
TBD - To be determined.

FAA's Omission of Key Cost Elements in the TAMR Business Case Masks the True Costs To Implement STARS and Increases the Risk of Further Cost Growth

FAA's current cost estimates for TAMR are similarly unreliable because FAA omitted key program cost elements from the cost baseline and business case approved in December 2011. According to AMS, the business case analysis at the final investment decision must present updated cost, schedule, benefit, and risk information for an alternative generated from an initial investment analysis. However, FAA's business case information was never updated. Additionally, FAA did not include an analysis to determine whether TAMR achieved the required 80-percent confidence level for success, and a cost/benefit analysis to justify the

expected benefits associated with this acquisition. Instead, FAA performed a cost effectiveness analysis[6] comparing two alternatives:

- Replacing all 11 TAMR Phase 3, Segment 1 sites with STARS at a cost of $462 million (Preferred Alternative)

- Maintaining the Segment 1 CARTS sites and replacing the 52 STARS Phase 1 sites with CARTS (Base Case) at a cost of $731 million

FAA chose the Preferred Alternative since the analysis indicated it was more cost effective and a better overall value.[7] However, this amount excludes a major known cost factor—technical refresh and modernization costs (estimated to cost $270 million between 2013 and 2017) to support computer hardware and software upgrades—even though some of these are key enhancements required to address the gap requirements. FAA stated that these were excluded because they were part of a separate cost baseline. However, several technical refresh activities are prerequisites to deploying STARS at the 11 Segment 1 sites.

In addition, the TAMR business case did not account for unknown, longer-term costs, such as maintaining and upgrading CARTS longer than originally planned at sites until they receive STARS. For example, FAA spent $16 million on CARTS upgrades at the New York TRACON because STARS was not ready for deployment and the TRACON needed to meet near-term ADS-B requirements. The original CARTS contract, awarded in March 1999, was slated to expire on September 2011. However, the CARTS contract had to be extended twice—first to March 2012 at a cost of $2 million, and then to March 2013 at a cost of $11 million—primarily due to delays in investment decisions for TAMR. After this contract expires, FAA anticipates awarding a 6-year CARTS contract focusing on equipment, software, maintenance, and engineering service; however, the costs to sustain CARTS in the long-term remain undetermined.

FAA's Cost Baseline Does Not Include Funds To Support the Last 2 Years of Implementation or Address Funding Shortfalls

FAA's cost baseline to support STARS deployment through fiscal year 2015 is $438 million. However, funds will be required to support FAA's terminal modernization goals beyond 2015, as the Agency plans to complete implementing initial STARS capabilities in 2016 and full STARS capabilities in 2017 for the 11 large TRACONs. FAA has yet to determine the required additional funding needed to support the remaining 2 years of TAMR implementation.

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[6] TAMR Phase 3, Segment 1 did not perform a traditional benefits analysis and relied on a cost effectiveness study. As stated in its business case analysis, "a cost effectiveness analysis is effective whenever it is unnecessary or impractical to consider the dollar value of the benefits provided by the alternative under consideration."

[7] FAA stated that it substituted a cost effectiveness analysis in alignment with Office of Management and Budget (OMB) guidance. However, the OMB document clearly states that its guidance should not supersede agency requirements.

Even before FAA extended the completion date for the 11 sites out by 2 years, it was already facing a $115 million funding shortfall. Table 4 shows FAA's approved baseline cost and funding plan and shortfall for the TAMR program at the time of the final investment decision.

Table 4. Funding Shortfall To Implement the 11 Sites

TAMR Phase 3 Segment 1	Cost Baseline ($ in Millions)						
Cost Element	Prior	FY 11	FY 12	FY13	FY14	FY15	Total
TAMR Phase 3 Segment 1	$11.1	$49.9	$140.2	$143.1	$76.5	$17.2	$438.0
Capital Investment Plan	$38.0	$59.9	$103.3	$74.7	$32.2	$14.8	$322.9
Delta: CIP less Baseline	$26.9	$10.0	($36.9)	($68.4)	($44.3)	($2.4)	($115.1)
Remaining Balance	**$26.9**	**$36.9**	**$0.0**	**($68.4)**	**($112.7)**	**($115.1)**	

Source: TAMR JRC Final Investment Decision, December 21, 2011.

In comparison with earlier planning estimates included in its Capital Investment Plan, FAA's cost baseline for TAMR results in shortfalls of about $68 million in 2013, $44 million in 2014, and $2 million in 2015. However, officials from FAA's budget office state that they have now eliminated the shortfall by reprogramming and readjusting funds from other capital programs. We caution that funding program shortfalls from capital budgets that are projected to be flat in the near future will negatively impact FAA's long-term ability to sustain and modernize existing systems and develop new systems.

FAA's Supporting Documents for the Final Investment Decision Did Not Adhere to AMS

Despite approving the TAMR plan for the 11 sites in December 2011, FAA did not provide a credible and complete picture of its investment and its impact to the NAS. We found that work products used to support the TAMR business case contained inconsistent information or lacked key details, further underscoring that FAA did not perform complete validation and verification activities before deciding to move forward. According to FAA's AMS policy for acquisitions, an investment analysis plan must be well conceived, low risk, well documented, and well understood. FAA is required to validate and verify its business case and other supporting work products that are the basis for the recommendation to approve or decline moving forward with a program prior to the final investment decision. Table 5 highlights specific problems we identified with work products FAA used to support the TAMR final investment decision.

Table 5. Incomplete Work Products Used for TAMR's Final Investment Decision

Work Product	AMS Requirements	Problems Identified
Implementation Strategy and Planning Document (ISPD)	• Defines overall implementation strategy and planning for the investment program. Conveys the most critical, relevant, and meaningful information about how a program will be implemented and managed. • The ISPD should be finalized before it is submitted to the JRC, contain a program schedule based on a work breakdown structure, and be consistent with the schedule in the business case analysis.	The ISPD included in the TAMR final investment decision did not contain a schedule with a work breakdown structure—and indicated that one would not be available until the final schedule is approved and authorized. A few days prior to the final investment decision meeting, FAA included a schedule in the ISPD as an addendum. However, the schedule conflicts with the schedules presented in both the acquisition program baseline and the business case analysis.
Program Requirements Document	• When presented at the final investment decision, must clearly define the operational framework and requirements the program must achieve.	Despite AMS requirements, FAA opted not to produce a program requirements document for the TAMR final investment decision because it initially indicated the program would primarily be a technical refresh effort. However, the effort has since become significantly more complex. FAA later indicated that in lieu of a requirements document, it would update the TAMR system-level specification document to include any new requirements. However, this specification document is not an effective substitute because it is much less specific, pertinent, and focused.
Independent Evaluation Review (IER)	• Prior to a final investment decision, FAA's Investment Planning and Analysis office validates investments by assessing the cost, benefits, risks, and schedule for a program. The group presents its findings to FAA senior management in the form of an IER.	The IER document contained two conflicting implementation schedules. Additionally the IER office appears to have verified the preliminary rather than the approved baseline schedule referenced in the acquisition program baseline. The preliminary schedule, referenced in the business case analysis, did not include the 2 years added to the approved baseline schedule. The extension of several baseline milestones in the approved schedule will likely result in additional costs over the $438 million approved.
Acquisition Program Baseline	• Identifies the binding agreement between FAA management and the program office concerning the cost, schedule, and capabilities that the program will provide for a major acquisition.	FAA did not clearly demonstrate that it performed a full analysis on the schedule identified in the document or the cost to implement the program.

Source: OIG analysis and FAA Acquisition Management System

Ultimately, FAA's work products supporting the TAMR business case lacked clarity because the information presented was not finalized, well documented, or validated. FAA officials indicated they were under pressure to make a decision on TAMR so that other interdependent NextGen programs could move forward with their schedule priorities. However, without clear analysis supporting a justification, decision makers cannot be assured that FAA's current implementation strategy is necessarily the most effective option.

CONCLUSION

Successfully modernizing terminal automation is critical to ensuring safety in the NAS, enhancing capacity, and minimizing delays along with realizing future NextGen capabilities. FAA's success depends on finalizing requirements, establishing and following comprehensive and realistic schedules, and setting clear cost targets for all aspects of the effort. Until FAA does so, its terminal automation modernization project remains at risk of uncontrolled cost increases, unanticipated schedule delays, and ineffective systems that do not provide the capabilities needed for a safe and modern NAS.

RECOMMENDATIONS

To improve FAA's effectiveness in achieving terminal modernization, we recommend the Agency:

1. Develop a requirements document for TAMR Phase 3 Segment 1 to ensure the operational and technical requirements for the 11 large TRACONs are specific, pertinent, and focused on requirements needed to transition CARTS to STARS.

2. Develop and implement a formal process to effectively manage, budget for, and incorporate new requirements (gaps) as they arise in the terminal modernization acquisition strategy.

3. Develop a comprehensive approved baseline schedule for TAMR Phase 3, Segment 1 that includes: (a) Initial Operating Capability and Operational Readiness dates for each of the 11 sites that STARS will replace; (b) timeframes for testing and validating new software and hardware requirements to support STARS deployment; and (c) software testing to the maximum extent possible to ensure products are suitable for deployment.

4. Update, verify, and validate the accurate and complete cost, schedule, and benefits for TAMR Phase 3, Segment 1, as prescribed by AMS.

AGENCY COMMENTS AND OFFICE OF INSPECTOR GENERAL RESPONSE

We provided a draft of this report to FAA on March 1, 2013, and received its response on April 23, 2013, which is included as an appendix to this report. FAA concurred with recommendations 2, 3, and 4, and partially concurred with recommendation 1. FAA's proposed actions for recommendations 1, 2, and 4 meet the intent of our recommendations and include reasonable timeframes for implementation. Although FAA partially concurred with recommendation 1, indicating that it would not be beneficial to create a new requirements document for the 11 large TRACONs at this time, the Agency proposed an alternative course of action that meets the intent of our recommendation. However, FAA's response to recommendation 3 does not address our concern, and we are requesting additional information, as detailed below.

FAA acknowledged that timeframes for TAMR baseline schedule activities may be adjusted due to unanticipated risk factors, such as local needs for site adaptation. However, we remain concerned with the Agency's position that it already maintains a *working* schedule for the TAMR program that includes these timeframes. As our report indicates, independent evaluations of TAMR's *working* schedule highlighted major concerns regarding the contractor's ability to complete initial operating capability (IOC) for all 11 sites by 2015. For example, MITRE reported in September 2011 that FAA's software development efforts for STARS would likely require additional time for operational testing and acceptance. To address this concern, FAA senior management approved a *baseline* schedule that pushed the completion of IOC for all 11 sites to 2016. However, this *baseline* schedule lacks details on the specific timeframes for testing and validating requirements. Accordingly, we are requesting that the Agency update the approved baseline schedule with the timeframes for testing and validating new software and hardware requirements. This will provide assurance that the program's official baseline schedule has allotted adequate time for operational testing and acceptance, and reduce overall confusion regarding discrepancies between FAA's baseline and working schedules. We consider recommendation 3 open and unresolved pending receipt of this information.

ACTIONS REQUIRED

FAA's planned actions for recommendations 1, 2, and 4 are responsive and we consider these recommendations resolved but open pending completion of the planned actions. For recommendation 3, we are requesting that the Agency provide additional information, as detailed above. In accordance with Department of Transportation Order 8000.1C, we request that FAA provide this information within 30 calendar days.

We appreciate the courtesies and cooperation of FAA representatives during this audit. If you have any questions concerning this report, please call me at (202) 366-0500 or Kevin Dorsey, Program Director, at (202) 366-1518.

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cc: FAA Deputy Administrator
     FAA Chief of Staff
     DOT Audit Liaison, M-1
     FAA Audit Liaison, AAE-100

EXHIBIT A. SCOPE AND METHODOLOGY

We conducted this performance audit from March 2011 through March 2013 in accordance with generally accepted Government auditing standards. 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.

To determine whether FAA's acquisition strategy for terminal modernization effectively addresses technological and operational risks, we focused our review on two key issues: (1) risks related to developing and implementing software and hardware requirements, and (2) whether FAA's final investment decision resulted in a reliable cost and schedule baseline.

We analyzed key planning and funding documents for the TAMR program. We reviewed various documents received from the FAA's TAMR Program Office and the FAA's William J. Hughes Technical Center in Atlantic City, NJ. These documents include: TAMR planning documents, investment decision documents, status briefings, requirements documents, schedule proposals, FAA budget documents, and NextGen planning documents. We also analyzed contractor documentation relating to STARS and CARTS, and MITRE industry reports associated with TAMR.

We interviewed TAMR program office officials at FAA Headquarters and the Technical Field Operational Support group at the FAA William J. Hughes Technical Center in Atlantic City, NJ. We also interviewed various FAA departments including: Terminal Services-Safety and Operations Support, Terminal Services-Logistics Management, Investment and Planning Analysis Office, and Acquisition and Business (Acquisition Executive). We also met with contracting officials from Raytheon Company and Lockheed Martin Corporation. We also consulted with OIG's Offices of Legal Counsel and Acquisition and Procurement Audits to obtain their insight on FAA's financing arrangement with the contractor for TAMR activities.

We conducted site visits at TRACONs slated for STARS in TAMR Phase 3, Segment 1: Potomac, Atlanta, Dallas, and Northern California. We also conducted site visits at Air Traffic Control Towers (ATCT)/TRACONs slated for TAMR Phase 3, Segment 2: Austin, TX, Waterloo, IA and Atlantic City, NJ. We also visited an ATCT/TRACON that currently uses STARS in Philadelphia, PA.

Exhibit A. Scope and Methodology

EXHIBIT B. ORGANIZATIONS VISITED OR CONTACTED

Federal Aviation Administration (FAA)

Headquarters

Terminal Automation Modernization-Replacement Program Office	Washington, DC
Investment & Planning Analysis (IP&A) Office	Washington, DC
Acquisition and Business Office	Washington, DC
Terminal Services	Washington, DC

Sites

William J. Hughes Technical Center	Atlantic City, NJ
Philadelphia ATCT/TRACON	Philadelphia, PA
Atlanta TRACON	Peachtree City, GA
Potomac TRACON	Warrenton, VA
Northern California TRACON	Mather, CA
Dallas TRACON	Dallas-Ft Worth, TX
Austin, TX ATCT/TRACON	Austin, TX
Waterloo, IA ATCT/TRACON	Waterloo, IA
Atlantic City, NJ ATCT/TRACON	Atlantic City, NJ

Industry

Raytheon Company	Washington, DC
Lockheed Martin Corporation	Washington, DC
MITRE Corporation	McLean, VA

EXHIBIT C. PROGRAM SCHEDULE FOR TAMR PHASE 3, SEGMENT 1

Facility	IOC	ORD
Dallas Fort-Worth TRACON	September 2014	May 2015
Northern California TRACON	TBD	TBD
Atlanta TRACON	TBD	TBD
Southern California TRACON	TBD	TBD
Minneapolis TRACON	October 2015	TBD
Potomac TRACON	TBD	TBD
Denver TRACON	TBD	TBD
St. Louis TRACON	TBD	TBD
Louisville TRACON	TBD	TBD
Chicago TRACON	TBD	TBD
New York TRACON	October 2016	October 2017

Source: FAA's Acquisition Program Schedule Baseline for TAMR Phase 3, Segment 1.

IOC - Initial Operating Capability is defined as site using TAMR Phase 3 hardware and software components operationally to control air traffic over a 2-4 hour period, typically on a mid-shift.

ORD - Operational Readiness Date.

TBD - To be determined.

Exhibit C. Program Schedule for TAMR Phase 3, Segment 1

EXHIBIT D. MAJOR CONTRIBUTORS TO THIS REPORT

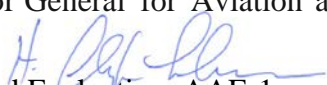| Name	Title
Kevin Dorsey	Program Director
Arnett Sanders	Project Manager
Constance Hardy	Senior Analyst
Katrina Knight	Senior Auditor
Kiesha Henson	Auditor
Jennifer Hoffman	Analyst
Amy Berks	Senior Counsel
Andrea Nossaman	Senior Writer-Editor
Audre Azuolas	Writer-Editor

APPENDIX. AGENCY COMMENTS

Federal Aviation Administration

Memorandum

Date: April 23, 2013

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: Federal Aviation Administration's (FAA) Response to Office of Inspector General (OIG) Draft Report: FAA's Acquisition Strategy for Terminal Modernization

Air Traffic Control modernization is providing continuous improvement using well established processes for transitioning to new systems and methods that will enable the National Airspace System (NAS) to handle increasing traffic density while further improving aviation safety. Presently, the FAA is operating both Standard Terminal Automation Replacement System (STARS) and Common Automated Radar Terminal System (CARTS) depending on the location. This increases the complexity of operations, training, and raises costs as compared to operating a single system. Further, completing the transition to a unified system using STARS is necessary to achieve the long term operational benefits envisioned under NextGen.

The FAA has already completed considerable progress with the implementation of STARS under the first phases of the program, and is now focusing much of its effort for this program on replacing the aging CARTS system at the 11 most complex Terminal Radar Approach Controls (TRACONS). While the OIG report presents a reasonable summary of the risks associated with the remaining efforts, it is important to realize that the risks discussed were derived from technical reports performed by contractors for the FAA, such as MITRE, and from discussions with FAA employees, and review of FAA documents. The key here is that the risks are known, and are being managed. For the handful of issues that continue to be identified, such as site specific "gaps," these too are both typical and anticipated.

Finally, the OIG draft report identified a number of minor procedural issues relating to the fulfillment of several individual elements of FAA's Acquisition Management System (AMS). While some schedules could have been better synchronized earlier in the process, some analyses could have been better documented, and there are still questions relating to

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out-year budget uncertainties, these issues do not modify the overall requirement for the system or the need to proceed with implementation.

FAA has carefully reviewed the information in the report and will ensure that it accommodates recommended actions to the fullest extent practicable and has effective systems and processes for identifying and managing risks as it completes its efforts on Terminal Automation Management/Replacement (TAMR). As described more fully in response to the recommendations, FAA has recognized opportunities to improve risk management processes, by tightening up overall and site specific requirements management, better synchronizing scheduling activities, and incorporating other lessons learned from other NAS modernization projects, such as En Route Automation Modernization (ERAM).

RECOMMENDATIONS AND RESPONSES

Recommendation 1: Develop a requirements document for TAMR Phase 3 Segment 1 to ensure the operational and technical requirements for the 11 large TRACONs are specific, pertinent, and focused on requirements needed to transition CARTS to STARS.

FAA Response: Partially Concur. The FAA recognizes the importance of complete and up to date requirements documentation for system acquisition. It has reviewed the documentation available in the combined requirements document for TAMR Phase 3 Segments 1 and 2 in arriving at its Joint Resources Council (JRC) Final Investment Decision (FID) and has determined that there is no demonstrable benefit to be gained by creating a separate or new document for TAMR Phase 3 Segment 1 requirements. As the system has been implemented over time, the program maintains an overall system specification/ requirements document for STARS System and Subsystem Specification (SSS).

The agency has determined that its needs can be addressed sufficiently through the configuration and the requirements management processes to ensure that specific and focused requirements are iteratively incorporated into existing documentation. As part of this requirements management process, the Agency established a process for managing site specific requirements. As the specific site surveys and planning activities continue and are completed at each of the 11 CARTS TRACON sites in the program baseline, potential requirements changes are evaluated and administered through the Engineering Change Proposal (ECP) Working Group. The ECP's role is to ensure a consistent and measured transition from CARTS to STARS at each site.

The FAA is currently improving upon the existing process to formalize the requirements management process (currently under development, as described in response to Recommendation 2 below), which will simultaneously maintain the STARS SSS through the program baseline. The resulting requirements document, reflecting the operational and technical requirements for the 11 large TRACONs, will be finalized by December 31, 2016 (in conjunction with the last site Initial Operating Capability (IOC) Acquisition Program Baseline (APB) milestone). As part of Configuration Management process for the program, the requirements document will be updated iteratively up to the last site deployment. At the completion of deployment, the requirements document will represent the fielded 'as-is' system.

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Recommendation 2: Develop and implement a formal process to effectively manage, budget for, and incorporate new requirements (gaps) as they arise in the terminal modernization acquisition strategy.

FAA Response: Concur. The FAA is addressing this process through two approaches:

1. Within the Air Traffic Organization (ATO), Mission Support (AJV), the Program Management Office, and Terminal Services are developing new processes and standards to ensure: 1) the enterprise standards for operational requirements; 2) the needs of individual service units; and 3) that the implementation requirements of specific programs and systems are consistent and compatible. AJV is leading the development of a requirements management process standard for the ATO, which it plans to complete by the end of Fiscal Year 2013.

2. The TAMR program is creating local process standards for formally managing requirements changes. Software is the responsibility of the Requirements Tiger Team (RTT), which validates proposed changes to the TAMR baseline and translates them into specific contractual requirements as a formal work plan for the contractor. The RTT also ensures that all contract requirements are formally introduced via ECPs to the STARS SSS. The ECP Working Group, working as a collaborative forum between the FAA and its vendor partner, is accountable for the review and disposition process to support the thorough and expeditious evaluation, disposition, and implementation of STARS hardware, firmware, and related Commercially Available Software ECPs. This work is planned to be completed by July 31, 2013.

Recommendation 3: Develop a comprehensive approved baseline schedule for TAMR Phase 3, Segment 1 that includes: (a) Initial Operating Capability and Operational Readiness dates for each of the 11 sites that STARS will replace; (b) timeframes for testing and validating new software and hardware requirements to support STARS deployment; and (c) software testing to the maximum extent possible to ensure products are suitable for deployment.

FAA Response to 3 (a): Concur. The FAA uses the working schedule for the TAMR program as the implementation mechanism for the APB. This includes IOC and Operational Readiness Date targets for each of the 11 large TRACON sites that STARS will replace. This approach, in keeping with the AMS best-practices and guidance, also builds upon lessons-learned from the ERAM program and other large-scale acquisitions. The target timeframes for these activities may adjust within the confines of the APB milestones established at FID to account for either unplanned or unanticipated risk factors. These include variables such as local needs for site adaptation, site readiness, the availability of site resources, and any other NAS changes that may have emerged in the interim.

Per AMS requirements, the program will undergo an Integrated Baseline Review (IBR) in May of 2013 and will employ the recommendations from this review to further enhance project management processes. The IBR results and recommendation implementation results will be provided to the OIG as part of our request to close this recommendation by September 30, 2013.

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FAA Response to 3 (b): Concur. The program's working schedule maintains this information, and the schedule for this work is governed through periodic Program Management Reviews (PMR) and other forums within the TAMR program office. TAMR schedule files that demonstrate timeframes for testing and validating new software and hardware requirements to support STARS deployment are located on a central Knowledge Sharing Network and maintained by the program office. Given that the program's working schedule maintains these data, and that the use of the working schedule to manage this information is in alignment with AMS guidance, the FAA requests that this request be closed.

FAA Response to 3 (c): Concur. In the area of software testing, the TAMR program is also incorporating lessons learned from the ERAM program. The test strategy for TAMR includes a range of structured events with entrance and exit criteria for deploying new software to TRACONs. This includes: a) early user involvement events involving controller system testing prior to government acceptance; b) informal risk mitigation testing involving the program office and vendor prior to software delivery at the William J. Hughes Technical Center test facility; and c) formal operational test and evaluation including software bug fixes, engineering change verification, regression tests, and operational evaluation by users prior to software delivery to the sites. The TAMR program office is in the process of codifying this process in standard documentation, which it plans to complete by September 30, 2013.

Recommendation 4: Update, verify, and validate the accurate and complete cost, schedule, and benefits for TAMR Phase 3, Segment 1, as prescribed by AMS.

FAA Response: Concur. The FAA is guided by the AMS for all of its acquisition programs, including TAMR. There are two key controls that serve to verify and validate the accuracy and completeness of the programs cost performance baseline. These controls are subsequent to the program's FID and implementation of the program, which is ongoing. The two key controls include:

1. Earned-Value Management (EVM) – TAMR is implementing a formal change control board for all program changes that impact either individual components of the TAMR program or the TAMR portfolio (across phases and segments) as a whole. This was implemented in February 2013, and will be documented in a Change Management Plan and will include the development of standard operating procedures to guide its execution. This Change Management Plan will be completed by September 30, 2013.

2. Post Implementation Review (PIR) – the PIR is used by the FAA to validate benefits accrual and to answer the following questions:

   o Did the FAA get what it asked for?

   o Is the investment program providing the service customer needs?

   o Are there any lessons learned about the acquisition management process?

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This review will begin by March 31, 2014, and a report is anticipated approximately six months after the work begins. The high-level TAMR Phase 3 Segment 1 PIR strategy is as follows:

- o Stringent monitoring of the integrated program schedule and EVM provides the means to measure and evaluate program adherence to cost and schedule baselines during the solution implementation phase; and,

- o Examine actual cost, schedule, benefits/improvement, and mission outcome performance against stated baseline goals.

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