

**TERMINAL MODERNIZATION:  
FAA NEEDS TO ADDRESS ITS SMALL,  
MEDIUM, AND LARGE SITES BASED ON COST,  
TIME, AND CAPABILITY**

*Federal Aviation Administration*

*Report Number: AV-2005-016*

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# Memorandum

U.S. Department of  
Transportation

Office of the Secretary  
of Transportation

Office of Inspector General

Subject: ACTION: Report on Terminal  
Modernization: FAA Needs To Address Its  
Small, Medium, and Large Sites Based on  
Cost, Time, and Capability  
AV-2005-016

Date: November 23, 2004

From: Kenneth M. Mead  
Inspector General

Reply to  
Attn. of: JA-10

To: Federal Aviation Administrator

This report presents the results of our review of the Federal Aviation Administration's (FAA) Standard Terminal Automation Replacement System (STARS) program. Since 1996, STARS has been the centerpiece of FAA's Terminal Modernization Program to replace 1970s-era computer systems and aging controller displays. STARS provides radar and flight data to air traffic controllers at FAA's terminal air traffic control sites. Air traffic passes through three distinct control environments. At the airport, the Tower has control. After take-off, control shifts to the Terminal Radar Approach Control (TRACON). Finally, en route centers control aircraft at higher altitudes between airports. STARS was designed to provide data to TRACON sites and their associated towers.

We began this review in response to fiscal year (FY) 2004 congressional direction to FAA and our office. Specifically, the Congress directed FAA to provide life-cycle cost estimates for the complete STARS program to the Appropriations Committees and directed us to review and validate FAA's STARS life-cycle cost estimates.<sup>1</sup> Although the Congress directed FAA to rebaseline the STARS program, the Agency has changed its approach and is not yet in position to rebaseline the STARS program. Until FAA rebaselines STARS, we cannot credibly validate the cost estimates as directed. This report provides information on the status of FAA's terminal modernization effort. Our objectives were to identify FAA's strategy to meet the needs of its small, medium, and large terminal

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<sup>1</sup> House Report 108-243, accompanying the Fiscal Year 2004 Act making appropriations for the Departments of Transportation, Treasury and Independent Agencies, July 30, 2003.

sites and consider the alternatives available to FAA to meet those needs. The exhibit contains our scope and methodology.

## **RESULTS**

Faced with additional cost growth in the STARS program, FAA is rethinking its terminal modernization approach—a long overdue step that should have been taken several years ago. In April 2004, FAA revised its approach and committed STARS deployments to just 50 out of 162 planned sites. The Agency is considering retaining some existing systems as an alternative to STARS and is reevaluating STARS costs and deployments. In FY 2005, FAA plans to decide whether to approve further STARS purchases. The essential question now facing FAA is how best to finish the terminal modernization effort. FAA needs to move forward expeditiously to address the needs of its small, medium, and large terminal sites based on three vectors: cost, time, and capability.

Of special concern is the state of aging displays at four large sites, such as Chicago and Denver. Under FAA's current plan, the Agency will not begin installing STARS and replacing the aging displays at the large sites until sometime in FY 2008. The entire STARS program, including Chicago and Denver, was originally planned to be completed by 2005. The aging displays need to be replaced well before the 2008 timeframe because, among other things, they are experiencing significant reliability problems. For example, controller displays at Denver are locking up randomly, and FAA officials from that facility told us that this problem has occurred 100 times in the past 3½ years and is now occurring a little over once a week.

### **Current Status of Terminal Modernization**

FAA selected STARS in 1996 as the centerpiece of its terminal modernization effort. The Agency began STARS after canceling the terminal portion of an earlier program, the Advanced Automation System. Included in the Advanced Automation System were plans to replace the existing 1970s-era equipment in terminals and towers throughout FAA's National Airspace System.

FAA's 1996 cost estimate for STARS was \$940 million, and the scheduled completion date was FY 2005 for 172 systems. However, STARS is not the program that was planned 8 years ago. Although the STARS acquisition was intended to maximize the use of commercially available equipment, significant human factors issues were identified in an early STARS prototype that required extensive software and hardware development. As a result, in FY 1999, the Agency added 3 years and more than \$460 million to its STARS schedule and cost

estimates. Since 1999, STARS has experienced software problems found during testing that required additional time and cost to resolve. It is also important to note that FAA has pursued STARS through a cost-plus contract, which places most of the risk of cost growth with the Government. As Figure 1 shows, STARS cost estimates continued to increase through 2003, and the STARS schedule continued to slip.

**Figure 1. Changes in STARS Cost and Schedule Estimates  
(Dollars in Millions)**

	1996	1999	2002	2003
Baseline Cost	\$940.2	\$1,402.6	\$1,690.0	\$1,724.2
Scheduled Completion Date	FY 2005	FY 2007	FY 2010	FY 2010

Because of the delays in developing STARS, FAA replaced 1970s-era systems at 141 terminal sites with a different system, Common ARTS, between 1998 and 2003 for about \$239 million. Since then, Common ARTS has performed well and meets FAA's requirements. However, because FAA considered Common ARTS an interim system, the Agency acquired color displays for only 7 of 11 large Common ARTS sites and did not replace the aging displays at most sites. In contrast, each site that receives STARS also receives color displays.

In April 2004, FAA decided to revise its STARS approach again after new estimates indicated STARS development and deployment costs would grow to more than \$2 billion and the schedule would slip to FY 2011. As we recently testified to Congress,<sup>2</sup> the Agency has very little ability to absorb further cost growth in any of its acquisition programs. Moreover, cost and schedule problems with ongoing modernization efforts have serious consequences because they result in costly interim systems, a reduction in the number of units procured, or the crowding out of other modernization projects.

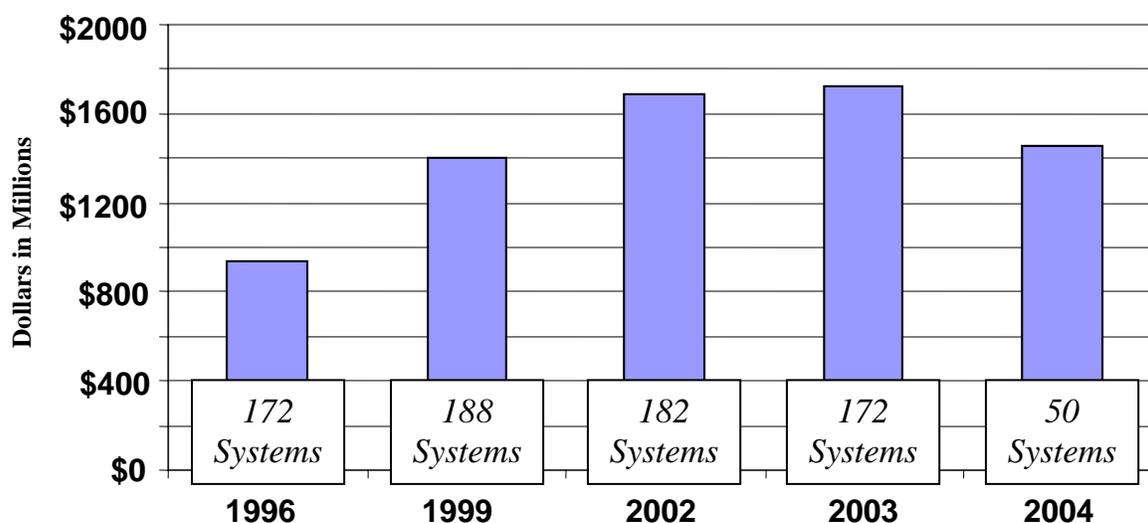
After receiving the \$2 billion estimate in April 2004, FAA formally changed its modernization plan and committed STARS to just 50 sites at an officially estimated cost of \$1.46 billion for development and deployment as opposed to the original estimate of \$940 million for over 170 sites. The \$1.46 billion estimate includes more than \$500 million FAA has already spent on development with the

<sup>2</sup> Testimony before the Senate Appropriations Committee, Subcommittee on Transportation, Treasury and General Government; "Key Issues for the FAA's FY 2005 Budget," CC-2004-038; April 22, 2004. OIG reports can be accessed on our website at [www.oig.dot.gov](http://www.oig.dot.gov).

STARS prime contractor. Development is still not complete. Other prime contractor costs and non-prime costs, such as FAA overhead, exceed \$600 million.

Overall, FAA has obligated more than \$1.1 billion for STARS through August 2004. Figure 1 shows the growth in FAA's official STARS cost estimates from the original \$940 million to \$1.7 billion between 1996 and 2003. Figure 2 shows the drop in the official development and deployment cost estimate to \$1.46 billion when FAA reduced STARS quantities to just 50 operational sites in April 2004.

**Figure 2. Growth in STARS Development and Deployment Cost Estimate and Effect of a Cut in Approved Quantities in 2004\***



\* The 50 systems in 2004 represent the number of approved operational sites. FAA also has several support facilities equipped with STARS systems for testing, training, and maintenance.

FAA has authorized deployment of 47 of the 50 STARS currently approved. Through August 2004, the Agency has purchased 39 STARS. Once STARS is deployed at the 47th site, all 173 existing terminal sites<sup>3</sup> will be equipped with either STARS or a modern Common ARTS, including the last 3 of the 50 approved STARS sites. Replacing these three sites with STARS was

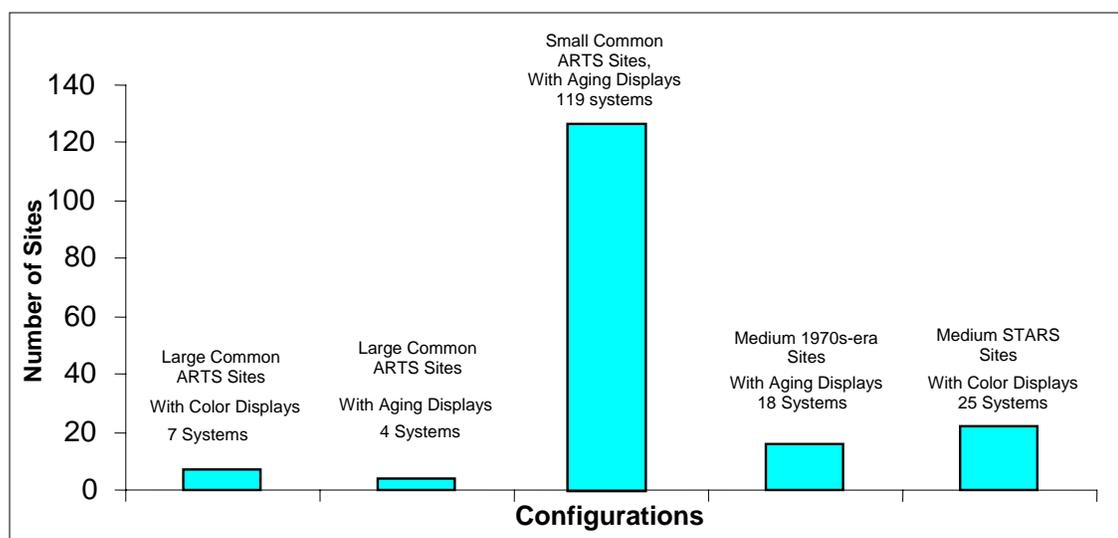
<sup>3</sup> As a result of site consolidations, FAA is reducing the total number of terminal sites and expects to eventually settle at 162 operational sites.

prohibited in FY 2004 until FAA provides complete STARS program cost estimates to Congress and we validate them.<sup>4</sup>

FAA's planned 50th STARS site is Chicago, a large Common ARTS site with aging displays. This site will be the first large Common ARTS to be replaced by STARS, and FAA risks encountering significant hurdles trying to replace it. The Agency expects software development to take at least 2 more years and cost \$57 million (without hardware and installation costs) before STARS will be ready for Chicago. FAA estimates installation will not be complete in Chicago until sometime in FY 2008.

We met with officials of the National Air Traffic Controllers Association and discussed the aging displays at Chicago. They expressed concern that FAA plans to wait several years before replacing aging displays even though new displays are commercially available and have been deployed at other sites, such as Southern California. Figure 3 shows the current distribution of Common ARTS, STARS, and 1970s-era terminal configurations at FAA's large, small, and medium terminal sites based on what systems are installed today.<sup>5</sup>

**Figure 3. FAA's Operational Terminal Configurations and Quantities of Each Configuration (September 2004)**



<sup>4</sup> FY 2004 Consolidated Appropriations Act, Conference Report, Division F, Title I: Department of Transportation; November 25, 2003.

<sup>5</sup> For the purposes of this report, we selected categories of terminal sites in terms of "small", "medium", and "large" that help describe FAA needs based on systems that are currently installed today. Because Common ARTS IIE is the prevalent system at FAA's smallest sites, such as Lubbock, Texas, we refer to all ARTS IIE sites as "small." Similarly, because Common ARTS IIIIE systems are operating at FAA largest facilities, such as Southern California, we refer to all Common ARTS IIIIE sites as "large." The remaining legacy systems and STARS sites are referred to as "medium."

## FAA Needs To Complete Modernization Based on Cost, Time, and Capability

Since 1996, FAA's modernization strategy to replace the 1970s-era systems has been to place STARS at all of its terminal sites. Until recently, STARS was FAA's "preferred solution" for terminal modernization. In commenting on our draft report, FAA stated that while it may have been biased toward STARS in the past, the Agency has put a new team in place that is objectively evaluating all alternatives. The Agency's current mix—Common ARTS at the small (119) and large (11) sites and STARS at the medium sites (43)—replaces the 1970s-era systems. The question that FAA must answer now is how best to finish the modernization effort and do so expeditiously. To answer this question, FAA needs to address the needs of its small, medium, and large sites and choose solutions based on three vectors: cost, time, and capability. By doing so, the Agency will resolve a number of important unknowns.

- **Small Sites.** The highest priority considerations for FAA's small sites are cost and capability given traffic volume and the complexity of airspace they are responsible for managing.<sup>6</sup> The automation systems at these sites have been replaced with Common ARTS in the recent past but still rely on older displays that prevent the use of advanced system capabilities, such as the color display of weather information. Although these small sites do not yet face the same time-critical issues that FAA's large, complex sites do, replacing the aging displays with modern color displays and doing associated upgrades would eliminate the need to continue maintaining obsolete equipment, and as we reported last year,<sup>7</sup> reduce STARS development and deployment costs.

FAA has produced a "rough order of magnitude" estimate of about \$200 million for replacing the aging displays using a Common ARTS display solution and doing associated upgrades at all the small sites. According to FAA and the STARS contractor, another alternative that FAA could consider is a scaled-down version of STARS, which would have fewer features than the full STARS system, to meet the modernization needs of the small sites. This concept may have merit but has not been fully analyzed in terms of cost and time.

- **Medium Sites.** The highest priority consideration for FAA's medium sites is system capability. Improving capability is necessary because delays in the STARS program have left 1970s-era systems and aging displays at a

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<sup>6</sup> FAA has already purchased STARS for four small sites. Once STARS goes operational at these sites, FAA will have 115 small sites with Common ARTS.

<sup>7</sup> OIG Report Number AV-2003-058, "FAA Needs To Reevaluate STARS Costs and Consider Other Alternatives," September 10, 2003.

number of these sites. Cost and time are no longer the driving factor for these sites because FAA has been purchasing STARS systems and color displays for several years. Only 8 more STARS with color displays need to be purchased and 18 to be installed to replace the last of the 1970s-era systems and aging displays at the medium sites. For FY 2005, the STARS program office has requested \$113.9 million to complete installation at the medium sites in 2006. Included in this amount is \$22 million for STARS development.

- **Large Sites.** While capability is always an important factor, the highest priority consideration for 4 of the 11 large sites now is timeliness. FAA deployed Common ARTS systems to 11 large and complex sites, such as New York and Southern California. However, only seven of the large sites received modern color displays.

According to FAA's Vice President for Terminal Services, the condition of the aging displays at the remaining four large sites (Chicago, Denver, Minneapolis, and St. Louis) has become critical. For example, the aging displays at these sites limit any further software enhancements to controller workstations, including safety improvements recommended by the National Transportation Safety Board during its investigation of a mid-air collision in October 2000. The Board recommended that FAA modify software at its facilities to help controllers better track aircraft and display information when problems arise.<sup>8</sup> FAA concurred and is in the process of deploying this modification to all sites, except for the four large sites with aging displays.

Denver will not receive STARS until sometime after Chicago receives STARS, currently planned for FY 2008. However, recent equipment failures at Denver clearly demonstrate its need for display modernization has become critical. Because of problems with aging displays, controller workstations are locking up on a random basis. FAA officials at the Denver facility told us that this has occurred 100 times in the past 3½ years and is now occurring a little over once a week. To fix the problem, technicians must restart the display, which takes a minimum of 90 seconds.

In addition, network communications components called transceivers that deliver data to the displays have been failing. These equipment failures are associated with FAA's decision to wait for STARS rather than upgrade the old displays and related network communications equipment. Denver now relies on network components that are no longer manufactured—these components can only be replaced by cannibalizing parts from retired

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<sup>8</sup> Letter from Acting NTSB Chairman Carol J. Carmody to FAA Administrator Garvey dated April 19, 2001.

systems. Although Chicago, St. Louis, and Minneapolis terminal facilities have not experienced the same failures rates, FAA officials at these sites have become concerned about this problem and the lack of spare parts. Officials of the National Air Traffic Controllers Association are particularly concerned about Chicago because of its importance to the overall smooth functioning of the National Airspace System.

FAA has not yet requested formal cost estimates for replacing color displays at these four sites. A “rough order of magnitude” estimate prepared by Lockheed Martin suggests that it would cost \$35 million to replace the displays and do other associated upgrades at these four large Common ARTS sites. In contrast, FAA estimates a development and deployment cost of more than \$100 million to deploy STARS (systems and displays) at the four sites. Deployment would begin in sometime in FY 2008.

Another alternative is relying on STARS color displays at Common ARTS sites. In July 2003, it was demonstrated to FAA that STARS color displays could operate with the Common ARTS software. Before FAA pursues this approach, the Agency would have to examine cost, time, and capability issues.

### **Aging Displays Can Be Replaced Before STARS Development Is Complete**

Time and cost vectors favor taking action to replace the aging displays at the small and large Common ARTS sites rather than waiting for STARS. FAA’s current plans will require at least 3 years to complete STARS development and deployment at the four large sites. As noted earlier, problems with aging displays need to be addressed sooner rather than later. Replacing aging displays represents a step that will extend the useful life of installed systems and enhance their capability and reliability.

In September 2003 (when FAA was projecting STARS would cost \$1.69 billion), we reported that based on FAA’s cost estimates, the Agency could augment STARS deployments by replacing just the aging displays at the large and small sites and save over \$268 million versus the preferred STARS solution. As the Agency’s STARS estimate has now risen to more than \$2 billion, FAA could generate even greater savings by replacing aging displays with commercially available color displays rather than waiting several years for the full STARS solution. To determine the actual amount of savings, we urge FAA to compare the cost to replace the aging displays at the small and large sites to the cost of a full STARS solution.

## **FAA Must Resolve Important Issues About the Capabilities Needed for Terminal Modernization**

Until recently, FAA viewed STARS as its preferred long-term solution. The Agency's justification was that STARS has superior capabilities that will be worth both the wait and the extra cost. FAA has cited STARS "fusion tracking," which is intended to track aircraft more precisely, and STARS computer security as important capabilities favoring the continued investment in STARS. Thus, the issue has tended to focus on which system, STARS or Common ARTS, was better.

FAA tasked the MITRE Corporation, the Agency's Federally Funded Research and Development Center, to conduct assessments of STARS and Common ARTS with respect to fusion tracking and its relative benefits, as well as information security. According to MITRE officials, their assessment does not show significant differences in the designs of the trackers. In our view, the focus has shifted from which system is better to what capabilities are needed and where, what fusion tracking will cost, and how long it will take to deploy.

- ***Fusion Tracking.*** In essence, fusion tracking (or sensor fusion) integrates data from multiple sources, such as radar and satellite-based navigation systems, to give FAA controllers more accurate information on the position of aircraft. According to Lincoln Laboratory, fusion tracking's potential benefit could come from reducing standard separation between aircraft, thereby allowing for more efficient use of airspace near airports. The use of fusion tracking in managing air traffic is still evolving.

Currently, STARS is deployed with a fusion tracker at more than 25 locations but not without problems. For instance, the Agency has documented that the STARS tracker can have difficulty accurately tracking aircraft as they change altitude or it can drop an aircraft's flight information (i.e., aircraft data tags) that should be displayed on the controller's screen. FAA has had two expert consultants, ARCON and Lincoln Laboratory, examining STARS fusion tracking problems and their root causes. In April 2004, ARCON concluded that further analysis of the STARS altitude tracker's performance was necessary and recommended implementation of an alternative altitude tracker that will augment or replace the existing one.

The Common ARTS fusion tracker is still under development and is in testing at Louisville, Kentucky. This tracker integrates both radar and satellite-based data, but a number of technical issues need to be resolved about how to merge data from different sources. It is unclear how much it would cost or how long it would take to deploy the Common ARTS fusion tracker.

As the MITRE study points out, both STARS and Common ARTS fusion trackers are based on state-of-the-art designs but are at different points in the development cycle. Before real benefits can be expected from fusion tracking, such as enhancing capacity, FAA needs to resolve several unknowns, regardless of which system is used.

Currently, FAA's experience with the Safe Flight 21 initiative shows that fusion tracking *when integrating data from radar and satellite-based navigation systems* (such as the Automated Dependent Surveillance Broadcast System) has potential benefits. However, STARS relies solely on *radar* fusion tracking and does not yet incorporate satellite-based data. A recent evaluation by Lincoln Laboratory of commercially available fusion trackers—including the STARS tracker—indicates that radar fusion tracking offers no more precise information than that provided by a single radar source.

In our view, the core issues are what capabilities are needed and where, what fusion tracking will cost, and when it can realistically be deployed. This is reinforced by the MITRE study, which found no significant differences in the design of the two trackers. The MITRE study also points out that development remains to determine how fusion will be used in the terminal environment and what procedures need to be modified.

- ***Computer Security.*** FAA officials have maintained in the past that STARS security provides a substantive increase over computer security in the existing Common ARTS system. This implies that the computer security features of the existing system are not adequate. However, as we reported in September 2003, FAA's Information Security Office has determined that both systems are acceptable and has assigned a moderate risk rating to each.

Similarly, FAA's Director of Airways Facilities has granted security authorization for both systems to operate in the National Airspace System. Moreover, the security vulnerabilities and security requirements are not the same for each system. For instance, because STARS is connected to outside locations, such as operational support facilities, remote STARS operators and support personnel could possibly gain root access to the STARS operating system. Additional security features to address certain shortfalls could be added to Common ARTS. As the MITRE study points out, this was known 3 years ago. Additional security could be added to Common ARTS at an estimated cost of \$3.8 million.

## Next Steps for Terminal Modernization

The goal is how best to finish the modernization effort and do so expeditiously and at a reasonable cost. FAA's experience shows that one size does not fit all for terminal modernization. FAA needs to recognize that the modernization needs of the sites vary with respect to cost, time, and capability and should evaluate solutions accordingly. Further, FAA must resolve a number of unknowns, such as whether a scaled-down version of STARS for small sites is feasible, before making further investments in STARS.

FAA needs to reduce the risk of cost growth in the STARS contract. As we testified in April 2004, cost-reimbursable contracts cause the Government, and eventually the taxpayer, to absorb cost growth associated with overruns.<sup>9</sup> FAA has been using a cost-reimbursable type of contract for STARS. However, because the timeframes associated with production options in the original STARS contract expired in September 2002, FAA is negotiating a new agreement with the STARS prime contractor.

In commenting on our draft report, FAA stated that the Agency has a signed memorandum of agreement with Raytheon to put STARS into a large Common ARTS facility. We are not persuaded that a memorandum of agreement executed by a Federal official in advance of appropriations is controlling, particularly when FAA is negotiating a new agreement with the prime contractor at a time when work continues on short-term extensions. The important issue here is doing what makes sense for air traffic control, safety, and the taxpayer.

In our opinion, the Government could reduce contract risk by not using cost-reimbursable elements or keeping their use to a bare minimum. Since FAA has already installed STARS at more than 25 sites, the Agency claims it has sufficient experience to predict these costs for other sites. Therefore, FAA should maximize the use of fixed price agreements for procuring and installing STARS.

## Recommendations

FAA cannot continue to delay making decisions about terminal modernization. A number of studies have been done, and the alternatives have been identified. Therefore, we are recommending that FAA take immediate action to:

1. Replace aging displays at its four large terminal sites that do not have color displays. This should be done expeditiously and based on the priority needs of individual sites. As our report indicates, FAA cannot wait 3 more years.

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<sup>9</sup> Testimony before the Senate Appropriations Committee, Subcommittee on Transportation/Treasury and General Government; Report Number CC-2004-038, "Key Issues for FAA's 2005 Budget," April 22, 2004.

2. Defer further investment in STARS beyond those needed to complete the 47 approved sites until the Agency completes its evaluation of moving forward with STARS or Common ARTS based on cost, schedule, and performance parameters. This is the evaluation we called for over 3 years ago in March 2001, and it should be completed within 6 months. As part this evaluation, FAA should:
  - (a) Request cost proposals for small terminal sites to replace aging displays with new color displays and implement a STARS solution, including a scaled-down version.
  - (b) Determine requirements for fusion tracking, as well as where it is needed, how much will cost, and how long it will take to deploy.
3. Negotiate a contract that maximizes the use of fixed price elements for completing the 47 sites already approved for STARS deployment, including installation and adaptation costs.

### **Agency Comments and Office of Inspector General Response**

On October 8, 2004, we provided FAA with a draft of this report for formal Agency comment. On November 15, 2004, FAA electronically provided us with their response, which is contained in its entirety in the Appendix. FAA made a number of comments regarding our description of capabilities and limitations of terminal systems currently in use or planned, as well as cost. We adjusted our report, where appropriate, based on these comments. A more detailed discussion of FAA comments and our response is contained later in this report.

FAA recognizes the need to replace aging displays and stated that the Agency is committed to a fair evaluation that identifies the best solution for each site. FAA also notes that while it may have been biased toward STARS in the past, the Agency has put a new team in place that is objectively evaluating all alternatives.

FAA commented that there are ramifications for the Department of Defense (DOD) with respect to increased costs and infrastructure support for DOD if the Agency decided to limit the number of STARS purchases. Given that FAA plans to deploy STARS to at least 47 sites, we do not understand why this would be the case. Although FAA is concerned about increased costs with STARS for DOD, FAA should be more concerned about the cost of its own terminal modernization efforts. We note that DOD did not wait for FAA to address human factors concerns (which surfaced in the 1990s) and deployed STARS at Eglin Air Force Base, Florida, in June 2000 well before FAA deployed the first "full STARS" to Philadelphia in November 2002. DOD continues to deploy STARS independent of FAA's development of STARS for large sites. If there are issues regarding

STARS and the Department of Defense, this is something that FAA's new team that is responsible for objectively evaluating terminal modernization should consider.

FAA concurred with our recommendation to replace aging displays at its four larger terminal sites that currently do not have color displays. FAA stated that it is conducting a comprehensive technical, cost, and risk evaluation to determine the best solution for the sites. However, it is uncertain from FAA's response when the Agency plans to take action at the four sites. The fact remains that some sites, such as Denver, face time-critical decisions about replacing aging displays. We are requesting that FAA clarify when this action will be taken.

FAA concurred with our recommendation to defer further investment in STARS beyond the 47 sites that have been approved and evaluate the long-term feasibility of moving forward with STARS or Common ARTS in terms of cost, schedule, and performance parameters. This should be done in 6 months. As noted in the report, replacing the aging displays at large sites will extend the useful life of installed systems and provide FAA time to evaluate how it should proceed with terminal modernization. Regarding our recommendation in the draft report on small sites, FAA pointed out that capability is an important factor as well as cost. We agree and have modified our recommendation accordingly.

FAA concurred, in part, with our recommendation to negotiate a firm fixed price contract for completing the 47 sites already approved for STARS deployment that includes installation and adaptation costs. FAA stated that it is negotiating a fixed price contract for STARS systems but intends to rely on a time and materials financial arrangement for installation. FAA stated that this would avoid higher risk adjusted costs that accompany fixed price installation. FAA also stated that it has sufficient experience with STARS to ensure that installations come in at their budgeted cost. This seems to create an even more compelling case to maximize the use of fixed price elements to control costs. We are requesting that FAA reconsider its response to this recommendation.

## **BACKGROUND**

FAA selected STARS in 1996 as the centerpiece of its terminal modernization effort. The Agency began STARS after dramatically restructuring an earlier program, the Advanced Automation System, that was significantly over cost and behind schedule. Included in that earlier program were plans to replace 1970s-era equipment in terminals and towers throughout FAA's National Airspace System. After FAA canceled the Advanced Automation System, the STARS program was selected to replace the 1970s-era systems.

FAA's 1996 cost estimate for STARS was \$940 million, and the scheduled completion date was FY 2005 for 172 systems. However, STARS is not the program that was planned 8 years ago. Although the STARS acquisition was intended to maximize the use of commercially available equipment, significant human factors issues were identified in an early STARS prototype that required extensive software and hardware development. In 1999, the Agency added 3 years and more than \$460 million to its STARS schedule and cost estimates, bringing the new estimate to \$1.4 billion and extending the schedule to FY 2007. Since 1999, STARS has experienced software problems found during testing that required additional time and cost to resolve.

FAA's latest STARS cost and schedule estimates indicate deploying STARS systems and color displays to all sites to meet Agency needs is not affordable within the approved \$1.54 billion STARS Capital Investment Plan.<sup>10</sup> Further, the current plan will not result in replacing 20-year old displays at a number of critical sites, including Chicago, until at least 2008.

Because of STARS delays, modern Common ARTS digital systems were developed and deployed between 1998 and 2003 to replace 1970s-era computer systems at more than 140 terminal sites for about \$239 million. Common ARTS meets FAA's requirements. However, because FAA considers Common ARTS an interim system, the Agency acquired modern color displays for only seven large Common ARTS sites and did not replace aging displays at most sites. In contrast, FAA includes color displays for all STARS sites.

## **ANALYSIS AND RECOMMENDATIONS**

Until recently, FAA's "preferred solution" for terminal modernization was to deploy STARS systems with color displays to all of its small, medium, and large terminal sites. In 2002, FAA began deploying STARS to medium sites, such as

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<sup>10</sup> FAA's Capital Investment Plan is a planning document for projecting future funding needs for its programs.

Philadelphia, and more than 25 medium sites are now operating with STARS. However, FAA operates more than 160 sites overall, and the Agency does not expect to complete STARS deployments to all sites before FY 2011. Faced with significant additional cost growth and schedule slippage, FAA is now rethinking its terminal modernization approach. This is a long overdue step that should have been taken several years ago. The essential question now facing FAA is how best to finish terminal modernization. FAA needs to move forward expeditiously to address the needs of its small, medium, and large terminal sites based on three vectors: cost, time, and capability.

### **Current Status**

In April 2004, facing a \$2.1 billion estimate for its preferred STARS solution, FAA formally revised its terminal modernization plan by committing STARS to just 50 sites, at an estimated development and deployment cost of \$1.46 billion. In addition to limiting STARS deployments, FAA has also revised its terminal modernization plan by committing to (1) consider retaining Common ARTS at some sites as an alternative to STARS, and (2) reevaluating STARS costs and deployments before considering further STARS purchases in FY 2005.

FAA's \$1.46 billion estimate for 50 sites includes more than \$500 million that FAA has spent on STARS development, although development was originally estimated to cost about \$80 million and is still not complete. Other prime contractor costs (such as production and installation) and non-prime costs (such as FAA overhead) exceed \$600 million.

In April 2004, STARS program officials presented a three-phase STARS deployment timeline to FAA decision-makers. In Phase 1, FAA plans to deploy STARS to the first 50 sites by FY 2007. For Phase 2, the Agency will decide in FY 2005 whether to approve 60 additional STARS for deployment by the end of FY 2009. For the final phase, in FY 2006, FAA will decide whether to approve 52 more STARS. Figure 4 shows the STARS program office's three-phase plan.

**Figure 4. Three-Phase STARS Deployment Timeline**

	<b>Phase 1</b>	<b>Phase 2</b>	<b>Phase 3</b>
Decision Date	April 2004	March 2005	Oct 2005
Scheduled Completion	FY 2007	FY 2009	FY 2011
Number of Operational Sites	50	60	52

## **Deploying STARS to All Sites Will Have a Significant Budgetary Impact**

FAA's \$2.1 billion estimate for STARS is more than \$300 million larger than last year's STARS program cost estimate. FAA is now operating in a constrained budget environment and has very little ability to absorb further cost growth in any of its acquisition programs.<sup>11</sup> Cost and schedule problems with ongoing modernization efforts have serious consequences because they result in costly interim systems, a reduction in the number of units procured, or the crowding out of other modernization projects.

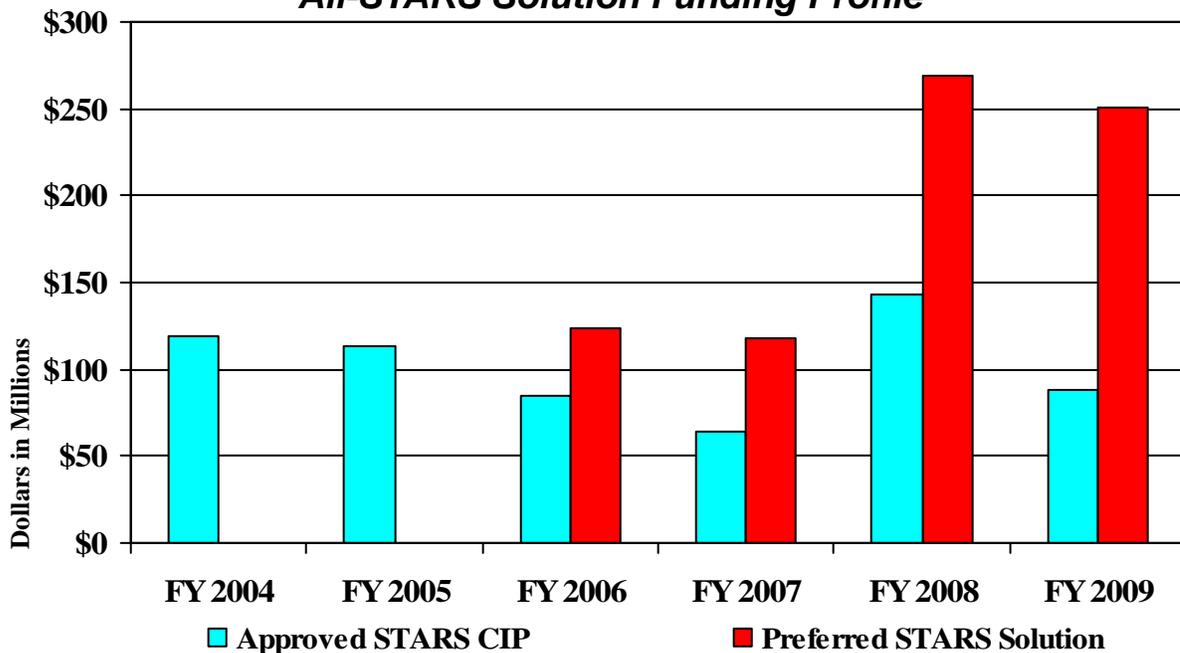
The combination of continuing STARS cost growth and a severely constrained budget environment has significantly changed FAA's terminal modernization equation. For instance, the Agency's approved Capital Investment Plan shows a \$231 million combined figure for FY 2008 and FY 2009 for STARS. However, implementing FAA's preferred STARS solution, which is to deploy STARS to 162 operational sites, requires a Capital Investment Plan profile of \$520 million, an increase of \$289 million for those 2 years.

Figure 5 illustrates the budgetary impact of FAA's all-STARS solution versus what is programmed for STARS in the Agency's approved Capital Investment Plan. Planning a program on the assumption that a 2-year budget increase of almost \$300 million will be forthcoming may be imprudent.

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<sup>11</sup> Inspector General testimony before the Senate Appropriations Committee, Subcommittee on Transportation/Treasury and General Government; "Key Issues for FAA's FY 2005 Budget," CC-2004-038; April 22, 2004.

**Figure 5. Approved STARS Capital Investment Plan Versus an All-STARS Solution Funding Profile**

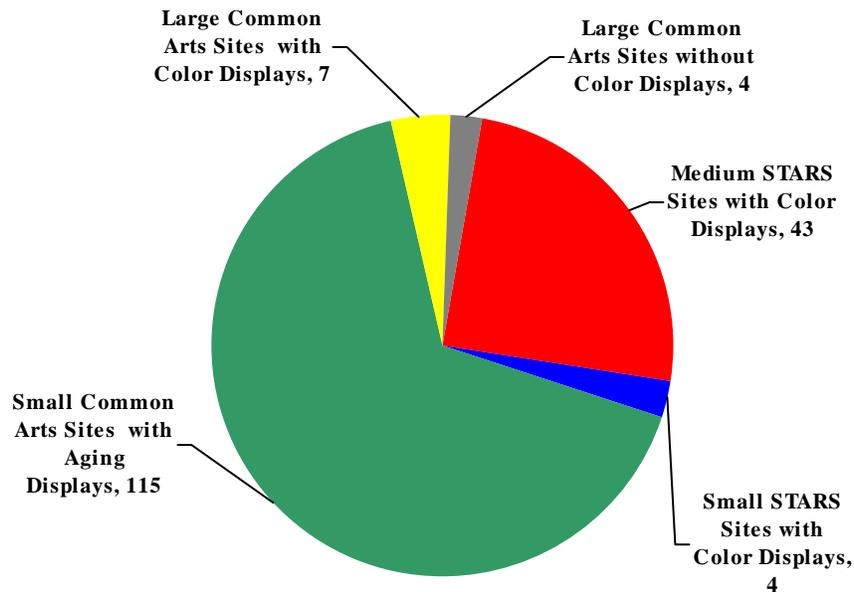


### FAA's Modernization Needs Have Changed

In 1996, FAA's terminal modernization needs and their solution were straightforward—replace 1970s-era systems and aging displays with STARS. However, STARS delays forced FAA into replacing the 1970s-era systems with an interim system, Common ARTS, between 1998 and 2003 at more than 140 small and large terminal sites, including 11 large and complex sites such as Chicago and Denver.

Today, FAA's revised plan formally commits STARS to a total of just 50 sites and approves STARS deployments to 47 of the 50 sites. After the 47th STARS is deployed, FAA will no longer have any 1970s-era systems left to replace. However, as Figure 6 shows, after the last 1970s-era system is retired, the vast majority of FAA's 162 planned operational sites will be equipped with Common ARTS and aging displays. Common ARTS meets FAA's requirements, but the Agency did not replace the aging displays at most sites when it was installed, preferring instead to wait for STARS. The question now is how to complete terminal modernization cost effectively and expeditiously.

**Figure 6. FAA's Terminal Site Configurations After Deploying 47 STARS**



### **FAA Needs To Complete Its Terminal Modernization Effort Based on Cost, Time, and Capability**

Once the 1970s-era systems are retired, the primary shortcoming at most sites will be the continued dependence on aging displays. FAA's next step must be to focus on this shortcoming and complete terminal modernization affordably and expeditiously. When FAA replaced the 1970s-era systems at the large and small sites with Common ARTS, the Agency matched the system to the size and complexity of the sites. For instance, FAA scaled the Common ARTS digital system hardware to terminal site needs. Large and complex sites like Southern California received triple-redundant systems capable of handling input from multiple radars and later received computer processor upgrades. Small sites like Lubbock, Texas, received a single system that receives data from a single primary radar. In completing terminal modernization, FAA needs to address its needs at small, medium, and large sites and choose solutions based on three vectors: cost, time, and capability.

#### **Small Sites**

The highest priorities for FAA's small sites are cost and capability given traffic volume and complexity of airspace they are responsible for managing. After FAA has replaced all of the 1970s-era systems, the Agency will have 115 small terminal sites with Common ARTS systems. These sites do not yet have the same critical issue of timeliness driving their modernization needs as do FAA's large, complex

sites. However, the small sites have aging, 20-year-old displays called Radar Alphanumeric Displays that prevent usage of full Common ARTS capabilities, such as the color display of weather information. Replacing the aging displays with modern color displays would eliminate the need for technicians to maintain obsolete hardware and allow air traffic controllers at the small sites with digital radar to use more Common ARTS functions, such as color display of weather information.

The Common ARTS contractor and FAA estimate that if the Agency retains Common ARTS systems at these 115 sites, replaces the aging displays with color displays, and does other upgrades, such as replacing outdated computer processors and adding a backup system, the cost would be approximately \$200 million. The Agency is analyzing its alternatives for these sites.

According to STARS program officials and the contractor, an alternative that FAA could consider for the small sites is a scaled-down version of STARS with color displays. This version would be less costly by having fewer features than the original STARS system now deployed at the medium sites. This concept may have merit, but it has not been fully analyzed in terms of cost and time and has not been demonstrated, tested, or deployed to any FAA site. To know whether a STARS solution makes sense for the small sites, the Agency needs to compare the cost of STARS to the cost of upgrading Common ARTS and replacing the aging displays with commercially available displays. For the small sites, we are recommending that FAA request cost proposals for (a) replacing aging displays with new color displays and (b) implementing a STARS solution and selecting the most cost-effective and timely alternative.

### ***Medium Sites***

The highest priority for FAA's medium sites is system capability. FAA did not deploy Common ARTS to these sites. Improving capability is necessary because delays in the STARS program have left a number of these sites with aging 1970s-era systems and aging displays. Cost and time are not a driving factor because FAA has been purchasing STARS systems and color displays for these sites for several years. Only 8 more STARS with color displays need to be purchased and 18 installed to replace the last of the 1970s-era systems. For FY 2005, the STARS program office has requested \$113.9 million to continue deploying to the medium sites. Due to the overall delays in the program, STARS components being purchased today are now facing obsolescence, even though they were modern in 1996. FAA plans to begin technology refresh efforts in FY 2006.

## **Large Sites**

While capability is always an important factor, the highest priority decision vector for FAA's large sites is timeliness because aging displays need to be replaced. FAA deployed Common ARTS systems to 11 large and complex sites, such as New York and Southern California. These are currently FAA's most advanced sites, and system capability and cost are not primary modernization drivers because seven of the large sites received modern color displays. Nevertheless, the Agency's current plan is to wait for STARS to be delivered beginning sometime in FY 2008 rather than replace these aging displays now.

STARS is not expected to be ready to deploy to Chicago until sometime in FY 2008 because FAA first needs to spend \$57 million for further development through FY 2007. We met with officials of the National Air Traffic Controllers Association and discussed the aging displays at Chicago. They expressed concern that FAA plans to wait several years before replacing the aging displays even though new displays are commercially available and have been deployed at other Common ARTS sites, such as Southern California.

According to FAA's Vice President for Terminal Services, the condition of the aging displays at the remaining four large sites (Chicago, Denver, Minneapolis, and St. Louis) has become critical. For example, the aging displays at the remaining four sites limit any further software enhancements to controller workstations, including safety improvements recommended by the National Transportation Safety Board during its investigation of a mid-air collision in October 2000. The Board recommended that FAA modify software at its facilities to help controllers better track aircraft and display information when problems arise.<sup>12</sup> FAA concurred and is in the process of deploying this modification to all sites, except for the four large sites with aging displays.

Denver will not receive STARS until after Chicago receives STARS (sometime in FY 2008 at the earliest), but recent equipment failures at the site clearly demonstrate Denver's need for display modernization has become critical. Because of problems with aging displays, controller workstations are locking up on a random basis. FAA officials at the Denver facility told us that this has occurred 100 times in the past 3½ years and is now occurring a little over once a week. To fix the problem, technicians must restart the display, which takes a minimum of 90 seconds.

In addition, network communications components called transceivers that deliver data to the displays have been failing. These equipment failures are associated with FAA's decision to wait for STARS rather than upgrade the old displays and

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<sup>12</sup> Letter from Acting NTSB Chairman Carol J. Carmody to FAA Administrator Garvey dated April 19, 2001.

related network communications equipment. Denver now relies on network components that are no longer manufactured—these components can only be replaced by cannibalizing parts from retired systems. Although Chicago, St. Louis, and Minneapolis terminal facilities have not experienced the same failures rates, FAA officials at these sites have become concerned about this problem and the lack of spare parts.

As an alternative to waiting several more years for STARS, FAA could start replacing the obsolete displays immediately with commercially available color displays and installing other associated upgrades to improve reliability. FAA implemented this same solution in Southern California and completed the work in less than 1 year. FAA has not yet requested formal cost proposals, but the Common ARTS contractor estimates that this solution for all four large sites could be completed for \$35 million. In contrast, FAA estimates that just completing the STARS software development will cost \$57 million through FY 2007. This estimate does not include hardware and installation costs. After STARS development is complete, FAA expects deployment to the four sites will take place beginning in FY 2008.

Another alternative is relying on STARS color displays at Common ARTS sites. In July 2003, it was demonstrated to FAA that STARS color displays could operate with the Common ARTS software. Before FAA pursues this approach, the Agency would have to examine cost, time, and capability issues.

### **Aging Displays Can Be Replaced Before STARS Development Is Complete**

Time and cost vectors favor taking action to replace the aging displays at the small and large Common ARTS sites rather than waiting for STARS. However, FAA's current plans will require at least 3 years to complete STARS development and deployment at the four large sites. As noted earlier, problems with aging displays need to be addressed sooner rather than later. Replacing aging displays represents a step that will extend the useful life of installed systems and enhance their capability and reliability.

In September 2003, when FAA was projecting STARS would cost \$1.69 billion, we reported that based on FAA's cost estimates, the Agency could augment STARS deployments by replacing aging displays at the small and large sites and save over \$268 million versus the preferred STARS solution. As the Agency's STARS cost estimate has now risen to more than \$2 billion, FAA would generate even greater savings by replacing aging displays rather than waiting for the full STARS solution. However, to determine the actual savings with a degree of

precision, we urge FAA to compare the actual cost to replace the aging displays at the small and large sites to the cost of a full STARS solution.

### **FAA Must Resolve Important Issues About the Capabilities Needed for Terminal Modernization**

Until recently, FAA viewed STARS as its preferred long-term solution. The Agency's justification was that STARS has superior capabilities that will be worth both the wait and the extra cost. In the past, FAA cited STARS "fusion tracking," which is intended to track aircraft more precisely, and STARS computer security as important capabilities favoring the continued investment in STARS. Also, FAA maintained that the STARS "open architecture" was its "most significant" feature and that STARS provides a substantive increase in redundancy. Thus, the focus has tended to be on which system was better.

FAA tasked the MITRE Corporation, the Agency's Federally Funded Research and Development Center, to conduct assessments of STARS and Common ARTS with respect to fusion tracking and its relative benefits, as well as security. According to MITRE officials, their assessment does not show significant differences in the designs of the trackers. In our view, the focus has shifted from which system is better to a question of what capabilities are needed and where, what fusion tracking will cost, and how long it will take to deploy.

- ***Fusion Tracking.*** In essence, fusion tracking (or sensor fusion) integrates data from multiple sources, such as radar and satellite-based navigation systems, to give FAA controllers more accurate information on the position of aircraft. According to Lincoln Laboratory, fusion tracking's potential benefit could come from reducing standard separation between aircraft, thereby allowing for more efficient use of airspace near airports. The use of fusion tracking in managing air traffic is still evolving.

Currently, STARS is deployed with a fusion tracker at more than 25 locations but not without problems. These problems have been identified by air traffic controllers and other personnel and are documented in recent FAA program technical reports. For instance, the Agency has documented that the STARS tracker can have difficulty accurately tracking aircraft as they change altitude or it can drop an aircraft's flight information (i.e., aircraft data tags) that should be displayed on the controller's screen. FAA has had two expert consultants, ARCON and Lincoln Laboratory, examining STARS fusion tracking problems and their root causes. In April 2004, ARCON concluded that further analysis of the STARS altitude tracker's performance was necessary and recommended implementation of an alternative altitude tracker that will augment or replace the existing one.

The Common ARTS fusion tracker is still under development and is in testing at Louisville, Kentucky. This tracker integrates both radar and satellite based data but a number of technical issues need to be resolved about how to merge data from different sources. It is unclear how much it would cost or how long it would take to deploy the Common ARTS fusion tracker.

As the MITRE study points out, both STARS and Common ARTS fusion trackers are based on state-of-the-art designs but are at different points in the development cycle. Before real benefits can be expected from fusion tracking, such as enhancing capacity, FAA needs to resolve several unknowns regardless of which system is used.

Currently, FAA's experience with the Safe Flight 21 initiative shows that fusion tracking *when integrating data from radar and satellite-based navigation systems* (such as the Automated Dependent Surveillance Broadcast System) has potential benefits. However, STARS relies solely on *radar* fusion tracking and does not yet incorporate satellite-based data. A recent evaluation by Lincoln Laboratory of commercially available fusion trackers—including the STARS tracker—indicates that radar fusion tracking offers no more precise information than that provided by a single radar source.

In our view, the core issues are what capabilities are needed and where, what it will cost, and when it can realistically be deployed. This is reinforced by the MITRE study, which found no significant differences in the design of the two trackers. The MITRE study also points out that development remains to determine how fusion will be used in the terminal environment and what procedures need to be modified.

- ***Computer Security.*** FAA officials have maintained that STARS security provides a substantive increase over computer security in the existing Common ARTS system. This implies that the computer security features of the existing system are not adequate. However, as we reported in September 2003, FAA's Information Security Office has determined that both systems are acceptable and has assigned a moderate risk rating to each.

Similarly, FAA's Director of Airways Facilities has granted security authorization for both systems to operate in the National Airspace System. Moreover, it is not meaningful to state that STARS provides a substantive increase in security since the security vulnerabilities and security requirements are not the same for the two systems. For instance, because STARS is connected to outside locations, such as operational support facilities, remote STARS operators and support personnel could possibly

gain root access to the STARS operating system. The Common ARTS contractor could add additional security features to Common ARTS to address certain shortfalls. As the MITRE study points out, this was known 3 years ago and additional security could be added to Common ARTS at an estimated cost of \$3.8 million.

- ***Open Architecture.*** FAA has stated that a modern “open architecture” is STARS’ most significant feature and that this will enable expansion and adaptation to new functional requirements. However, the system is based on a proprietary computer standard and is not truly “open.” Therefore, FAA depends on the original computer equipment manufacturer. FAA refers to this as being “somewhat vendor-specific.”

Further, due to overall program delays, STARS components being purchased today are now facing obsolescence, even though they were modern in 1996. For example, recently purchased STARS computers contain refurbished (i.e., used) “Ultra 5” computer processors because Ultra 5s are no longer manufactured. To address this, FAA plans to begin modernizing STARS through a technology refresh program beginning in FY 2006. FAA points out that Common ARTS will also face technology refresh questions in the future.

Currently, FAA is negotiating with the STARS contractor for development of an Ultra 5 replacement processor. However, FAA currently has little choice but to purchase refurbished Ultra 5s while waiting for development of the new processor and software modifications to be completed.

In addition, FAA has not demonstrated that the STARS architecture readily enables expansion and adaptation to new functional enhancements. For instance, FAA has had a difficult experience in attempting to add a “final monitor aid” function to STARS. This is a function for air traffic controllers who control aircraft on final approach at airports with closely spaced parallel runways. The final monitor aid function is intended to enable the controllers to increase capacity by directing aircraft to safe and near simultaneous landings (rather than staggered landings) even in conditions of low visibility. After 2 years of effort and several million dollars invested, FAA does not have a working STARS final monitor aid function deployed.

- ***Redundancy.*** FAA maintains that STARS is superior because it provides quadruple redundancy: two full service systems and two emergency backups. While the two full service systems have all the safety features, the emergency backup does not have safety features such as minimum safe altitude warning or collision avoidance alarms. These safety features are

required in the existing backup systems at the Agency's large terminal sites. To make STARS equivalent to existing systems, FAA will need to develop safety features for the STARS emergency backup system.

Currently, the large terminal sites have triple redundancy with safety alarms in each level of backup. More specifically, the first two Common ARTS backup systems are the same as the primary operating system. Additionally, some sites have a relatively new system called Radar Gateway that provides another layer of backup. At small terminal sites, FAA has no requirement for a backup system so none was purchased when the existing Common ARTS computer systems were installed. Of course, FAA could choose to add backup systems at the small sites if the Agency believes it is necessary. Cost estimates for these modifications have not been developed.

### **Next Steps for Terminal Modernization**

The goal is how best to finish the modernization effort and do so expeditiously and at a reasonable cost. FAA's experience shows that one size does not fit all for terminal modernization. FAA needs to recognize that the modernization needs of the sites vary with respect to cost, time, and capability and should evaluate solutions accordingly. Further, FAA must resolve a number of unknowns, such as whether a scaled-down version of STARS for small sites is feasible, before making further investments in STARS.

### **FAA Needs To Reduce the Risk of Cost Growth in the STARS Contract**

FAA needs to reduce the risk of cost growth in the STARS contract. As we testified in April 2004, cost-reimbursable contracts cause the Government, and eventually the taxpayer, to absorb cost growth associated with overruns. FAA has been using a cost-reimbursable type of contract for STARS. However, because timeframe for production options in the original STARS contract expired in September 2002, FAA is negotiating a new agreement with the STARS prime contractor.

In commenting on our draft report, FAA stated that the Agency has a signed memorandum of agreement with Raytheon to put STARS into a large Common ARTS facility. We are not persuaded that a memorandum of agreement executed by a Federal official in advance of appropriations is controlling, particularly when FAA is negotiating a new agreement with the prime contractor at a time when work continues on short-term extensions. The important issue here is doing what makes sense for air traffic control, safety, and the taxpayer.

According to FAA, the new agreement will be limited to the purchase of the eight systems needed to complete the replacement of the 1970s-era systems. In addition to the purchase of the equipment, this agreement will also cover the necessary software development and installation work for these systems. FAA's plan for this new agreement calls for a mixture of fixed price and time and materials contract elements. FAA expects that the purchase and development cost will make up 60 to 70 percent of the total and be fixed price. The remaining 30 to 40 percent covering STARS installation and adaptation will be cost-reimbursable. In our opinion, the Government could reduce contract risk by not using cost-reimbursable elements or keeping their use to a bare minimum. Since FAA has already installed STARS at more than 25 sites, the Agency claims it has sufficient experience to predict these costs for other sites. Therefore, FAA should maximize the use of fixed price agreements for procuring and installing STARS.

## **RECOMMENDATIONS**

FAA cannot continue to delay making decisions about terminal modernization. A number of studies have been done and the alternatives have been identified. Therefore, we are recommending that FAA take immediate action to:

1. Replace aging displays at its four large terminal sites that do not have color displays. This should be done expeditiously and based on the priority needs of individual sites. As our report indicates, FAA cannot wait 3 more years.
2. Defer further investment in STARS beyond those needed to complete the 47 approved sites until the Agency completes its evaluation of moving forward with STARS or Common ARTS based on cost, schedule, and performance parameters. This is the evaluation we called for over 3 years ago in March 2001, and it should be completed within 6 months. As part this evaluation, FAA should:
  - (a) Request cost proposals for small terminal sites to replace aging displays with new color displays and implement a STARS solution, including a scaled-down version.
  - (b) Determine requirements for fusion tracking, as well as where it is needed, how much will cost, and how long it will take to deploy.
3. Negotiate a contract that maximizes the use of fixed price elements for completing the 47 sites already approved for STARS deployment, including installation and adaptation costs.

## **AGENCY COMMENTS AND OFFICE OF INSPECTOR GENERAL RESPONSE**

On October 8, 2004, we provided FAA with a draft of this report for formal Agency comment. On November 15, 2004, FAA electronically provided us with their response, which is contained in its entirety in the Appendix. FAA recognizes the need to replace aging displays and stated that the Agency is committed to a fair evaluation that identifies the best solution for each site. The draft report did refer to STARS as FAA's preferred solution. Because of FAA's comments, we state that FAA is rethinking its approach and we no longer refer to STARS as the Agency's current preferred alternative. FAA also notes that while it may have been biased toward STARS in the past, the Agency has put a new team in place that is objectively evaluating all alternatives. We adjusted our report, where appropriate, based on these comments.

FAA made a number of comments with respect to our description of capabilities and limitations of terminal systems currently in use or planned. Specifically, FAA points out that the Common ARTS fusion tracker is still under development, and much work remains to complete the tracker. We agree and have made adjustments to our report to reflect the developmental nature of the tracker.

With respect to STARS cost growth (from \$1.69 billion to over \$2 billion), FAA stated that cost growth with the program is attributable to the extension of time and the inability to accelerate the program as a result of competing capital programs and funding, rather than increases in development and deployment costs. The causation of schedule slips with STARS is directly attributable to extensive software and hardware development. As the report notes, STARS development is still not complete. Also, with a cost-plus contract, delays typically translate into additional costs.

Related to STARS software development, FAA stated that it would cost \$12 million to develop the necessary software for Chicago alone. However, FAA's cost estimates provided to our office earlier this year show that a total of \$57 million will have to be spent on software before STARS can complete deployment for Phase 1, which includes Chicago.

FAA commented that there are ramifications for DOD with respect to increased costs and infrastructure support for DOD if the Agency decided to limit the number of STARS purchases. Given that FAA plans to deploy STARS to at least 47 sites, we do not understand why this would be the case. Although FAA is concerned about increased costs with STARS for DOD, FAA should be more concerned about the cost of its own terminal modernization efforts. We note that DOD did not wait for FAA to address human factors concerns (that surfaced in the 1990s) and deployed STARS at Eglin Air Force Base, Florida, in June 2000 well

before FAA deployed the first “full STARS” to Philadelphia in November 2002. DOD continues to deploy STARS independent of FAA’s development of STARS for large sites. If there are issues regarding STARS and DOD, this is something that FAA’s new team that is responsible for objectively evaluating terminal modernization should consider.

FAA concurred with our recommendation to replace aging displays at its four larger terminal sites that currently do not have color displays. FAA stated that it is conducting a comprehensive technical, cost, and risk evaluation to determine the best solution for the sites. However, it is not clear from FAA’s response when the Agency plans to take action at the four sites. The fact remains that some sites, such as Denver, face time-critical decisions about replacing aging displays. We are requesting that FAA clarify its response.

FAA concurred with our recommendation to defer further investment in STARS beyond the 47 sites that have been approved and to evaluate the long-term feasibility of moving forward with STARS or Common ARTS in terms of cost, schedule, and performance parameters. This should be done in 6 months. As noted in the report, replacing the aging displays at large sites will extend the useful life of installed systems and provide FAA time to evaluate how it should proceed with terminal modernization. Regarding our recommendation in the draft report on small sites, FAA pointed out that capability is an important factor as well as cost. We agree and have modified our recommendation accordingly.

FAA concurred, in part, with our recommendation to negotiate a firm fixed price contract for completing the 47 sites already approved for STARS deployment that includes installation and adaptation costs. FAA stated that it is negotiating a fixed price contract for STARS systems but intends to rely on a time and materials financial arrangement for installation. FAA stated that this would avoid higher risk adjusted costs that accompany fixed price installation. FAA also stated that it has sufficient experience with STARS to ensure that installations come in at their budgeted cost. This seems to create an even more compelling case to maximize the use of fixed price elements to control costs. We are requesting that FAA reconsider its response to this recommendation.

## **ACTION REQUIRED**

We request that FAA reconsider or clarify its response to our recommendations, given the modifications made to the final report. In accordance with Department of Transportation Order 8000.1C, we request that you provide your written response within 30 calendar days advising us of your planned actions as well as target dates for taking action. You may provide alternative courses of action that you believe would resolve the issues presented in this report. We appreciate the

cooperation and assistance provided by your staff during our review. If you have any questions concerning this report, please contact me at (202) 366-1992 or David A. Dobbs, Assistant Inspector General for Aviation Audits, at (202) 366-0500.

cc: FAA Deputy Administrator  
FAA Chief of Staff  
Anthony Williams, ABU-100  
Martin Gertel, M-1

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## **EXHIBIT. SCOPE AND METHODOLOGY**

Our objectives were to (1) identify the modernization needs of FAA's small, medium, and large terminal sites, and (2) consider the alternatives available to FAA to meet those needs. To address our first objective, we acquired deployment data identifying the current configuration of terminal automation systems and displays at every operational terminal site in the National Airspace System. For the purposes of this report, we selected categories of terminal sites in terms of "small," "medium," and "large" that help describe FAA needs based on systems that are installed today. We also acquired historical and current cost, schedule, and performance data for FAA's STARS and Common ARTS terminal modernization programs. We analyzed these data to identify the modernization needs of FAA's small, medium, and large terminal sites. After a number of system failures occurred at FAA's Denver TRACON, we visited the facility to determine what the site's immediate modernization needs were.

After identifying what the modernization needs were for the various sites, we considered the alternatives available to FAA to meet those needs. We evaluated FAA's cost and schedule estimates for completing terminal modernization using two alternatives: (a) an "all STARS" solution, and (b) a Common ARTS solution that adds color displays. After determining that implementing the STARS alternative would require a higher cost and lengthier deployment plan than the Common ARTS alternative, we reviewed available performance data related to particular claims of STARS superiority, including a recent report by MITRE Corporation comparing the two systems. After FAA users reported concerns about STARS performance at a number of operational sites, we acquired and reviewed open STARS program technical reports related to FAA's efforts to address STARS radar tracker problems. For comparison, we also collected Common ARTS fusion tracker program technical reports for review.

While conducting this review, we interviewed key FAA officials responsible for managing major program acquisitions, terminal automation programs in general and the STARS and Common ARTS programs in particular. We also met with representatives of the STARS prime contractor, Raytheon; the Common ARTS prime contractor, Lockheed-Martin; and MITRE Corporation, which conducted a technical assessment of the STARS and Common ARTS systems. We discussed terminal modernization needs with user representatives of the National Air Traffic Controllers Association and the Union of Professional Airways Systems Specialists.

We performed our work from December 2003 through September 2004 in accordance with Government Auditing Standards as prescribed by the Comptroller General of the United States.

## APPENDIX. MANAGEMENT COMMENTS

### Federal Aviation Administration's (FAA) Response to

### Office of Inspector General's Draft Report: Terminal Modernization: Due to Continuing Cost Growth, FAA is Reevaluating its Current Approach

#### **I Overview**

*The FAA recognizes the need to replace the aging displays and associated equipment in its most critical terminal control facilities. The draft report supports the FAA's commitment to examine the alternatives, but rather than wait for the agency to complete its analysis, assumes the cost of deploying Common ARTS to the remaining sites is lower than STARS. The FAA believes this conclusion was reached without a comprehensive analysis, and as such, is premature. After encouraging the FAA to make a thorough study of the alternatives six months ago, the FAA believes the OIG should give the agency the time it needs to complete its analysis.*

The Terminal Automation Modernization and Replacement (TAMR) decisions will be based on comprehensive technical, cost and risk to service evaluations. The FAA will assess key operational data such as the amount and complexity of air traffic operations, the history of automation interruptions resulting in delays, site-unique requirements, obsolescence impacts, and legal exposure. The technical re-evaluation of the Terminal NAS and cost/benefits will be the basis for the Agency's priority determination of the "best value" approach for optimizing the equipment configuration at every specific TRACON. The FAA is committed to a fair evaluation that identifies the best solution for each site.

***II Capabilities and limitations:*** *The draft report does not adequately address the capability issues and operational needs.*

- The draft report (pages 6 and 19) notes that some STARS components are facing obsolescence, and that technical refresh costs will rise in future years. The FAA recommends the report note that the same is true for the Common ARTS components.
- The draft report (page 8) infers that the STARS and Common ARTS fusion trackers are at similar stages of development, or even that problems with the STARS tracker may mean it is behind the Common ARTS tracker. This is inaccurate. The Common ARTS fusion tracker is still under development, and has only been deployed to one site for testing purposes only. While the FAA and contractor are enhancing the STARS tracker, it is fully integrated into the STARS platform and operational at 45 sites (including the DoD sites). The report should acknowledge that significant work remains to be completed on the Common ARTS tracker, and that until FAA determines the costs of making it fully functional, a valid comparison between the two systems cannot be made.
- The draft report (page 19, open architecture) states that the existing STARS is based on a proprietary computer standard, and therefore its design is not truly open. It also notes the contractor plans to develop a new replacement processor. Actually, the contractor is not developing a replacement processor. Instead, it will be selected from those available in the commercial marketplace and must, by FAA direction, be "qualified" before it can be used on the contract. Also, the operating system is not being modified. Once the processor is chosen, an appropriate commercial operating system will be used that allows STARS to continue to meet all STARS requirements. STARS commercial processors currently operate on a version of SUN Solaris (UNIX-based) commercial operating system.
- The draft report (page 5) states: "Figure 3 shows the current distribution of Common ARTS, STARS, and 1970s-era terminal configurations at FAA's large, small, and medium terminal sites." The assumption that all Common ARTS IIIE TRACONs are large, Common ARTS IIEs are small, and all STARS TRACONs are medium is mistaken. Based on flight operations, several Common ARTS IIE TRACONs are medium to large, Louisville TRACON is small to medium and the 28 STARS TRACONs are all either medium to large facilities. Therefore the FAA's operational and technical urgency and timing to modernize specific TRACONs in the NAS is different than that presented in the draft report. Of the 35 FAA Operational Evolution Plan (OEP) – our most critical airports, STARS will be operational at 18 of those sites at the end of Phase 1A. By the end of FY05,

there will be 7 OEP STARS sites that are “larger” than the CARTS site of MSP and a planned 12 OEP STARS sites larger than STL.

The draft report suggests the FAA continues to have a bias in favor of STARS. While that may have been the case 2 years ago, the FAA has a new team in place that is objectively evaluating all possible alternatives under the TAMR initiative.

### **III Cost**

The draft report (page 3) refers to a \$2 Billion cost for STARS, but does not point out that most of this projected cost growth (as compared to the prior estimate of \$1.69B) is attributable primarily to extension of time/inability to accelerate as a result of competing capital programs and funding priorities, rather than increases in development and deployment costs.

### **IV Legal and Joint DoD Ramifications**

To the extent that the draft report directs an outcome for terminal modernization, the FAA is currently under contract to Raytheon for the full STARS deployment. Raytheon may have legal recourse if we terminate the contract for convenience of the Government. In addition, we have a signed MOA, which resolved the 1999 protest, to put STARS into a Common ARTS IIIIE facility.

STARS is a joint FAA Department of Defense (DoD) program, currently fully operational at 28 FAA sites as well as 18 DoD sites. Often understated, the FAA/DoD partnership began as early as 1994 with the formulation of the joint STARS Operational Requirements Document and has continued ever since. In fact, the first STARS system (ISC) was operational at Eglin AFB, FL in June 2000. The program as originally planned, requires the FAA to plan for, obtain and implement the STARS program, including the infrastructure to support the DoD’s planned deployments for all of its fixed-base air traffic control needs, world-wide. While this approach saved the Government from implementing two independent, costly development programs, it put the liability to effectively implement STARS squarely on the FAA. Decreasing STARS procurement quantities will in all likelihood increase costs to the DoD for procuring systems to meet its needs. DoD plans to deploy STARS worldwide to 106 radar control facilities and 75 towers independent of the FAA’s decisions.

### **V Response To Recommendations**

**Recommendation 1:** Replace aging displays at its four large terminal sites that currently do not have color displays.

**FAA Response:** Concur. The FAA recognizes that replacement of the monochrome displays at the four large terminal sites is important, especially at

### **Appendix. Management Comments**

Chicago and Denver where time is of a more critical nature than at St. Louis or Minneapolis. However, capability at these sites is important as well. The FAA is conducting a comprehensive technical, cost and risk evaluation to determine the best solution for these four sites.

**Recommendation 2:** Request cost proposals for (a) replacing aging displays with new color displays, and (b) implementing a STARS solution at its small terminal sites. FAA should select the least expensive option.

**FAA Response:** Non-concur. The FAA believes it is premature to initiate a new competitive bid for the CARTS IIE sites before it completes its technical, cost and risk evaluation. The evaluation will provide the basis for determining the best value equipment configuration at each terminal facility, consistent with Recommendation 3. The FAA expects to complete its evaluation by summer 2005.

**Recommendation 3:** Defer further STARS purchases beyond those needed to complete the 47 approved STARS sites and evaluate the long-term feasibility of moving forward with the preferred STARS solution. This evaluation should be based on cost, schedule, and performance parameters and should include a comparison of the capability and functionality of FAA's most complex STARS sites (i.e., Boston) to a similarly sized large Common ARTS site.

**FAA Response:** Concur. The FAA will conduct a comprehensive technical, cost and risk evaluation to determine the best solution for all the remaining sites.

**Recommendation 4:** Negotiate a fixed price contract for completing the 47 sites already approved for STARS deployment that includes installation and adaptation costs.

**FAA Response:** Concur, in part. The FAA is negotiating a firm fixed price contract for the remaining systems, representing 65 percent of the STARS budget. However, based on the lessons learned from earlier STARS installations, the FAA is contracting for the installation support on a time and materials basis. Installation represents about ten percent of STARS spending. The FAA used a cost-plus contract for the first 28 STARS installations, and the actual costs never exceeded the agency's estimates. The FAA believes a time and materials contract for the remaining 19 installations will avoid the higher risk-adjusted costs that accompany fixed price installations. The FAA also believes that it has sufficient experience with STARS to ensure that these installations come in at their budgeted cost.

## **VI Other Specific Comments:**

Top of page 2. “FAA’s cost estimating and analysis process for STARS has been slowed considerably by the Agency’s decision to reconsider its terminal modernization approach.”

- This sentence implies that FAA has been responsible for delaying the IG’s response to Congress. FAA began providing data to the OIG in December 2003 and continued doing so until July 2004. Since that time, the agency has been providing timely responses to inquiries from the OIG.

Page 3. “Development was originally estimated to be \$80 million and is still not complete.”

- Sentence needs to be clarified to indicate that this figure represents the estimated development at the date of contract award. It should also be pointed out that the computer-human interface enhancements, which caused a significant amount of development cost growth, were supported by the OIG at the time.

Page 4. “...at least 2 more years and cost \$57 million without hardware...”

- The \$57 million applies to all eleven CARTS IIIE sites. The development costs for Chicago alone are estimated to be \$12 million.

Page 20. Paragraph on Redundancy and emergency back-up.

- The paragraph does not make it clear that both of the STARS full service levels have full safety features. Furthermore, the Radar Gateway feature of CARTS is a relatively new upgrade that is only available at only 7 of the 11 IIIE sites (not at any of the IIE sites and not at ORD, MSP, STL or DEN).