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Report to Congressional Requesters

June 2005

NATIONAL AIRSPACE SYSTEM

FAA Has Made Progress but Continues to Face Challenges in Acquiring Major Air Traffic Control Systems

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GAO-05-331

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Highlights

Highlights of GAO-05-331, a report to congressional requesters

NATIONAL AIRSPACE SYSTEM

FAA Has Made Progress but Continues to Face Challenges in Acquiring Major Air Traffic Control Systems

Why GAO Did This Study

The Federal Aviation Administration's (FAA) multibillion-dollar effort to modernize the nation's air traffic control (ATC) system has suffered from cost, schedule, and/or performance shortfalls in its system acquisitions for more than two decades and has been on our list of high risk programs since 1995. FAA's performance-based Air Traffic Organization (ATO) was created in February 2004, in part, to address these legacy challenges.

In this report, GAO examined (1) FAA's experience in meeting cost, schedule, and performance targets for major ATC system acquisitions; (2) steps taken to address legacy problems with the program and additional steps needed; and (3) the potential impact of the constrained federal budget on this program.

What GAO Recommends

GAO recommends that the Secretary of Transportation direct FAA to provide detailed information to Congress about the impact of planned funding cuts on the agency's ability to modernize the ATC system, and the National Airspace System (NAS).

In commenting on a draft of this report, the Department of Transportation (DOT), FAA, and ATO said they generally agreed with the report. They did not comment on the recommendation.

www.gao.gov/cgi-bin/getrpt?GAO-05-331.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Gerald L. Dillingham, (202) 512-2834, dillinghamg@gao.gov.

What GAO Found

The ATO met its acquisition goal for fiscal year 2004. However, prior to the establishment of the ATO, FAA had experienced more than two decades of cost, schedule, and/or performance shortfalls in acquiring major systems under its ATC modernization program. For example, 13 of the 16 major system acquisitions that we reviewed in detail have experienced cost, schedule, and/or performance shortfalls when assessed against their original milestones. These 13 system acquisitions experienced total cost growth from $1.1 million to about $1.5 billion; schedule extensions ranging from 1 to 13 years; and performance shortfalls, including safety problems. We found that one or more of four factors—funding, requirements growth and/or unplanned work, stakeholder involvement, and software complexity—have contributed to these legacy challenges. While FAA met its recent acquisition goal, it is important to note that this goal is based on updated program milestones and cost targets for system acquisitions, not those set at their inception. Consequently, they do not provide a consistent benchmark for assessing progress over time. Also, as indicators of annual progress, they cannot be used in isolation to measure progress over the life of an acquisition.

Although additional steps are warranted, FAA has taken some positive steps to address key legacy challenges it has had with acquiring major systems under the modernization program. For example, the ATO has cut funding for some major systems that were not meeting their goals and is reassessing all capital investments to help ensure that priority systems receive needed funding. The ATO has improved its management of software-intensive acquisitions and information technology investments and begun to more actively involve stakeholders. As we recommended, the ATO plans to establish an overall policy to apply its process improvement model to all software-intensive acquisitions. However, additional steps could be taken to improve its management of system acquisitions. For example, the ATO could use a knowledge-based approach to managing system acquisitions, characteristic of best commercial practices, to help avoid cost, schedule, and performance problems.

The ATO will also be challenged to modernize the ATC system under constrained budget targets, which would provide FAA with about $2 billion less than it planned to spend through 2009. To fund its major system acquisitions and remain within these targets, the ATO has eliminated planned funding to start new projects and substantially reduced planned funding for other areas. However, when forwarding its budget submission for review by senior officials at FAA, DOT, the Office of Management and Budget, and Congress, the ATO provides no detail on the impact of the planned funding reductions on ATC modernization and related activities to modernize the NAS. Our work shows that the ATO should provide these decisionmakers with detailed information in its budget submissions about the impact of funding decisions on modernization efforts. Without this type of information, decision-makers lack important details when considering FAA's annual budget submissions.

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Abbreviations

ACE-IDS	Automated Surface Observing System Controller Equipment Information Display System
ADL	Aeronautical Data Link
ADS-B	Automatic Dependent Surveillance-Broadcast
AFSS	Automated Flight Service Stations
ALSIP	Approach Lighting System Improvement Program
AMS	Acquisition Management System
ARCSCC	FAA Air Traffic Control System Command Center
ARTCC	Air Route Traffic Control Centers
ARTS	Automated Radar Terminal System
ASWON	Aviation Surface Weather Observation Network
ASDE-X	Airport Surface Detection Equipment – Model X
ASOS	Automated Surface Observing System
ASR-9	Airport Surveillance Radar – Model 9
ASR-11	Airport Surveillance Radar – Model 11
ATC	Air Traffic Control
ATCBI-6	Air Traffic Control Beacon Interrogator Replacement
ATCT	Air Traffic Control Towers
ATO	Air Traffic Organization
ATOP	Advanced Technologies and Oceanic Procedures
AWOS	Automated Weather Observing System
AWSS	Automated Weather Sensors Systems
C3	Command, Control, and Communications
CARTS	Common Automated Radar Terminal System
CCS	Command Center Conference Control System
CDM	Collaborative Decision Making
CFE	Communications Facilities Enhancements
CMMI	Capability Maturity Model Integration
CNS	Communications, Navigation, and Surveillance

CIWS	Corridor Integrated Weather System
COTS	Commercial-Off-the-Shelf
CPDLC	Controller-Pilot Data Link Communications
CTS	Critical Telecommunications Support
DME	Distance Measuring Equipment
DOD	Department of Defense
DSP	Departure Spacing Program
E-Scan	Electronic Scan
ECG	En Route Communication Gateway
ERAM	En Route Automation Modernization
ETVS	Enhanced Terminal Voice Switches
FAA	Federal Aviation Administration
FFP2	Free Flight Phase 2
FIS	Flight Information Service
FISDL	Flight Information Service Data Link
FTI	FAA Telecommunications Infrastructure
GAO	U.S. Government Accountability Office
GNSS	Global Navigation Surveillance Systems
HAATS	Houston Area Air Traffic System
HOCSR	HOST/Oceanic Computer System Replacement
IATS	Initial Academy Training System
ICAO	International Civil Aviation Organization
iCMM	integrated Capability Maturity Model
ILS	Instrument Landing System
IOC	Initial Operating Capability
IT	Information Technology
ITIM	Information Technology Investment Management
ITWS	Integrated Terminal Weather System
JRC	Joint Resources Council
LAAS	Local Area Augmentation System
LRR	Long-range Radar
NAS	National Airspace System
NDI	Non-Developmental Item
NASR	National Airspace System Resources
NEXCOM	Next Generation Air-to-Ground Communication System
NEXRAD	Next Generation Weather Radar
NIMS-2	National Airspace System Infrastructure Management System-Phase 2
NOTAM	Notice to Airmen
NTSB	National Transportation Safety Board
NWS	National Weather Service
OASIS	Operational and Supportability Implementation System

OMB	Office of Management and Budget
ORD	Operational Readiness Date
PRM	Precision Runway Monitor
RFI	Radio Frequency Interference
RIRP	Runway Incursion Reduction Program
RTCA	Radio Technical Commission for Aeronautics
RVR	Runway Visual Range
SAWS	Stand-alone Weather Sensors
SF-21	Safe Flight 21 Program
SLEP	Service Life Extension Program
STARS	Standard Terminal Automation Replacement System
TDLS	Tower Data Link Services
TFM-I	Traffic Flow Management-Infrastructure
TMA	Traffic Management Advisor
UHF	Ultra High Frequency
URET	User Request Evaluation Tool
VOR	Very High Frequency Omni-directional Range
VORTAC	Very High Frequency Omni-directional Collocated with Tactical Air Navigation
VRRP	Voice Recorder Replacement Program
VSCS	Voice Switching and Control System
WAAS	Wide Area Augmentation System
WMSCR	Weather Message Switching Center Replacement

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Congressional Requesters

In 1981, the Federal Aviation Administration (FAA) began what it initially envisioned as a 10-year modernization program to upgrade and replace the National Airspace System's (NAS) facilities and equipment to meet projected increases in traffic volumes, enhance the system's margin of safety, and increase the efficiency of the air traffic control (ATC) system—a principal component of the NAS. To date, FAA has spent $43.5 billion for its NAS modernization effort[1] and plans to spend an additional $9.6 billion through fiscal year 2009, primarily to upgrade and replace ATC systems and facilities.[2] For more than two decades, ATC system acquisitions under the NAS modernization program[3] have experienced significant cost growth, schedule delays, and performance problems. As a result, the ATC modernization program has been on our list of high-risk programs since 1995. To improve FAA's management of the modernization program, Congress, in 1995, gave the agency acquisition and human capital flexibilities,[4] which FAA has largely implemented.

In 2000, Congress and the administration took further steps to improve the modernization program's management. Through legislation and an executive order, they laid the foundation for, among other things, a performance-based organization to manage FAA's ATC investments and operations and a chief operating officer to lead it. In response, FAA hired a chief operating officer in August 2003 and created the Air Traffic

[1]For purposes of this report, "NAS modernization" refers to ATC facilities, equipment, and related expenses.

[2]The estimates are presented in then-year dollars, which means that they represent the nominal dollar sum of the estimated spending in different years. To estimate future-year spending, FAA incorporates assumptions on inflation developed by the Office of Management and Budget (OMB).

[3]This report, as well as our work for more than two decades on FAA's ATC modernization program, has assessed progress for major ATC system acquisitions based on the cost, schedule, and performance goals set at the inception of each program.

[4]Department of Transportation Appropriations Act, Pub. L. 104-50, § 348 (1995).

Organization (ATO)[5] in February 2004. The ATO inherited the decades-long legacy of cost, schedule, and/or performance problems with major ATC system acquisitions and at the same time received $400 million less for fiscal year 2005 than it had planned to spend for ATC modernization. In addition, projected funding levels from the administration are about $2 billion less than FAA had planned to spend for fiscal years 2005 through 2009.

The ATC modernization program is critical to meeting future air traffic safety, capacity, and efficiency needs. FAA reported that U.S. airlines carried nearly 690 million passengers in 2004 and that it expects the number of passengers to reach 1 billion by 2015. According to FAA, the agency has spent about 58 percent, or $25.1 billion, of the $43.5 billion total for NAS modernization on system acquisitions designed to replace or upgrade various ATC systems.

In light of past problems with and continuing concerns about funding major ATC system acquisitions under the ATC modernization program, you asked us to examine (1) FAA's experience in meeting cost, schedule, and/or performance targets for major system acquisitions under its ATC modernization program; (2) the steps FAA has taken to address long-standing challenges with the ATC modernization program and additional steps that are needed; and (3) the potential effects of the constrained budget environment on FAA's ability to modernize the ATC system. To address these objectives, we reviewed in detail 16 of the 55 system acquisitions[6] under the ATC modernization program, primarily by interviewing FAA officials and obtaining and analyzing key acquisition

[5]Wendell H. Ford Aviation Investment and Reform Act for the 21st Century, Pub. L. 106-181, § 303 (2000); E.O.13180. Under the executive order, part of the ATO's purpose is to "develop methods to accelerate air traffic control modernization and to improve aviation safety related to air traffic control."

[6]According to FAA officials, the number of system acquisitions in the ATC modernization program can vary annually, when Congress earmarks funds for a specific system acquisition. As of March 2005, the number of system acquisitions under the program was 55.

documents.[7] We selected these 16 systems in July 2004, when this review was still a part of our broader work on FAA's efforts to modernize the NAS.[8,9] Specifically, we selected the 16 ATC system acquisitions with the largest life-cycle costs that met the following criteria: each system had cost, schedule, and performance targets; was discussed in prior GAO and Department of Transportation Inspector General (DOT IG) reports, had not been fully implemented or deployed by 2004, and received funding in 2004. We reviewed this list with FAA officials to ensure that we did not exclude any significant system. In fiscal year 2005, these 16 major ATC system acquisitions account for about 36 percent of FAA's facilities and equipment budget.[10] (See app. I for additional information on these 16 systems.) We also collected information on the remaining 39 system acquisitions under this program, which account for about 19 percent of FAA's facilities and equipment account for fiscal year 2005.[11] (See app. II for additional information on these 39 systems.) In addition, we reviewed past GAO and DOT IG reports. We interviewed FAA officials within the recently created ATO and collected and analyzed the documents they provided. We also interviewed officials with the Aircraft Owners and Pilots Association, Air Transport Association, Department of Defense (DOD), National Air Traffic

[7]At the time of our audit, FAA planned to deploy 64 Operational and Supportability Implementation Systems (OASIS) to automated flight service stations by 2005. However, after deploying 19 such systems in 2004, FAA discontinued the system's deployment, pending a decision about whether to contract out the operation of automated flight service stations. In February 2005, FAA awarded a contract to Lockheed Martin to operate these stations.

[8]Our methodology for selecting the 16 system acquisitions to review in detail was based on the fiscal year 2004 appropriation for FAA's facilities and equipment budget, which was available when the engagement was designed. However, to make the report as current as possible, we have used fiscal year 2005 funding levels where appropriate, including the status sheets for each of the 16 systems in appendix I. See app. III for additional information on our methodology.

[9]Our review of FAA's NAS modernization efforts will be issued later this year.

[10]FAA does not have a formal definition of "major" systems under its Acquisition Management System; however, agency officials told us that if a system acquisition has a formally approved baseline, we could consider it "major." Using this definition, 25 of the 55 system acquisitions under the ATC modernization program are major.

[11]The remaining 45 percent of the facilities and equipment budget for fiscal year 2005 will be spent on facilities, mission support, and personnel-related activities.

Controllers Association, and RTCA.[12] Furthermore, we convened a panel of international aviation experts.[13] Our review did not focus on FAA's efforts to modernize its airports and other agency facilities. We conducted our review from November 2004 through May 2005 in accordance with generally accepted government auditing standards. (See app. III for additional information on our objectives, scope, and methodology.)

Results in Brief

The ATO has shown progress during its first year of operation by meeting its acquisition goal for fiscal year 2004. However, for more than two decades, FAA has experienced cost growth, schedule extensions, and/or performance problems in acquiring major systems under its ATC modernization program and has been on our list of high-risk programs since 1995.[14] Since their inception, 13 of the 16 major system acquisitions that we reviewed in detail for this engagement have experienced cost, schedule, and/or performance shortfalls when assessed against their original baselines or performance targets. Specifically, the total cost for these 13 major system acquisitions ranged from $1.1 million to about $1.5 billion over their original cost targets. In addition, these 13 system acquisitions also experienced schedule extensions that ranged from 1 to 13 years[15] over their original schedule targets. Furthermore, several of these 13 system acquisitions experienced performance shortfalls related to

[12]Organized in 1935 and once called the Radio Technical Commission for Aeronautics, RTCA is today known just by its acronym. RTCA is a private, not-for-profit corporation that develops consensus-based performance standards for ATC systems. RTCA serves as a federal advisory committee, and its recommendations are the basis for a number of FAA's policy, program, and regulatory decisions.

[13]GAO, *Experts' Views on Improving the U.S. Air Traffic Control Modernization Program*, GAO-05-333SP (Washington, D.C.: April 2005).

[14]GAO, *High-Risk Series: An Update*, GAO-05-207 (Washington, D.C.: January 2005); GAO, *Air Traffic Control: FAA Needs to Ensure Better Coordination When Approving Air Traffic Control Systems*, GAO-05-11 (Washington, D.C.: Nov. 17, 2004); GAO, *Air Traffic Control: FAA's Acquisition Management Has Improved, but Policies and Oversight Need Strengthening to Help Ensure Results*, GAO-05-23 (Washington, D.C.: Nov. 12, 2004); GAO, *Information Technology: FAA Has Many Investment Management Capabilities in Place, but More Oversight of Operational Systems Is Needed*, GAO-04-822 (Washington, D.C.: Aug. 20, 2004); and GAO, *Air Traffic Control: System Management Capabilities Improved, but More Can Be Done to Institutionalize Improvements*, GAO-04-901 (Washington, D.C.: Aug. 20, 2004).

[15]Schedule extensions were calculated based on the date FAA plans to deploy the last system.

safety. Our work indicates that one or more of the following four factors have contributed to the legacy challenges FAA has experienced in meeting system acquisitions' cost, schedule, and/or performance targets: (1) receiving funding for acquisitions at lower levels than called for in agency planning documents, (2) adding requirements and/or unplanned work, (3) not sufficiently involving stakeholders throughout system development, and (4) underestimating the complexity of software development. Three of the major 16 ATC system acquisitions we reviewed in detail are currently operating within their original cost, schedule, and performance targets, despite challenges that are symptomatic of past problems. To its credit, the ATO has reported that it met its annual acquisition performance goal for fiscal year 2004: to meet 80 percent of designated milestones and maintain 80 percent of critical program costs within 10 percent of the budget as published in its Capital Investment Plan. However, in our opinion, having and meeting such performance goals is commendable, but it is important to note that these goals are updated program milestones and cost targets, not those set at the program's inception.[16] Consequently, they do not provide a consistent benchmark for assessing progress over time. Moreover, as indicators of annual progress, the goals cannot be used in isolation to measure progress in meeting cost and schedule targets over the life of an acquisition. Finally, given the problems FAA has had in acquiring major ATC systems for over two decades, it is too soon to tell whether meeting these annual performance goals will ultimately improve the agency's ability to deliver system acquisitions as promised.

FAA has taken a number of positive steps, primarily through the ATO, to address key legacy challenges it has had with acquiring major systems under its ATC modernization program; however, additional steps are warranted to reduce risk and strengthen oversight. Some of the positive steps taken directly address the four factors we identified as contributing to cost, schedule, and/or performance problems, while others support more general efforts to improve the modernization program's management. For example, the ATO has demonstrated a willingness to cut some major acquisitions that are not meeting their performance targets, even after investments of significant resources, and is reassessing all of its capital investments to help ensure that high-priority system acquisitions receive needed funding. The ATO has also improved its management of information

[16]Our statements about cost, schedule, and/or performance in this report and in our past reports are based on the original targets that FAA established and approved at the start of its acquisition programs.

technology investments and software-intensive acquisitions; these efforts are positive steps toward minimizing growth in requirements and unplanned work and better assessing the complexity of software development. For example, on a number of software-intensive acquisition projects, the ATO has applied a process improvement model that resulted in positive outcomes such as enhanced productivity and greater ability to predict schedules and resources. As we recommended, FAA plans to institutionalize the use of this model by establishing a policy to define the ATO's expectations for process improvements and a plan to address and coordinate process improvement activities throughout the organization.[17] The ATO has also begun to include stakeholders in all phases of system development, so that they can provide input in response to technical or financial developments. However, we have identified additional steps that are needed to reduce risk and strengthen oversight. For example, we found that the ATO does not use a knowledge-based approach to system acquisitions, characteristic of best commercial practices for managing commercial and DOD product developments, which would help avoid cost, schedule, and/or performance problems.[18] We recommended, among other things, that FAA take several actions to more closely align its acquisition management system with commercial best practices. FAA said that our recommendations would be helpful to them as they continue to refine this system. Continued improvement and management attention will be crucial if the organization is to succeed in addressing key legacy challenges.[19]

The current constrained budget environment, which includes lower future budget targets than those of recent years, poses further challenges to the ATO as it attempts to modernize the ATC system. FAA plans to spend $4.4 billion from fiscal year 2005 through fiscal year 2009 to fund key modernization efforts; however, this funding level is about $2 billion less than the agency had expected in appropriations for this 5-year period. To fund its major system acquisitions while remaining within the budget targets, the ATO has eliminated planned funding to start new projects and reduced planned funding for other areas. However, when forwarding its budget submission for review by senior FAA, DOT, and OMB officials and by Congress, the ATO provides no detail on the impact of the planned funding reductions on ATC modernization and related activities to

[17] GAO-04-901.

[18] GAO-05-23.

[19] GAO-05-207.

modernize the NAS. Our work shows that the ATO should provide these officials and Congress with detailed information in its budget submissions about the impact of reduced budgets on both ATC and NAS modernization. To do so, the ATO should explicitly identify the trade-offs it is making to reach budget targets, highlighting those programs slated for increased funding and those slated for reduced funding. Without this type of information, decision-makers lack important details when considering FAA's annual budget submissions. We are recommending that FAA provide this information to Congress annually.

In commenting on draft of this report, DOT, FAA, and ATO generally agreed with the report and provided technical comments, which we incorporated as appropriate. The FAA officials said they are continuing to consider our recommendation and indicated they would provide a written statement required by 31 U.S.C. 720.[20]

Background

The mission of FAA, as a DOT agency, is to provide the safest, most efficient aerospace system in the world. To fulfill its mission, FAA must rely on an extensive use of technology, including many software-intensive systems. FAA constantly relies on the adequacy and reliability of the nation's ATC system, which comprises a vast network of radars; automated data processing, navigation, and communications equipment; and ATC facilities.[21] Through this system, FAA provides services such as controlling takeoffs and landings and managing the flow of traffic between airports.

FAA is organized into several staff support offices and five lines of business, which include Airports, Aviation Safety, Commercial Space

[20]31 U.S.C. § 720 requires, in part, that agencies report the actions taken on our recommendation to the Senate Committee on Homeland Security and Governmental Affairs and to the House Committee on Government Reform not later than 60 days from the date of the report.

[21]FAA uses three types of facilities to control traffic: airport towers, terminal radar approach control facilities, and en route centers. Airport towers direct traffic on the ground, before landing, and after takeoff within 5 nautical miles of the airport and about 3,000 feet above the airport. Terminal radar approach control facilities sequence and separate aircraft as they approach and leave airports, beginning about 5 nautical miles and ending about 50 nautical miles from the airport and generally up to 10,000 feet above the ground. Air route traffic control centers, called en route centers, control aircraft in transit and during approaches to some airports, generally controlling air space that extends above 18,000 feet for commercial aircraft.

Transportation, the Office of Security and Hazardous Materials, and the newly formed ATO.[22] The ATO was formed in February 2004 to, among other things, improve the provision of air traffic services and accelerate modernization efforts. To create the ATO, FAA combined its Research and Acquisition and Air Traffic Services into one performance-based organization, bringing together those who acquire systems and those who use them, respectively. The ATO is led by FAA's chief operating officer, consists of 10 service units,[23] and has 36,000 of FAA's 48,000 employees.

The ATO is the principal FAA organizational unit responsible for acquiring ATC systems through the use of the agency's Acquisition Management System (AMS). Because FAA formerly contended that some of its modernization problems were caused by federal acquisition regulations, Congress enacted legislation in November 1995 that exempted the agency from most federal procurement laws and regulations and directed FAA to develop and implement a new acquisition management system that would address the unique needs of the agency. In April 1996, FAA implemented AMS. AMS was intended to reduce the time and cost of fielding new system acquisitions by introducing (1) a new investment system that spans the life cycle of an acquisition, (2) a new procurement system that provides flexibility in selecting and managing contractors, and (3) organizational and human capital reforms that support the new acquisition system.

AMS provides high-level acquisition policy and guidance for selecting and controlling ATC system acquisitions through all phases of the acquisition life cycle, which is organized into a series of phases and decision points that include (1) mission analysis, (2) investment analysis, (3) solution implementation, and (4) in-service management. To select system acquisitions, FAA has two processes--mission analysis and investment analysis–that together constitute a set of policies and procedures, as well as guidance, that enhance the agency's ability to screen system acquisitions submitted for funding. Also through these two processes, FAA assesses and ranks each system acquisition according to its relative costs, benefits,

[22]Executive Order 13180 created the ATO. The executive order was later amended by Executive Order 13264, which removed the description of air traffic services as an "inherently governmental function."

[23]The 10 service units that make up the ATO include Safety, Communications, Operations Planning, Finance, Acquisition and Business Services, En Route and Oceanic Services, Terminal Services, Flight Services, System Operations Services, and Technical Operations Services.

risks, and contribution to FAA's mission; a senior, corporate-level decision-making group then selects system acquisitions for funding. After a system acquisition has been selected, FAA officials are required to formally establish the life-cycle cost, schedule, benefits, and performance targets—known as acquisition program baselines,[24] which are used to monitor the status of the system acquisition throughout the remaining phases of its life cycle.

Through its NAS modernization program, FAA is upgrading and replacing ATC facilities and equipment to help improve the system's safety, efficiency, and capacity. These systems involve improvement in the areas of automation, communication, navigation and landing, surveillance, and weather to support the following five phases of flight (see fig. 1):

- Preflight – The pilot performs flight checks and the aircraft is pushed-back from the gate. For preflight, we looked at Collaborative Decision Making (CDM) and OASIS.

- Airport Surface – The aircraft taxis to the runway for takeoff or, after landing, to the destination gate to park at the terminal. For airport surface, we examined the Airport Surface Detection Equipment – Model X (ASDE-X).

- Terminal Departure – The aircraft lifts off the ground and climbs to a cruising altitude. For terminal departure, we examined the following systems: Airport Surveillance Radar (ASR-11), Integrated Terminal Weather System (ITWS), Local Area Augmentation System (LAAS), Standard Terminal Automation Replacement System (STARS), and Traffic Management Advisor (TMA).

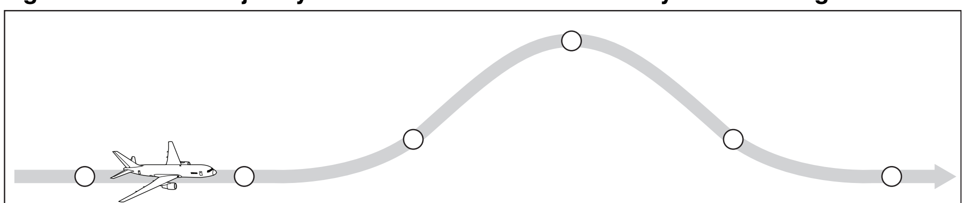
- En route/Oceanic -- The aircraft travels through one or more center airspaces and approaches the destination airport. For en route and oceanic, we examined the following systems: Air Traffic Control Radar Beacon Interrogator-Replacement (ATCBI-6), Advanced Technologies and Oceanic Procedures (ATOP), Controller-Pilot Data Link Communications (CPDLC), and User Request Evaluation Tool (URET).

[24]In December 2004, FAA revised its Acquisition Management System, including changing the name Acquisition Program Baseline to Exhibit 300 Program Baseline.

- Terminal Arrival -- The pilot lowers, maneuvers, aligns, and lands the aircraft on the destination airport's designated landing runway. For terminal arrival, we looked at the systems already listed under terminal departure: ASR-11, ITWS, LAAS, STARS, and TMA.

In addition, for the major ATC systems that support multiple phases of flight, we examined the following systems: En Route Communications Gateway (ECG), En Route Automation Modernization (ERAM), Next-Generation Air-to-Ground Communication (NEXCOM), and Wide Area Augmentation System (WAAS). Furthermore, for major ATC systems that support NAS infrastructure, we examined FAA Telecommunications Infrastructure (FTI) and NAS Infrastructure Management System (NIMS)–Phase Two.[25] (See app. I for additional information on these 16 systems.)

Figure 1: Sixteen Major Systems We Examined in Detail by Phase of Flight



Preflight	Airport surface	Terminal departure	En route/ oceanic	Terminal arrival	Airport surface
CDM[a] OASIS	ASDE-X	ASR-11 ITWS LAAS STARS TMA[a]	ATCBI-6 ATOP CPDLC URET[a]	ASR-11 ITWS LAAS STARS TMA[a]	ASDE-X
Multiple stages of flight ECG, ERAM, NEXCOM, WAAS					
Infrastructure FTI, NIMS					

Source: FAA.

[a]CDM, TMA, and URET are decision support tools that fall under the Free Flight program, which is currently called Free Flight Phase 2 (FFP2). We reviewed FFP2 as a single system acquisition.

[25]Air Traffic Control involves a number of other systems, such as the Common Automated Radar Terminal System, used in the terminal arrival and terminal departure phases.

FAA Has Had Difficulty Meeting Cost, Schedule, and/or Performance Targets for Major System Acquisitions, but Made Progress in Fiscal Year 2004

For more than two decades, FAA has experienced cost growth, schedule extensions, and/or performance problems in acquiring major systems under its ATC modernization program and has been on our list of high-risk programs since 1995. For example, 13 of the 16 major system acquisitions we reviewed in detail continue to experience cost, schedule, and/or performance shortfalls when assessed against their original baselines. The three other major system acquisitions that we reviewed in detail are currently operating within their original cost, schedule, and performance targets, but are experiencing challenges symptomatic of past problems. Of the remaining 39 system acquisitions within the ATC modernization program, few have had problems meeting cost and schedule targets.[26] However, the ATO made progress during its first year of operation by meeting its acquisition goal for fiscal year 2004.

Thirteen of the 16 Major ATC System Acquisitions We Reviewed in Detail Continue to Experience Shortfalls When Assessed against Original Performance Targets

Thirteen of the 16 major system acquisitions that we reviewed in detail for this engagement under the ATC modernization program have continued to experience cost growth, schedule delays, and/or performance problems when assessed against their original performance targets (see table 1). These major system acquisitions had total cost growth ranging from $1.1 million to about $1.5 billion over their original cost targets. In addition, these systems required extensions in their initial deployment schedules ranging from 1 to 13 years. Furthermore, several systems experienced safety-related performance problems.

[26]Many of these systems are referred to as "buy-it-by-the-pound" systems, which, generally, are commercially available at a set level of performance, and, therefore, do not have performance goals per se.

Table 1: Changes in Cost and Schedule Targets for 16 Major ATC System Acquisitions

Dollars in millions

ATC system	Original date	Cost targets: Original cost	Cost targets: Current cost (as of March 2005)	Change	Last-site implementation targets: Original date	Last-site implementation targets: Current date	Last-site implementation targets: Change (in years)
Airport Surface Detection Equipment – Model X (ASDE-X)	September 2001	$424.3	$510.2	$85.9[a]	2007	2009[b]	2
Airport Surveillance Radar Model – 11 (ASR-11)	November 1997	$743	$916	$173	2005	2013	8
ATC Radar Beacon Interrogator – Replacement (ATCBI-6)	August 1997	$281.8	$282.9	$1.10	2004	2008	4
Advanced Technologies and Oceanic Procedures (ATOP)	June 2001	$548.2	$548.2	None	2006	2006	None
Controller-Pilot Data Link Communications (CPDLC)	1999	$166.7	To be determined	N/A	June 2005	To be determined	N/A
En Route Communications Gateway (ECG)	March 2002	$245.2	$245.2	None	2005	2005	None
En Route Automation Modernization (ERAM)	June 2003	$2,150	$2,150	None	December 2010	December 2010	None
Free Flight Phase 2 (FFP2)	June 2002	$546.2	$546.2	None	2006	2007	1
FAA Telecommunications Infrastructure (FTI)	July 1999	$205.7	$310.2	$104.5[c]	2008	2008	None
Integrated Terminal Weather System (ITWS)	June 1997	$276.1	$286.1	$10.0	July 2003	2009+	6+
Local Area Augmentation System (LAAS)	January 1998	$530.1	$696.1	$166.0	2006	To be determined	N/A
Next Generation Air-to-Ground Communication (NEXCOM)	September 1998	$405.7 (First segment only)	$986.4 (First segment only)	$580.7	2008	To be determined	N/A
NAS Infrastructure Management System – Phase 2 (NIMS–2)	May 2000	$172.9	$172.9	None	2005	2010[d]	5
Operational and Supportability Implementation System (OASIS)	April 1997	$174.7	$155.50	($19.2)	2001	2004	3

(Continued From Previous Page)

Dollars in millions

ATC system	Original date	Cost targets: Original cost	Cost targets: Current cost (as of March 2005)	Change	Last-site implementation targets: Original date	Last-site implementation targets: Current date	Last-site implementation targets: Change (in years)
Standard Terminal Automation Replacement System (STARS)	February 1996	$940	$1,460 (Phase 1 only)	$520	2005	2008	3
Wide Area Augmentation System (WAAS)	1994	$509	$2,036[e]	$1,527	December 2000	2013	13

Source: GAO presentation of FAA data.

N/A: Not applicable.

[a]According to FAA officials, the change in cost target for ASDE-X was due to an increase in the scope of the project.

[b]FAA plans to extend ASDE-X's current deployment target from 2007 to 2009 because the project's budgets were cut in fiscal years 2004 and 2005.

[c]The increased costs were for requirements which, while included in the original baseline, were unknown at the time the original baseline was prepared.

[d]In light of reduced funding, FAA is revising NIMS-2's targets; a Joint Resource Council decision is planned for May 2005.

[e]September 1999 and May 2004 estimates for WAAS development exclude $1.3 billion in satellite communications leases.

For 12 of the 13 major system acquisitions[27] we reviewed in detail with cost, schedule, and performance shortfalls, one or more of the following four key factors contributed to these shortfalls:

(1) The funding level received was less than called for in agency planning documents. Most major ATC system acquisitions have cost, schedule, and performance baselines that are approved by FAA's Joint Resources Council–the agency's body responsible for approving and overseeing major system acquisitions. Each baseline[28] includes annual funding levels that the council agrees are needed for a system acquisition to meet its cost, schedule, and/or performance targets. The estimated cost for a given year assumes that the program received all funding for prior fiscal

[27]FAA Telecommunications Infrastructure was not directly affected by these four factors, but did experience cost growth.

[28]In December 2004, FAA revised its acquisition management system policy by replacing the requirement for an acquisition program baseline with a requirement for preparing an OMB Exhibit 300 Baseline, which includes additional information required for FAA's annual budget formulation and submission process.

years as described in the baseline. In practice, however, this is not always the case. For example, when FAA's budget level does not allow all system acquisitions to be fully funded at the levels approved in their baselines, FAA may elect to fully fund higher-priority acquisitions and provide less funding for lower-priority acquisitions than called for in their baselines. When a system acquisition does not receive the annual funding levels called for in its baseline, its ability to meet cost, schedule, and/or performance targets can be jeopardized, for example, by requiring the agency to defer funding for essential development or deployment activities until sufficient funding becomes available, which, in turn, could require FAA to maintain costly legacy systems until a new system is deployed. Receiving less funding than the agency approved for a given acquisition was a factor contributing to the inability of 8 of the 16 major system acquisitions we reviewed in detail to meet their cost, schedule, and/or performance targets. The ASR-11 acquisition, a digital radar system, illustrates how reduced funding has resulted in schedule delays. FAA officials stated that because of funding reductions and reprogramming, the program received $46.45 million less than requested for fiscal years 2004 and 2005 and program officials plan to request that the program's deployment schedule be extended to 2013.[29] According to FAA officials, in general, schedules for system acquisitions may slip under such circumstances (e.g., the rate of software development may be reduced and planned hardware and software deployments may be delayed). The ATO's chief operating officer testified in April 2005 that receiving multiyear rather than annual funding from Congress for system acquisitions would help FAA to address this problem by providing funding stability for system acquisitions. In addition, according to a senior DOT official, 50 percent of cost growth is a result of an unstable funding stream.

(2) The system acquisition experienced requirements growth and/or unplanned work. Requirements that are inadequate or poorly defined prior to developing a system may contribute to the inability of system acquisitions to meet their original cost, schedule, and/or performance targets. In addition, unplanned development work can occur when the agency misjudges the extent to which commercial-off-the-shelf (COTS)/

[29]The ASR-11 program is scheduled to go to the Joint Resources Council in fiscal year 2005 to extend the program's schedule to 2013 and to revise the baseline funding.

nondevelopmental item (NDI)[30] solutions, such as those procured by another agency, will meet FAA's needs. Requirements growth and/or unplanned work contributed to the inability of 7 of the 16 major system acquisitions we reviewed in detail to meet their cost, schedule, and/or performance targets.

(3) Stakeholders were not sufficiently involved in design and development: Insufficient involvement of relevant stakeholders, such as air traffic controllers and maintenance technicians, throughout the development and approval processes for a system acquisition can lead to costly changes in requirements and unplanned work late in the development process. Not involving stakeholders sufficiently contributed to the inability of 4 of the 16 major system acquisitions to meet their cost, schedule, and/or performance targets.

(4) The complexity of software development was underestimated.[31] Underestimating the complexity of developing software for system acquisitions or the difficulty of modifying available software to fulfill FAA's mission needs may contribute to unexpected software development, higher costs, and schedule delays. Underestimation contributed to the inability of 3 of the 16 major system acquisitions we reviewed in detail to meet their cost, schedule, and/or performance targets. (See table 2.)

[30]FAA defines a COTS item as a product or service that has been developed for sale, lease, or license to the general public. The product is currently available at a fair market value. FAA defines a NDI as an item that was previously developed for use by a government (federal, state, local, or foreign) and that requires limited further development. For example, the Army's SINCGARS radio is the core of FAA's NEXCOM radio, and the software FAA selected for ATOP was NDI software from New Zealand's air navigation system.

[31]For purposes of this report, the underestimation of software complexity refers to poor estimation of the level of effort that would be required to modify software to meet requirements (e.g., COTS or NDI).

Table 2: Four Key Factors Contributing to Cost Growth, Schedule Extensions, and/or Performance Problems for 13 ATC System Acquisitions

Name of system	The funding level received was less than called for in agency planning documents	The system acquisition experienced requirements growth and/or unplanned work	The complexity of software development was underestimated	Stakeholders were not sufficiently involved
ASDE-X	X			
ASR-11	X	X		
ATCBI-6	X			
CPDLC		X		
FFP2	X			
ITWS	X	X	X	
LAAS		X	X	X
NEXCOM	X	X		
NIMS-2	X	X		
OASIS	X	X		X
STARS		X		X
WAAS			X	X
FTI[a]				

Source: GAO presentation of FAA data.

Note: Blank spaces in the chart denote that the specific factor was not a key contributor to a program's inability to meet cost, schedule, or performance targets.

[a]FTI was not directly impacted by any of these four factors, but did experience cost growth.

Several of the 16 major systems acquisitions we reviewed in detail effectively illustrate how these four factors can interact to contribute to cost growth, schedule extensions, and performance problems. For example, for WAAS, a precision approach and landing system augmented by satellites, two of the four key factors came into play: underestimation of software complexity and insufficient stakeholder involvement. Specifically, FAA underestimated the complexity of the software that would be needed to support this system when it accelerated the implementation of performance targets, which included moving up the commissioning of WAAS by 3 years. FAA originally planned to commission WAAS by 2000; however, at the urging of government and aviation industry groups in the 1990s, it decided to change the commissioning date to 1997. FAA then tried to develop, test, and deploy WAAS within 28 months, although the software development alone was expected to take 24 to 28 months.

In retrospect, FAA acknowledged that the agency's in-house technical expertise was not sufficient to address WAAS's technical challenges and that expert stakeholders should have been involved earlier. Although WAAS was being developed by an integrated product team that included representatives from several FAA offices, the team did not effectively resolve problems in meeting a required performance capability—that pilots be warned in a timely manner when a system may be giving them potentially misleading and therefore hazardous information. Consequently, in 2000, FAA convened a panel of expert stakeholders to help it meet this requirement. These actions resulted in unplanned work and contributed to the rise in WAAS's cost from the original estimate of $509 million in 1994 to $2.036 billion in 2005, and to a 6-year extension in its commissioning date. According to FAA, adding 6 years to the program's life cycle also contributed to increased costs.[32]

Another example involves STARS, a joint program of FAA and DOD that replaced outdated monochromatic controller workstation monitors with multicolor monitors in ATC facilities. While joint FAA and DOD acquisitions offer the opportunity to leverage federal resources, in the case of STARS, the interaction of insufficient stakeholder involvement and subsequent unplanned work contributed to cost growth and schedule extensions. Specifically, FAA and DOD decided to acquire COTS equipment, rather than developing a new system. This strategy envisioned immediately deploying STARS to the highest priority ATC facilities and making further improvements later, thereby avoiding the increasing cost of maintaining the legacy system. However, this strategy provided for only limited evaluation by FAA and DOD controllers and maintenance technicians during the system's development phase, although these employees were identified as stakeholders in developing the system's requirements. While DOD controllers adopted and began using the original COTS version of STARS, FAA elected to modify the acquisition strategy and suspended the STARS deployment to address FAA controller and technician concerns with the new system. These concerns included, for example, that many features of the old equipment could be operated with knobs, allowing controllers to focus on the screen. By contrast, STARS was menu-driven and required the controllers to make several keystrokes and use a trackball, diverting their attention from the screen. The maintenance

[32]FAA also transferred $1.3 billion--the cost of satellite leases--from the operations account to the facilities and equipment account, bringing the total estimate at completion cost to $3.3 billion.

technicians also identified differences between STARS and its backup system that made it difficult to monitor the system. For example, the visual warning alarms and the color codes identifying problems were not the same for the two systems.

According to FAA, the original COTS acquisition strategy that limited the involvement of controllers and maintenance technicians to just prior to deployment caused unplanned work for the agency because it had to revise its strategy for acquiring and approving STARS; this contributed to an increase in the overall cost of STARS of $500 million and a schedule extension of 5 years to deploy the system to its first site. The interaction of these factors also contributed to the agency's ability to deploy STARS at only 47 of the 172 facilities initially planned. As of February 2005, FAA was developing a long-term acquisition plan to modernize or upgrade the highest-priority Terminal Radar Approach Control facilities that direct aircraft in the airspace that extends from the point where the tower's control ends to about 50 nautical miles from the airport. The plan consists of alternatives to STARS, including the existing Common Automated Radar Terminal System (CARTS), which STARS was designed to replace.[33] Finally, to help avoid similar problems in the future, stemming from the insufficient involvement of stakeholders during critical phases of a system's design, development, and implementation, FAA has been more proactive in involving the stakeholders that will operate and maintain system acquisitions.

A final example of how these factors can interact is FAA's acquisition of OASIS, which is designed to replace outdated technology in FAA's automated flight service stations. The new system is intended to improve the ability of air traffic specialists[34] to process flight plans, deliver weather information, and provide search and rescue services to general aviation pilots. In August 1997, FAA awarded a contract to replace the Flight Service

[33]FAA began fielding CARTS in 1997, as the interim primary terminal automation system until it was replaced with STARS. To date, the agency has not ruled out keeping CARTS as an alternative, if STARS proves to be unaffordable or does not perform as expected. CARTS was not one of the systems FAA was acquiring in fiscal year 2004, when we designed our methodology.

[34]Air traffic specialists are controllers and automation specialists who work at flight service stations throughout the United States and provide, among other things, briefings of weather conditions along a pilot's route of flight and information on traffic conditions for landing and departing at airports where there is no control tower and no restrictions on the use of airspace.

Automation System and console workstations. However, unplanned work, insufficient involvement of stakeholders, and lower funding than the agency had determined was needed to meet cost, schedule, and performance targets have together contributed to cost growth and schedules extensions. For example, the agency saw the system acquisition schedule slip because of a larger-than-planned development effort. According to the DOT IG, FAA identified a number of significant concerns, including the inadequate weather graphics capabilities for air traffic specialists. In our view, this indicates that stakeholders were not sufficiently involved throughout the system's design and development phases. As a result, FAA eliminated the option of COTS procurement. In addition, the OASIS program was rebaselined in March 2000, when the system acquisition received only $10 million of the $21.5 million called for in its baseline for that year. This reduction in funding reduced the rate of software development, delayed and reduced the rate of planned hardware and console deployments, and led to the incremental deployment of operational software. This contributed to a delay in the first-site implementation from July 1998 to July 2002. According to FAA officials, because OASIS received less funding than the agency had approved for fiscal year 2004 and 2005, its deployment to automated flight service stations was postponed.

As of February 2005, FAA had deployed 19 OASIS units: 16 at automated flight service stations and 3 at other sites. Software upgrades that are under way will be completed by June 2005. FAA plans neither installations nor software upgrades beyond those at the automated sites, because the agency awarded a contract to a private vendor in February 2005 to operate flight service stations. Until then, FAA has directed the program to remain within its current Capital Investment Plan funding levels for fiscal years 2004 through 2006.[35] According to FAA, since it completed its evaluation of OASIS in February 2005, planning for the program's implementation and baseline remain unchanged. FAA plans to phase out OASIS between March 2006 and March 2007 in accordance with the new service provider's transition plan.

[35]The Capital Investment Plan, a 5-year financial plan, allocates funds to NAS projects on the basis of a detailed analysis of project funding by FAA functional working groups. The plan includes estimates for the current fiscal-year budget and for 4 future-year expenditures for each line item in the facilities and equipment budget.

Three of the Major ATC System Acquisitions We Reviewed in Detail Currently Operate within Their Original Cost, Schedule, and Performance Targets, Despite Challenges

Three of the 16 major ATC system acquisitions we reviewed in detail are currently operating within their original cost, schedule, and performance targets; however they have experienced challenges, including symptoms of one or more of the four factors cited earlier, such as requirements growth. These system acquisitions include (1) ECG, a communications system gateway that serves as the point of entry and exit for data used by FAA personnel to provide air traffic control at 20 en route facilities; (2) ERAM, a replacement for the primary computer system used to control air traffic; and (3) ATOP, an integrated system for processing flight data for oceanic flights.

While ECG has not exceeded its original cost, schedule, and performance targets, it encountered requirements growth when FAA added a new capability to address a security weakness. According to FAA officials, correcting this weakness cost about $25,000, and an additional $480,000 will likely be needed to improve the monitoring capability for this system's operation. However, these cost increases will not exceed the system's cost or schedule targets. ERAM and ATOP also have areas that warrant attention. For example, ERAM is a high-risk effort because of its size and the amount of software that needs to be developed—over 1 million lines of code are expected to be written for this effort. In addition, the DOT IG reports that, to date, ERAM has experienced software growth of about 70,000 lines of code. While the DOT IG considers this amount of software growth to be modest, given FAA's long-standing difficulties with developing this volume of software for system acquisitions while remaining within cost, schedule, and/or performance targets, sustained management attention is warranted. For ATOP, when FAA tried to accelerate the initial deployment of this system by 14 months, it was unable to do so, because of poorly defined requirements, unrealistic schedule estimates, and inadequate evaluation by the contractor. In addition, according to contract provisions, FAA assumed responsibility in February 2005 for the cost of resolving any additional software problems it identifies.

Overall, although these system acquisitions are currently operating within their cost, schedule, and performance targets, the challenges they have experienced thus far indicate that they will require the sustained attention of FAA's senior managers to help ensure that they stay on track.[36]

[36]GAO-05-207.

FAA Has Experienced Cost Growth and Schedule Extensions for the Remaining 39 System Acquisitions under the ATC Modernization Program

For the 39 system acquisitions that make up the balance of FAA's ATC modernization program, only 9 are considered "major" or directly comparable to the 16 major ATC system acquisitions we reviewed in detail.[37] (See table 3.) Of these 9 major systems, 2 have required changes in their cost targets. For example, for an automated weather observation system, the Aviation Surface Weather Observation Network,[38] the cost has increased by 15 percent because of system capacity issues, among other things. For another system that will be used on an interim basis for managing air traffic until the new primary computer system is available, the Host and Oceanic Computer System Replacement, the cost has decreased by 13 percent because the agency determined that parts of the existing system could be sustained through fiscal year 2008, which is within the scope of the program.[39] The remaining 30 systems are not directly comparable, because they do not involve acquiring a new system. Instead, they are what FAA terms "buy-it-by-the pound" purchases—systems that are commercially available and ready for FAA to use without modification, such as a landing system purchased to replace one that has reached the end of its useful life. (See app. II for additional information on these 39 systems.)

[37]As mentioned previously, FAA does not have a formal definition of "major" systems, but suggested that we consider a system as major if it has a baseline for cost, schedule, and performance formally approved by senior agency officials. Using this definition, we consider 9 of the remaining 39 systems major. These 9 major systems bring the total number of major systems under the ATC modernization program to 25.

[38]Aviation Surface Weather Observation Network (ASWON) automates surface weather observation information, replacing labor-intensive and high-cost manual surface weather observations.

[39]The Host and Oceanic Computer System Replacement (HOCSR) is an interim upgrade and modernization program designed to replace the En Route Host Computer hardware, software, and peripheral equipment to reduce delays and improve reliability.

Table 3: Description and Status of Nine Additional Major ATC System Acquisitions with Cost, Schedule, and Performance Targets

Dollars in millions

	Development costs		Deployment schedule	
ATC system acquisition and system description	Original	Current	Original	Current
HOST/Oceanic Computer System Replacement (HOCSR) - The HOCSR program replaces the main ATC computer processor and some peripherals, while ensuring the supportability of other peripherals until they are replaced by En Route Automation Modernization (ERAM).	$424.10	$368.50	Start: December 1998 Finish:June 2004	Start: December 1998 Finish: April 2004
Command Center Conference Control System (CCS) - Replace OTS - This ongoing program involves replacing the existing telephone system at the FAA Air Traffic Control System Command Center (ARCSCC) in Herndon, Va. The existing telephone system is becoming unsupportable and can no longer perform ARCSCC command functions.	12.70	12.70	Start: Fiscal Year 2005 Finish: Fiscal Year 2005	Start: Fiscal Year 2005 Finish: Fiscal Year 2005
Ultra High Frequency (UHF) Radio Replacement - The UHF radio replacement project replaces aging equipment used to communicate with DOD aircraft. FAA maintains the UHF air and/or ground communication service for air traffic control of military operations in the United States.	85.15	85.15	Start: Fiscal Year 2003 Finish: Fiscal Year 2010	Start: Fiscal Year 2010 Finish: Fiscal Year 2010
Capstone Phase 1 - Capstone is a congressionally directed demonstration program primarily intended to improve aviation system safety in Alaska through the introduction of new communications, navigation, and surveillance technologies. The Capstone program is a part of a larger program known as the Safe Flight 21 Program (SF-21), which is designed to establish pockets of broadcast service technology enhancements to support the demonstration of new technology-driven safety and efficiency benefits.	18.55	18.55	Start: Fiscal Year 2000 Finish: Fiscal Year 2003	Start: N/A Finish: N/A
ASR-9 / Mode S Service Life Extension Program (SLEP) - The ASR-9 program provides aircraft detection and separation services at congested airports, which reduces aircraft delays and improves safety.	186.50	186.50	Start: TBD Finish: TBD	Start: TBD Finish: TBD
Precision Runway Monitor (PRM) – The PRM system is an accurate, electronic scan radar that tracks and processes aircraft targets at a 1-second update rate.	145.80	145.80	Start: October 1997 Finish: 2007	Start: October 1997 Finish: January 2007
En Route System Modification – This program will replace obsolete en route components, such as processors; upgrade the controllers' displays and the infrastructure that supports those displays; and configure the consoles to accommodate additional processors.	201.90	201.90	Start: N/A Finish: May 2009	Start: N/A Finish: N/A
Initial Academy Training System (IATS) – This high-fidelity training system for the FAA Academy will enable the training of an increasing number of new air traffic controllers as the existing workforce retires.	23.35	23.35	Start: September 2005 Finish: September 2005	Start: September 2005 Finish: September 2005

(Continued From Previous Page)

Dollars in millions

ATC system acquisition and system description	Development costs		Deployment schedule	
	Original	Current	Original	Current
Aviation Surface Weather Observation Network (ASWON) – The primary purpose of ASWON is to support FAA and National Weather Service (NWS) modernization by automating surface weather observation to meet the needs of pilots, operators, and air traffic personnel without incurring the high costs of labor-intensive manual surface weather observations.	$350.90	$403.80	Start: September 2002 Finish: September 2010	Start: Unknown Finish: Unknown

Source: GAO presentation of FAA data.

To its credit, FAA has reported that it met its annual acquisition performance goal for fiscal year 2004--to meet 80 percent of designated milestones and maintain 80 percent of critical program costs within 10 percent of the budget as published in its Capital Investment Plan.[40] Specifically, it set annual performance cost goals and schedule milestones for 41 of the 55 system acquisitions under the ATC modernization program. For these 41 system acquisitions, FAA set 51 schedule milestones and met 46 of them—with "meeting the goal" defined as achieving 80 percent of its designated program milestones. It also set and met its annual cost performance goals for each of these 41 system acquisitions. In our opinion, having and meeting such performance goals is commendable, but it is important to note that these goals are updated program milestones and cost targets, not those set at the program's inception.[41] Consequently, they do not provide a consistent benchmark for assessing progress over time. Moreover, as indicators of annual progress, they cannot be used in isolation to measure progress in meeting cost and schedule targets over the life of an acquisition. Finally, given the problems FAA has had in acquiring major ATC systems for over two decades, it is too soon to tell whether meeting these annual performance goals will ultimately improve the agency's ability to deliver system acquisitions as promised.

[40]According to FAA, 43 capital projects were included in the fiscal year 2004 acquisition performance goal--41 of these projects fall under the ATC modernization program.

[41]Our statements about meeting cost, schedule, and/or performance targaets in this report and in our past reports are based on the original targets that FAA established and approved at the start of its acquisition programs.

FAA Has Taken Some Positive Steps to Address Key Legacy Challenges, but Additional Steps Are Warranted to Reduce Risk and Strengthen Oversight

FAA has taken a number of positive steps, primarily through the ATO, to address key legacy challenges in acquiring major systems under its ATC modernization program; however, we have identified additional steps that are warranted to reduce risk and strengthen oversight. Some of the steps FAA has taken directly address the four factors we identified as contributing to cost, schedule, and/or performance problems, while others support more general efforts to improve the modernization program's management. The steps taken and additional steps needed are discussed below by key areas.

Steps Taken to Address the Four Factors We Identified As Contributing to Performance Shortfalls and Additional Steps Needed

To address the concern that some system acquisitions have had difficulty meeting performance targets because they have not received annual funding at the levels called for in key planning documents, the ATO has taken several steps. For example, the ATO has demonstrated a willingness to cut major programs that were not meeting their performance targets even after a significant investment of agency resources. The ATO is currently reviewing all of its capital projects to reassess priorities. Both of these actions should help improve the chances that sufficient funding will be available for priority system acquisitions to conduct the annual activities necessary to keep them on track to meet cost, schedule, and performance targets.

Specifically, for fiscal year 2005, the appropriation for FAA's facilities and equipment budget, which funds the ATC modernization program, was $393 million less than the agency had planned to spend. FAA absorbed the $393 million reduction largely by cutting funding for three of the major system acquisitions we reviewed in detail: a digital e-mail-type capability between controllers and pilots was suspended (CPDLC); the next generation air-to-ground communication system had the funding cut for a major component (NEXCOM); and a precision-landing system augmented by satellites for use primarily by commercial airlines (LAAS) was returned to research and development to focus the remaining funding for the system on resolving a key performance shortfall. FAA also plans to defer funding for CPDLC and LAAS for fiscal year 2006.

FAA decisions to cut or eliminate funding for system acquisitions in its current ATC modernization system may prove to be positive in the long run. For example, although FAA and National Air Traffic Controllers

Association officials say that the cuts the agency made to 3 of its 16 major ATC system acquisitions will delay system benefits until the acquisitions are fully developed and deployed, the cuts demonstrate FAA's willingness to suspend major ATC system acquisitions, despite large resource investments. In addition, by delaying a system acquisition, FAA may later be able to save time and money by leveraging the experiences that others have had with developing and deploying systems that provide similar capabilities (e.g., the controller-pilot e-mail-type capability for which FAA cut funding is now in use in both Canada and Europe). Furthermore, as FAA continues to reassesses its funding priorities, it could explore cost-saving options including taking steps to systematically (1) evaluate the costs and benefits of continuing to fund system acquisitions across the ATC modernization program at current and planned levels to identify potential areas for savings and (2) identify potentially lower-cost alternatives to current system acquisitions, such as lower-cost controller workstations.

FAA has also taken a number of steps to address two other factors—reduce the risk of requirements growth and/or the need to undertake unplanned work—and to improve its ability to better assess and manage the risks associated with acquiring major ATC systems that require complex software development. However, additional steps are needed in these areas.

- *Processes for acquiring software and systems:* FAA has made progress in improving its process for acquiring software-intensive systems–including establishing a framework for improving its system management processes, and performing many of the desired practices for selected FAA projects.[42] The quality of these systems and software, which are essential to FAA's ATC modernization program, depends on the value and maturity of the processes used to acquire, develop, manage, and maintain them. In response to our previous recommendations, FAA developed an FAA-integrated capability maturity model (iCMM). Since FAA implemented the model, a growing number of system acquisitions have adopted the model, and its use has paid off in enhanced productivity, higher quality, greater ability to predict schedules and resources, better morale, and improved communication and teamwork. However, ATO did not mandate the use of the process improvement model for all software-intensive acquisition

[42]GAO, *Air Traffic Control: System Management Capabilities Improved, but More Can Be Done to Institutionalize Improvements*, GAO-04-901 (Washington, D.C.: Aug. 20, 2004).

projects. In response to our recommendation, the ATO informed us of its plans to establish, by June 30, 2005, an overall policy defining the ATO's expectations for process improvement, and by September 30, 2005, a process improvement plan to address and coordinate improvement activities throughout the organization.

- *Management of information technology investments:* In 2004, we reported that FAA has made considerable progress in managing its information technology investments.[43] However, we also found that FAA's lack of regular review of investments that are more than 2 years into their operations is a weakness in the agency's ability to oversee more than $1 billion of its information technology investments as a total package of competing investment options and pursue those that best meet the agency's goals. FAA recently informed us that it has taken a number of steps aimed at achieving a higher maturity level, including establishing service-level mission need statements and service-level reviews, which address operational systems to ensure that they are achieving the expected level of performance. While these steps could resolve some of the deficiencies that we previously reported, we have not yet performed our own evaluation of these steps. FAA could potentially realize considerable savings or performance improvements if these reviews result in the discontinuation of some investments, since operating systems beyond their second year of service accounted for 37 percent of FAA's total investment in information technology in fiscal year 2004.

- *Enterprise architecture:* FAA has established a project office to develop a NAS enterprise architecture—a blueprint for modernization—and designated a chief architect, and has committed resources to this effort, and issued its latest version of its architecture.[44] However, FAA has not yet taken key steps to improve its architecture development, such as designating a committee or group representing the enterprise to direct, oversee, or approve the architecture; establishing a policy for developing, maintaining, and implementing the architecture; or fully developing architecture products that meet contemporary guidance and

[43] GAO-04-822.

[44] GAO, *Federal Aviation Administration: Stronger Architecture Program Needed to Guide Systems Modernization Efforts*, GAO-05-266 (Washington, D.C.: Apr. 29, 2005).

describe both the "As Is" and "To Be" environments and developing a sequencing plan for transitioning between the two.

To help address concerns that stakeholders have not been sufficiently involved throughout the development of major systems acquisitions, FAA has taken a number of steps. For example, when the ATO was created, it brought together the FAA entities that develop systems and those who will ultimately use them. Specifically, it reorganized FAA's air traffic services and research and acquisition organizations along functional lines of business to bring stakeholders together and integrate goals. The ATO is also continuing with a phased approach to system acquisitions that it began using under Free Flight Phase 1,[45] through which it has begun to involve stakeholders more actively throughout a system acquisition's development and deployment. However, as we reported in November 2004, FAA needs to take additional steps to ensure the continued and active involvement of stakeholders in certifying new ATC system acquisitions.[46] In addition, the union that represents the specialists who install, maintain, troubleshoot, and certify NAS systems, recently testified that over the past 2 years, FAA has systematically eliminated the participation of these specialists in all but a few modernization programs.[47] Given the importance of stakeholder involvement in the development and deployment of new ATC systems, their continued involvement in ATC modernization efforts will be important to help avoid the types of problems that led to cost growth and delays for STARS.

Other Steps FAA Has Taken to Improve the Modernization Program's Management and Additional Steps That Are Needed

Reassessment of capital investment to decrease operating costs: Both the FAA Administrator and the ATO's chief operating officer have committed to basing future funding decisions for system acquisitions on their contribution to reducing the agency's operating costs while maintaining safety. This is consistent with our 2004 recommendation that FAA consider its total portfolio of investments as a package of competing options.

[45]Under Free Flight Phase 1, FAA developed a suite of tools to assist controllers with managing air traffic.

[46]GAO-05-11.

[47]*On Transforming the Federal Aviation Administration: A Review of the Air Traffic Organization (ATO) and the Joint Program Development Office (JPDO)*, Statement of Thomas Brantley, President, Professional Airways Systems Specialists (PASS) AFL-CIO, before the House Committee on Transportation and Infrastructure, Subcommittee on Aviation, April 7, 2005.

Currently, only 1 of the 55 system acquisitions in FAA's ATC modernization program—FAA Telecommunications Infrastructure—helps to reduce the agency's operating costs. Most of FAA's major system acquisitions are aimed at increasing the capacity of the NAS and delivering benefits to system users. The ATO is in the process of reviewing all of its capital investments, including system acquisitions under the ATC modernization program, to identify areas of cost savings and to focus limited funding on investments that will reduce operating costs. However, because FAA has only recently begun to incorporate this type of analysis of the costs and operational efficiency of system acquisitions into the decision-making and management processes, it is too early to assess the results.

Acquisition Management System: The ATO has taken a number of steps to improve its Acquisition Management System (AMS). For example, it has revised AMS to require that acquisition planning documents be prepared in a format consistent with that prescribed by OMB for use in justifying all major capital investments. In addition, the ATO revised AMS in December 2004, in part to respond to recommendations we made about needed changes in its investment management practices for information technology.[48] However, we have not yet independently assessed the sufficiency of these changes. Moreover, additional changes to AMS are warranted. For example, while AMS provides some discipline for acquiring major ATC systems, it does not use a knowledge-based approach to acquisitions, characteristic of best commercial and DOD practices. A knowledge-based approach includes using established criteria to attain specific knowledge at three critical junctures in the acquisition cycle, which we call knowledge points, and requiring oversight at the corporate executive level for each of these knowledge points. Experience has shown that not attaining the level of knowledge called for at each knowledge point increases the risk of cost growth and schedule delays.[49] We recommended, among other things, that FAA take several actions to more closely align its acquisition management system with commercial best practices. FAA said that our recommendations would be helpful to them as they continue to refine this system.

[48]GAO-04-822.

[49]For more information on using a knowledge-based approach, see GAO, *Air Traffic Control: FAA's Acquisition Management Has Improved, but Policies and Oversight Need Strengthening to Help Ensure Results*, GAO-05-23 (Washington, D.C.: Nov. 12, 2004).

Cost accounting and cost estimating practices: FAA has improved its financial management by moving forward with the development of a cost accounting system, which it plans to fully deploy by 2006. Ultimately, FAA plans to use this cost information routinely in its decision-making. When implemented, this cost accounting system will address a long-standing GAO concern that FAA has not had the needed cost accounting practices in place to effectively manage software-intensive investments, which characterize many of agency's major ATC system acquisitions. This type of information can be used to improve future estimates of cost for these acquisitions.[50]

Organizational culture: FAA has also sought to establish an organizational culture that supports sound acquisitions. We have ongoing work to assess FAA's efforts concerning cultural change.

ATO business practices: To improve its investment management decision-making and oversight of major ATC acquisitions, the ATO has informed us that it has initiated the following steps, which we have reported are important to effective oversight:[51]

- integrated AMS and OMB's Capital Planning and Investment Control Process to develop a process for analyzing, tracking, and evaluating the risks and results of all major capital investments made by FAA;
- conducted Executive Council[52] reviews of project breaches of 5 percent in cost, schedule, and/or performance to better manage cost growth;
- issued monthly variance reports to upper management to keep them apprised of cost and schedule trends; and

[50]GAO, *High-Risk Series: An Update*, GAO-05-207 (Washington, D.C.: January 2005).

[51]GAO-05-23; GAO-04-822.

[52]The ATO's Executive Council is responsible for further implementing acquisition reform for major ATC system acquisitions.

- increased the use of cost monitoring or earned value management[53] systems to improve oversight of programs.

However, much work remains before the ATO will have key business practices in place.

Specifically, according to the ATO's chief operating officer, it will be at least 2 years before the ATO has completed the basic management processes needed to use the new financial management systems it has been putting in place.

Despite progress to date, until the agency addresses the residual issues cited above, it will continue to risk the project management problems affecting cost, schedule, and/or performance that have hampered its ability to acquire systems for improving air traffic control.

A Constrained Budgetary Environment Could Further Challenge the ATO's Efforts to Modernize the ATC System

The ATO will be further challenged to modernize the ATC system in the current constrained budget environment and remain within the administration's future budget targets, which are lower than those of recent years. Specifically, for fiscal year 2005, FAA requested $393 million less than it had planned to spend for activities under the facilities and equipment budget account, which funds the ATC modernization program and related modernization activities. In addition, the President's fiscal year 2006 budget submission calls for an additional cut to this budget account of $77 million from FAA's planned level, which would bring the fiscal year 2006 funding level to about $470 million below the fiscal year 2004 appropriation. Moreover, FAA officials told us that funding for the facilities and equipment account is likely to hold near fiscal year 2004 levels, or at about $2.5 billion annually, for the next 5 years. In total, FAA plans to spend $4.4 billion during fiscal years 2005 through 2009 on key modernization efforts, despite FAA receiving about $2 billion less than it had planned in appropriations over this 5-year period for its facilities and equipment

[53]Earned value management compares the actual work performed at certain stages of a job to its actual costs—rather than comparing budgeted and actual costs, the traditional management approach to assessing progress. By measuring the value of the work that has been completed at certain stages in a job, earned value management can alert program managers, contractors, and administrators to potential cost growth and schedule delays before they occur and to problems that need correcting before they worsen.

budget, which funds the ATC modernization program and related modernization activities.

To fund its major system acquisitions while remaining within the administration's budget targets, the ATO has eliminated planned funding to start new projects and substantially reduced planned funding for other areas. These funding decisions are reflected in FAA's updated Capital Investment Plan. This plan shows substantially reduced funding for two major system acquisitions in fiscal year 2005—CPDLC and LAAS--and defers funding for them in fiscal year 2006. For the remaining 14 major ATC system acquisitions we reviewed in detail, FAA plans to increase funding by $533 million between fiscal year 2005 and fiscal year 2009. In contrast, for the remaining 39 system acquisitions, FAA has reduced funding by $420 million for this period.

The planned increases in funding for these 14 major system acquisitions also come at the expense of other modernization activities outside the ATC modernization program, such as capital expenditures to replace aging ATC facilities that will house the system acquisitions. For example, FAA reports that it needs $2.5 billion (2005 dollars) annually to renew its aging physical infrastructure—assuming a $30 billion value of its assets and a 7- to 12-year useful life. According to the ATO, much of its physical infrastructure, including the buildings and towers that house costly ATC systems, is over 30 years old and needs to be refurbished or replaced.[54] However, FAA plans to reduce funding for facilities by nearly $790 million between fiscal year 2005 and fiscal year 2009—a plan that runs counter to its reported need to refurbish or replace its physical infrastructure. Furthermore, FAA also plans to cut $1.4 billion from its spending plans for fiscal years 2005 through 2009 for, among other things, new system acquisitions in the ATC modernization pipeline that do not yet have agency-approved cost, schedule, and performance targets or baselines (e.g., a new technology that would allow pilots to "see" the location of other aircraft on cockpit display).[55]

Our work has shown that FAA has taken some important steps to prioritize the 55 system acquisitions under its ATC modernization program. These

[54]We have not verified FAA's reported needs to refurbish or replace these structures/ facilities.

[55]Automatic Dependent Surveillance-Broadcast (ADS-B).

revised priorities are reflected in its most recent plans, which detail the areas where FAA plans to make cuts within its facilities and equipment budget to live within its expected means during fiscal years 2005 through 2009. However, our work has also shown that these plans do not provide detailed information about the trade-offs that are underlie decisions to fully fund some systems and to defer, reduce, or eliminate funding for others and how these cuts will affect FAA's modernization efforts, including what impact they will have on interdependent system acquisitions. To convey information to decision-makers on the impact of reduced funding on modernization, the ATO should detail its rationale and explicitly identify the trade-offs it is making to reach the administration's budget targets, highlighting those programs slated for increased funding and those slated for reduced funding. Key information includes delayed benefits, the impact of cutting one ATC system acquisition on related or interdependent systems, and increased costs for maintaining legacy systems until new systems are deployed. Overall, the ATO needs to explicitly identify the implications of deferring, reducing, or cutting funding for a particular system or activity on the agency's ability to modernize both the ATC system and related components of the NAS in the near, mid, and longer term. While funding deferrals, reductions, and cuts to ATC system acquisitions and related activities in FAA's facilities and equipment budget may be beneficial and necessary in the long run, it is important for senior agency, department, OMB, and congressional decision-makers to have complete information to make informed decisions about the trade-offs that are being made when they consider annual budget submissions.

As part of our research, we sought the perspective of an international group of experts, who also suggested that the ATO should provide the administration and Congress with detailed information in its budget submissions about the impact of reduced budgets on both ATC and NAS modernization.[56] These experts were a part of an international panel of aviation experts we convened to address, among other issues, how federal

[56]The panel consisted of foreign and domestic aviation experts from industry, government, private think tanks, and academia. Their fields of expertise included aviation safety, economics, and engineering; transportation research and policy; and government and private-sector management. Former FAA officials and current executives of the air traffic organizations in Canada and the United Kingdom were among the experts, as was the chairman of EUROCONTROL's Performance Review Commission. GAO, *Experts' Views on Improving the U.S. Air Traffic Control Modernization Program*, GAO-05-333SP (Washington, D.C.: April 2005).

budget constraints have affected ATC modernization and what steps the ATO could take in the short term to address these constraints.

For example, aviation experts emphasized the need for the ATO—which is now the organizational entity responsible for acquiring ATC systems—to prioritize its capital investments, as well as its investment in operating systems, with affordability in mind. These experts believe that the ATO needs to review all of its spending plans for modernization, determine which programs can realistically be funded, and select programs to cut. Moreover, they indicated that the ATO should have a mechanism to explain to Congress the implications that cutting one system has on other systems. For example, according to one of these experts, the current budget process tears apart a highly layered, interdependent system and does not reveal synergies between projects. Then, when the budget request goes to Congress, he said, "you have no opportunity to try to explain to anybody the interconnections of these programs." As a result, when the appropriators decide not to fund a project, they may not understand how their decision will affect other projects.

Conclusions

The constrained budgetary environment makes it more important than ever for FAA to meet cost, schedule, and performance targets for each of the major ATC systems it continues to fund and to ensure that related activities, such as those to refurbish or replace the buildings that house ATC modernization systems, receive sufficient funding. The need for FAA to accommodate a 25 percent increase in demand for air travel over the next decade underscores the importance of these efforts. FAA has demonstrated a commitment to live within its expected means during fiscal years 2005 through 2009 by setting priorities among its ATC system acquisitions and identifying areas where it plans to cut funding. However, without detailed information about the trade-offs that underlie decisions to fully fund some systems and to defer, reduce, or eliminate funding for others, FAA's plans do not allow senior agency, department, OMB, and congressional decision-makers to assess the implications of approving annual budget submissions for the ATC modernization program and related modernization activities that support more comprehensive efforts to modernize the NAS.

Recommendation for Executive Action

To help ensure that key administration and congressional decision-makers have more complete information to assess the potential impact of annual budget submissions on individual ATC system acquisitions, the overall ATC modernization program, and related larger-scale NAS modernization activities funded through the facilities and equipment budget, we recommend that the Secretary of Transportation direct FAA to identify which activities under the ATC modernization program have had funding deferred, reduced, or eliminated and to provide detailed information about the impact of those decisions on FAA's ability to modernize the ATC system and related components of the NAS in the near, mid, and longer term. This information should be reported to Congress annually.

Agency Comments

We provided a copy of our draft report to DOT for review and comment. The draft was reviewed by officials throughout DOT and FAA, including the Vice President for Acquisition and Business Service. These officials provided comments through email. They generally agreed with the report and provided technical comments on specific aspects of the report, which we incorporated as appropriate. The FAA officials said they are continuing to consider our recommendation and indicated they would provide a response to it as required by 31 U.S.C. §720.

As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies of this report to interested congressional committees, the Secretary of Transportation, and the Administrator, FAA. We will also make copies available to others upon request. In addition, the report will be available at no charge on the GAO Web site at http://www.gao.gov.

Please call me at (202) 512-2834 if you or your staff have any questions about this report. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Key contributors to this report are listed in appendix IV.

Gerald L. Dillingham, Ph.D.
Director, Physical Infrastructure Issues

List of Congressional Requesters

The Honorable Tom Davis
Chairman
The Honorable Henry A. Waxman
Ranking Minority Member
Committee on Government Reform
House of Representatives

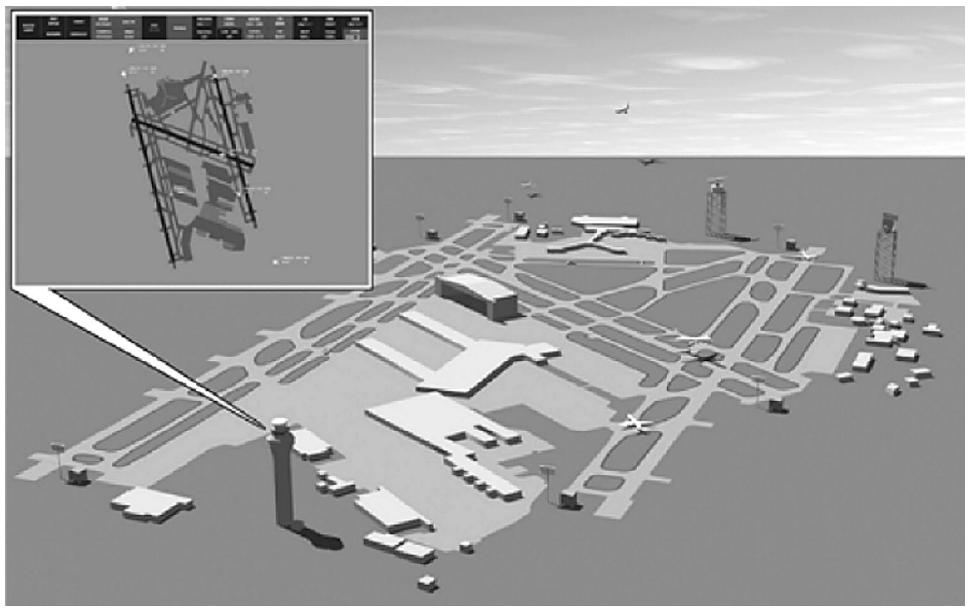
The Honorable Don Young
Chairman
The Honorable James L. Oberstar
Ranking Democratic Member
Committee on Transportation and Infrastructure
House of Representatives

The Honorable John L. Mica
Chairman
The Honorable Jerry Costello
Ranking Democratic Member
Subcommittee on Aviation
Committee on Transportation and Infrastructure
House of Representatives

Background and Status of FAA's 16 Major System Acquisitions We Reviewed in Detail

Airport Surface Detection Equipment–Model X (ASDE-X)

Figure 2: ASDE-X Screen Depicting an Airport Layout with Active Aircraft Targets



Source: Photo courtesy of FAA.

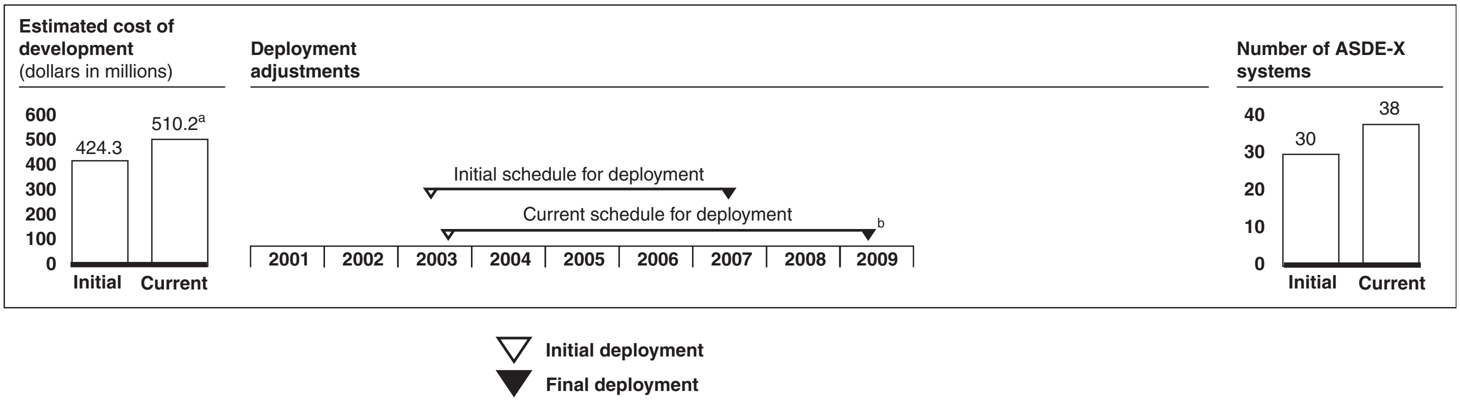
Note: Contractor for this system is Sensis Corporation.

Purpose and Status

ASDE-X enables air traffic controllers to track the surface movement of aircraft and vehicles. It was developed to reduce runway incursions, reported as increasing from 186 in 1993 to 383 in 2001.[1] ASDE-X improves the ability of controllers to maintain awareness of the operational environment and to anticipate contingencies. The detection system automatically predicts potential conflicts and seamlessly covers airport runways, taxiways, and other areas.

[1]FAA defines runway incursion as any occurrence at an airport involving an aircraft, vehicle, person, or object on the ground that creates a collision hazard or results in a loss of separation between aircraft taking off, intending to take off, landing, or intending to land.

Figure 3: Changes to ASDE-X Schedule and Cost Targets



Source: GAO presentation of FAA data.

[a]According to FAA officials, the change in cost target for ASDE-X was due to an increase in the scope of the project.

[b]FAA plans to extend ASDE-X's current deployment target from 2007 to 2009 because the project's budgets were cut in fiscal years 2004 and 2005.

In June 2002, FAA decided to upgrade seven additional airports increasing the project's total cost by $80.9 million. As of September 2004, FAA had placed three systems in operation and installed six others. FAA officials said they propose to extend the deployment baseline from 2007 to 2009 because budgets were cut in fiscal years 2004 and 2005; in addition, internal and external funding was reprogrammed for other high-priority activities. The ASDE-X program office is working on alternative cost estimates and plans to present them to the Joint Resources Council by June 2005.

Airport Surveillance Radar Model-11 (ASR-11)

Figure 4: ASR-11 Equipment

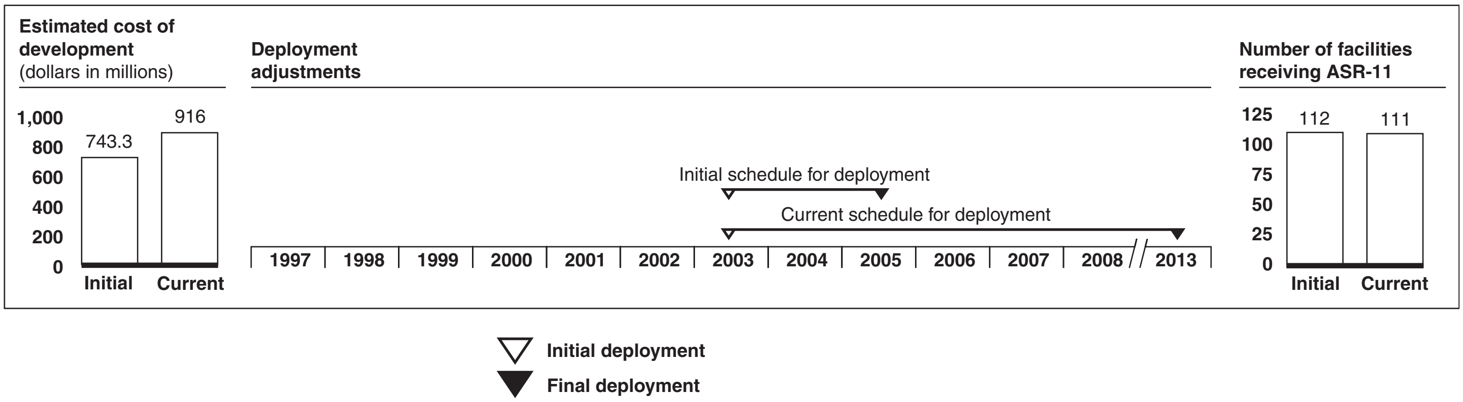
Source: Photo courtesy of FAA.

Note: Contractor for this system is Raytheon.

Purpose and Status

ASR-11 replaces aging analog radars, such as ASR-7 and ASR-8, with a single, integrated digital radar system. ASR-11 reduces operational costs, improves safety, and accommodates future capacity increases. ASR-11 also provides surveillance information to existing systems, such as the Standard Terminal Automation Replacement System (STARS) in terminal facilities and other systems in en route ATC facilities. As of March 2005, five sites have been commissioned into the NAS and five additional sites are in full operational capability.

Figure 5: Changes to ASR-11 Schedule and Cost Targets



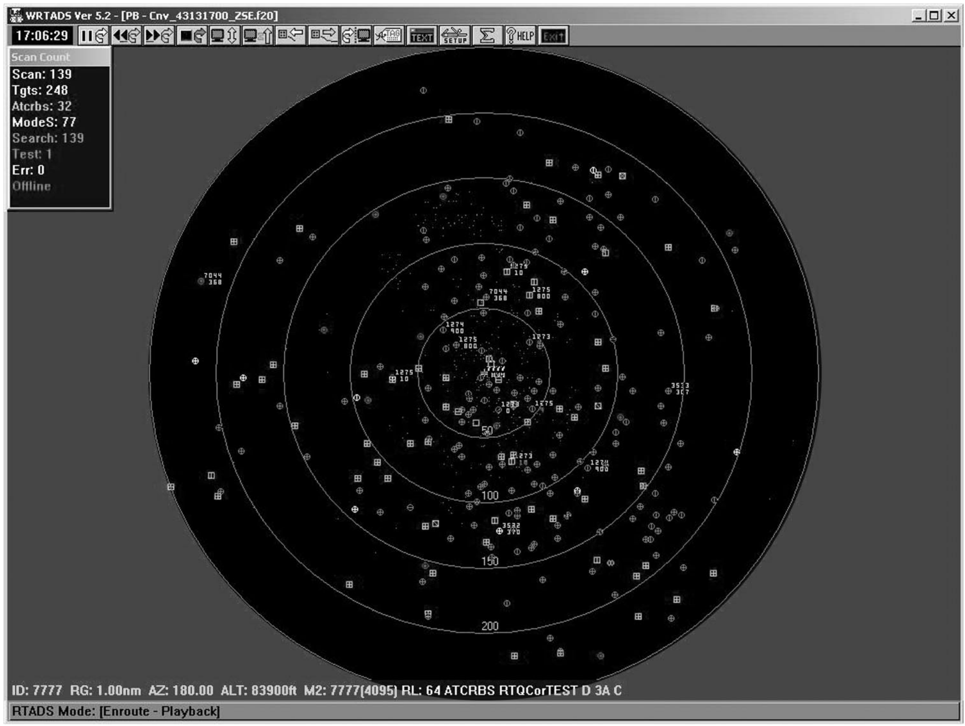
Source: GAO presentation of FAA data.

ASR-11 has experienced unplanned work, and the funding level received was less than the agency-approved funding level for the system acquisition; both factors contributed to schedule extensions and cost increases. FAA misjudged the extent to which the high-level requirements that were used to support the Department of Defense's procurement of the commercial-off-the-shelf/nondevelopmental item (COTS/NDI) could result in a product capable of meeting FAA's mission or user needs. As a result, unplanned software changes were required. The program requested $98.8 million for fiscal year 2004, based on the system's acquisition program baseline, but received $74.3 million. In May 2004, FAA reprogrammed $2.35 million from ASR-11's appropriated funds to the Essential Air Service.[2] Due to funding reductions, FAA decreased the number of ASR-11 systems to be purchased from 112 to 111. The 2005 request of $107.6 million was not approved; the reduction to $87.5 million may result in additional cost growth or the elimination of planned replacement sites. The ASR-11 program is scheduled to go to the Joint Resources Council in fiscal year 2005 to extend the program's schedule to 2013 and to revise the baseline funding, primarily because of deferrals and budget reductions. As of March 2005, five sites have been commissioned into the NAS and five additional sites are fully operational.

[2]The objective of the Essential Air Service program is to ensure that small communities that had received scheduled passenger air service before deregulation will continue to have access to the nation's air transportation system.

Air Traffic Control Radar Beacon Interrogator-Replacement (ATCBI-6)

Figure 6: ATCBI-6 Screen Display Depicting All Transponder-Equipped Aircraft



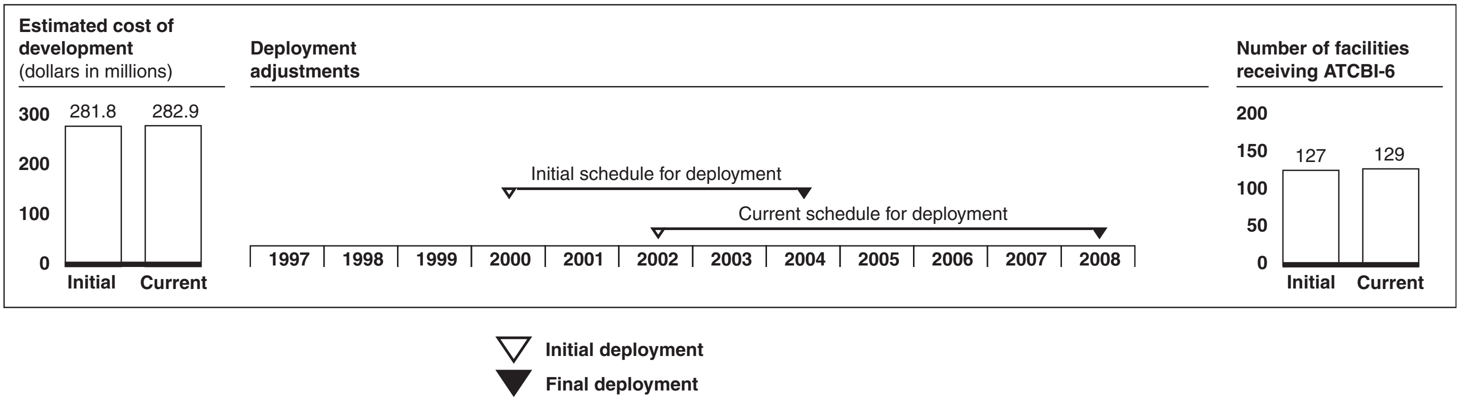
Source: Photo courtesy of FAA.

Note: Contractor for this system is Raytheon.

Purpose and Status

ATCBI-6 is part of the agency's continuing effort to upgrade equipment to provide greater system capability and reliability that will, in turn, reduce operating costs. The ATCBI-6 replacement program will replace existing en route air traffic control beacon interrogator (ATCBI-4/5) equipment. The new ATCBI-6 radars will be able to determine both range and direction to and from aircraft, in addition to forwarding this information to the appropriate Air Route Traffic Control Centers' automation systems.

Figure 7: Changes to ATCBI-6 Cost and Schedule Targets

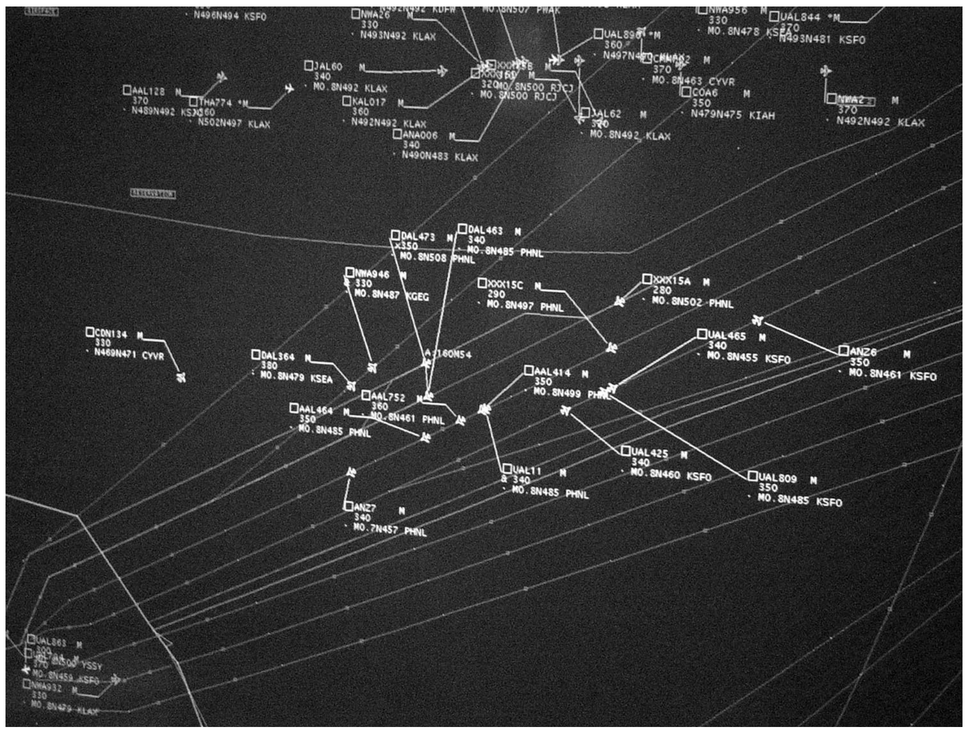


Source: GAO presentation of FAA data.

Funding reductions of $31.0 million for fiscal years 2002 and 2003 contributed to the extension of ATCBI-6's schedule. According to FAA, if funding reductions continue, further delays could occur with the system's deployment, installation, and commissioning activities. As of September 2004, the contractor has been meeting the new contract delivery schedule.

Advanced Technologies and Oceanic Procedures (ATOP)

Figure 8: ATOP Equipment Reporting Aircraft Position Information



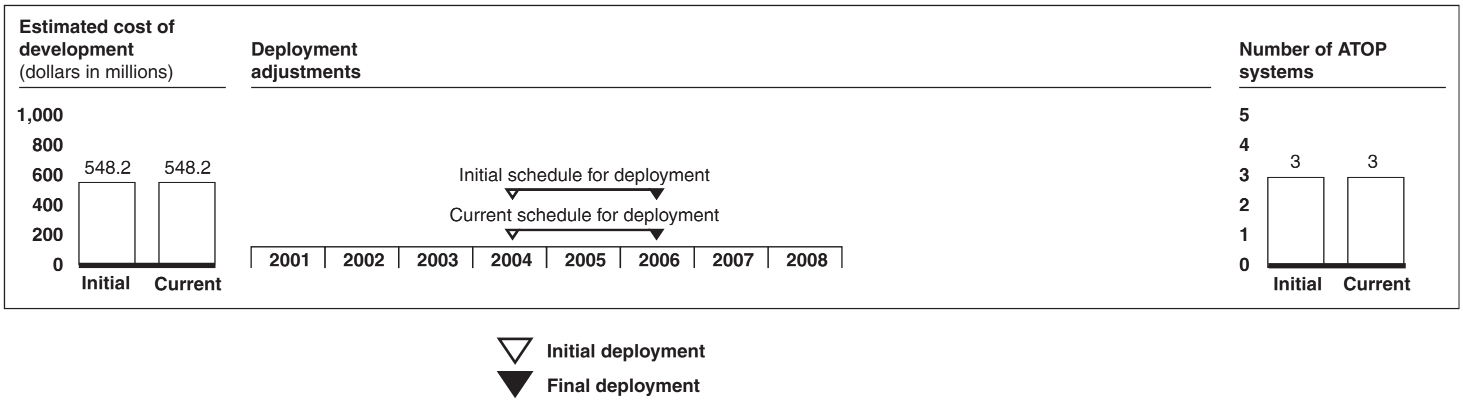
Source: Photo courtesy of FAA.

Note: Contractor for this system is Lockheed Martin.

Purpose and Status

ATOP replaces aging oceanic ATC systems and procedures with an integrated system of new controller workstations, data-processing equipment, and software that will enhance the control and flow of oceanic air traffic to and from the United States. The system automatically updates information on an aircraft's location and supersedes the current manual process. FAA controls oceanic air traffic at three sites: Anchorage, Alaska; New York, New York; and Oakland, California.

Figure 9: Changes to ATOP Schedule and Cost Targets



Source: GAO presentation of FAA data.

The ATOP program is operating within its cost, schedule, and performance targets. ATOP achieved its initial operational capability milestone in June 2004. The contractor had originally agreed to a more aggressive development schedule in order to achieve this milestone by April 2003, or 14 months earlier. FAA determined, however, that the contractor could not meet this accelerated date because of poor requirements development, unrealistic schedule targets, and inadequate estimation of software complexity. This exacerbated the scheduled transition from the current oceanic system to ATOP. Consequently, FAA spent an additional $4 million a year to operate and maintain the old system until ATOP is fully operational. According to FAA, the ATOP program office did not overspecify the operational and performance requirements; it wrote the technical document at a level that allowed the contractor to select the appropriate solutions and did not restrict design innovations. Yet, FAA's internal documents revealed that the requirements were not adequately defined. For example, the ATOP Investment Analysis Study reported to the Joint Resources Council prior to the contract award that the lack of more detailed ATOP requirements at this stage of acquisition added risk and was of concern to the investment analysis team.

According to FAA, the agency has taken steps to recognize the concerns identified by the ATOP Investment Analysis Study by maintaining requirements, encouraging controller participation, and robustly testing the system. FAA officials stated that the agency has developed a transition plan for the three sites. To accelerate the transition schedule and offset facility attrition, the ATOP program filled eight new controller positions at the New

York site and six at the Oakland site. In addition, ATOP training schedules are in place, and classes for FAA's Air Traffic and Airway Facilities personnel are under way. Although the contractor's costs to develop ATOP have grown by approximately $20 million, FAA is not responsible for payment because it has a fixed-price contract arrangement with the contractor. Yet, according to the Department of Transportation's Inspector General, FAA would have to pay for all software problems after February 28, 2005. After February 2005, Lockheed Martin will continue to work on software changes under the time and materials portion of the ATOP contract. FAA plans to maintain the acquisition program baseline milestones by relying on current contractor staffing and resources. FAA expects to conduct full transition exercises in June 2005 at the New York and Oakland sites.

Controller-Pilot Data Link Communications (CPDLC)

Figure 10: CPDLC Text Message on an Aircraft Display

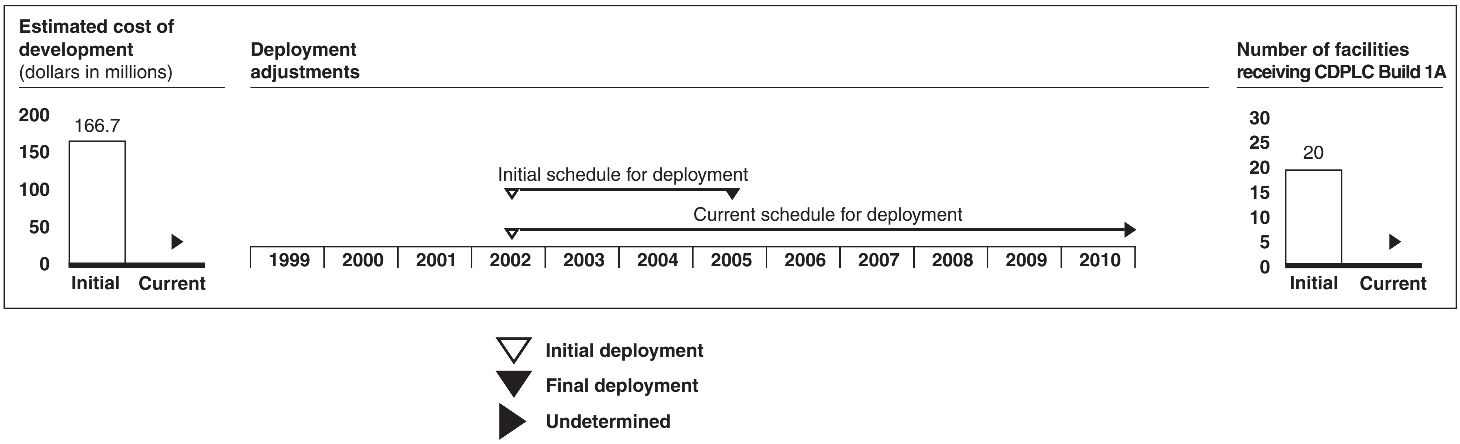
Source: Photo courtesy of FAA.

Note: Contractor for this system is to be determined.

Purpose and Status

CPDLC will allow pilots and controllers to transmit digital data messages directly between FAA automated ground computers and aircraft. By digitally transmitting routine air traffic control (ATC) messages between pilots and controllers, CPDLC will alleviate voice congestion, enhance ATC efficiency, and increase capacity by allowing controllers to handle more aircraft. FAA originally planned to implement CPDLC in several phases. Build 1, the initial development phase, was deployed in Miami for 2 years and consisted of four information services: initial contact, transfer of communications, altimeter setting, and predefined menu text. Build 1A would have added five additional services, including speed, altitude, and route clearance, but it was deferred by a Joint Resources Council decision in April 2003. Presently, FAA is conducting a preliminary investment analysis of National Build, which is intended to deploy the CPDLC system to all 20 Air Route Traffic Control Centers after they have implemented the En Route Automation Modernization (ERAM) program.

Figure 11: Changes to CPDLC Schedule and Cost Targets

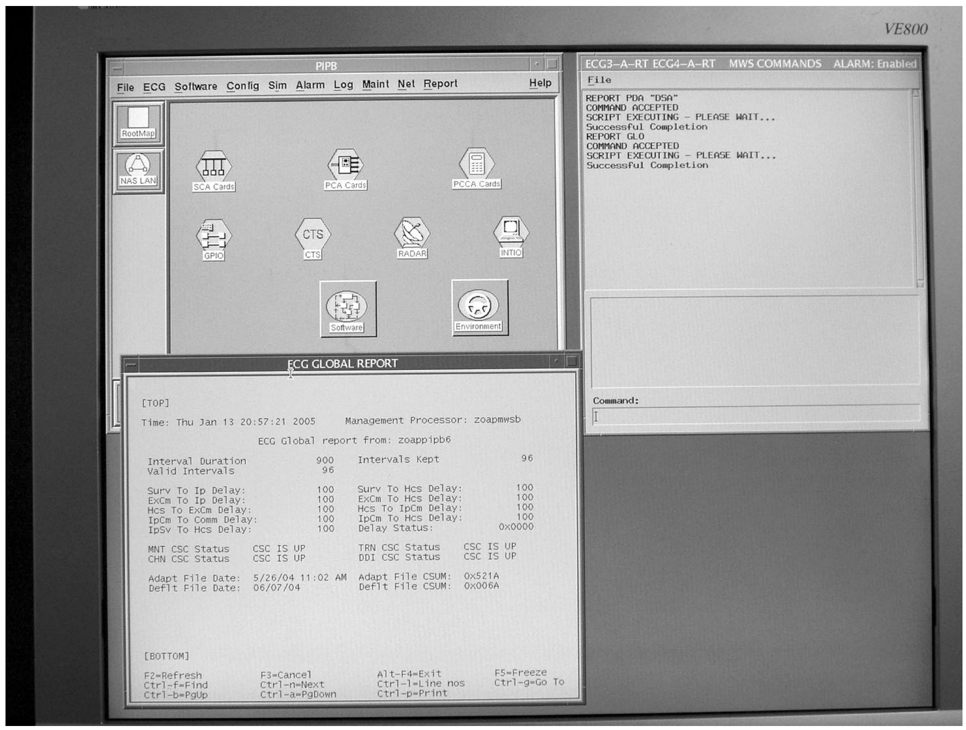


Source: GAO presentation of FAA data.

CPDLC Build 1, implemented at Miami Air Route Traffic Control Center in October 2002, operated for 2 years. FAA's acquisitions office had awarded the CPDLC Build 1A development contract before fully understanding the system's requirements, including those of FAA's aircraft certification office. Additionally, detailed interoperability requirements of air and ground equipment were not complete before the contract was awarded. According to FAA, additional CPDLC hardware, software, and other requirements increased costs by $69.8 million over the original baseline of $166.7 million. The revised cost target presented to the Joint Resources Council in April 2003 was $236.5 million, about a 42 percent increase from its original cost target, for only 8 of the 20 proposed Build 1A locations. FAA decided to suspend acquisition of Build 1A because of concerns about the high costs of communications service provider messages, the uncertainty of integrating CPDLC with ERAM, and the ability of airlines to install, and benefit from, the CPDLC avionics equipment.

En Route Communications Gateway (ECG)

Figure 12: ECG Maintenance Workstation Display



Source: Photo courtesy of FAA.

Note: Contractor for this system is Lockheed Martin.

Purpose and Status

ECG replaces the interim Peripheral Adapter Module Replacement Item (PAMRI). Providing an interface from radar sites to en route centers, PAMRI has been operating for 10 years and has exceeded its life expectancy. The open and expandable platform of the ECG will allow for new connectivity and functionality as the NAS evolves.

Figure 13: Changes to ECG Schedule and Cost Targets

Source: GAO presentation of FAA data.

FAA is on schedule to complete ECG deployment in calendar year 2005. Tests revealed a weakness in security: limitations in designing the monitoring capability prevented appropriate monitoring unless a system technician remained logged on. To ensure that only authorized personnel had access to the system and that the monitoring could be done without a technician on-site, the ECG program office implemented a "guest" logon that enabled monitoring and prevented unauthorized access. According to FAA officials, correcting the weakness cost about $25,000, which falls within the program's budget and schedule. An additional challenge concerns monitoring the ECG system from the System Operations Control (SOC)[3] positions. This issue may require SOC personnel to leave their posts if ECG requires some intervention to, among other things, discover why an event occurred. FAA is evaluating an improvement in the monitoring capability at the SOC positions. The estimated cost is $480,000, which falls within the program's budget and schedule.

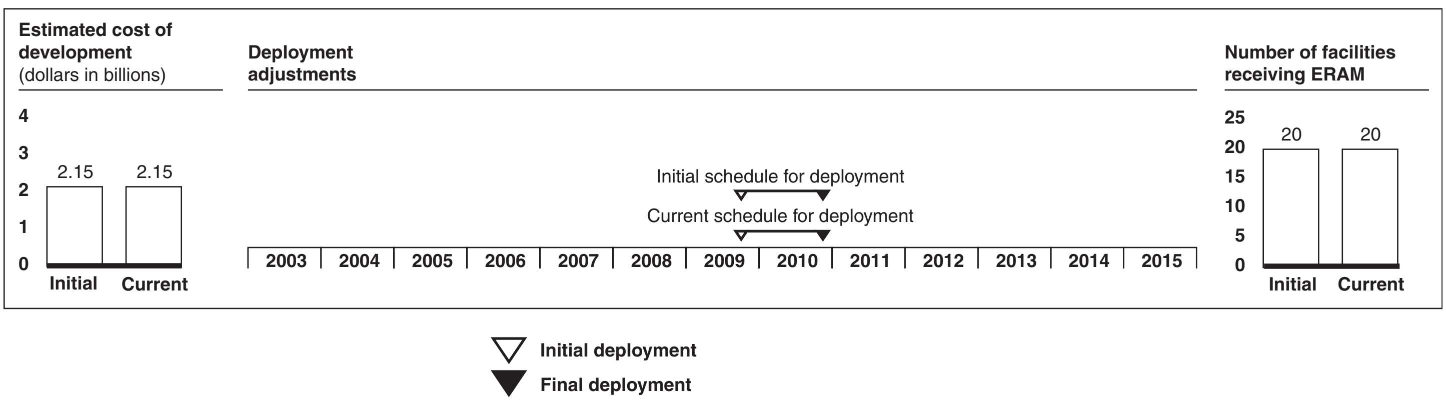
[3]The System Operations Center (SOC) is the workspace on the operations control room floor where managers monitor the state of the equipment providing air traffic services.

En Route Automation Modernization (ERAM)

Purpose and Status

Modular and expandable, ERAM will replace software and hardware in the host computers at FAA's 20 en route air traffic control centers, which provide separation, routing, and advisory information. ERAM's flight data processing capabilities will provide flexible routing around restrictions, such as congestion and weather. It will improve surveillance by increasing the number and types of surveillance sources, such as radars. ERAM will provide safety alerts to prevent aircraft collisions and congestion.

Figure 14: Changes to ERAM Schedule and Cost Targets

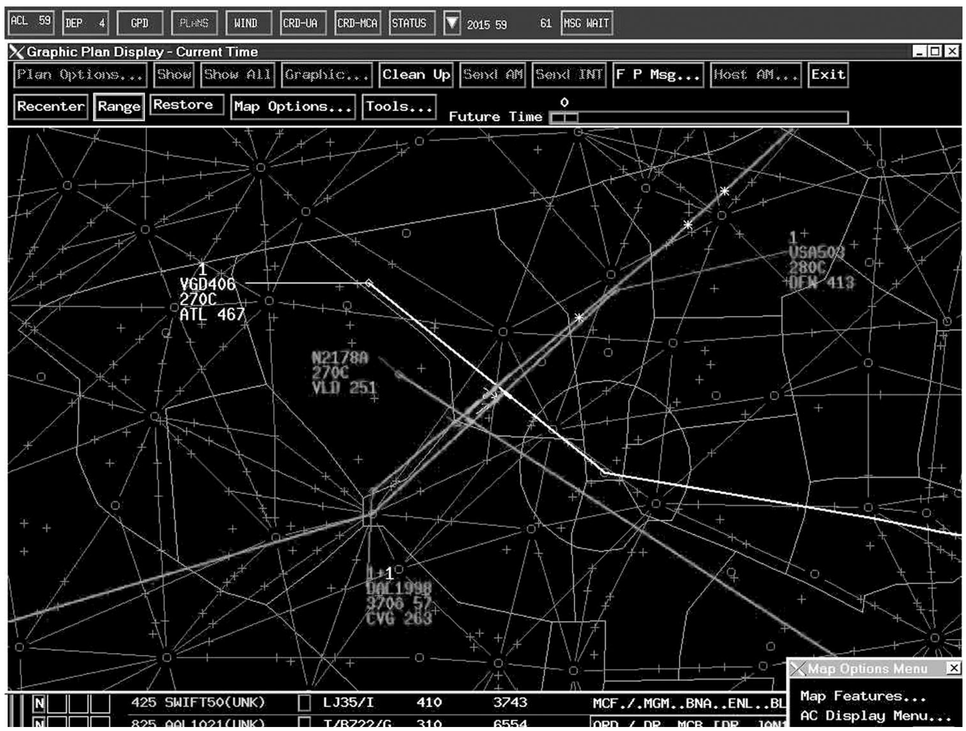


Source: GAO presentation of FAA data.

ERAM has not breached schedule or cost parameters, but it remains a high-risk program because of its size and its amount of software code (more than 1 million lines). The contractor has reported that engineering costs are rising because of lower productivity than originally planned and an increase in the number of lines of software code. According to FAA officials, the contractor's management reserve can absorb additional software development costs.

Free Flight Phase 2 (FFP2)

Figure 15: Free Flight Phase 2 User Request Evaluation Tool



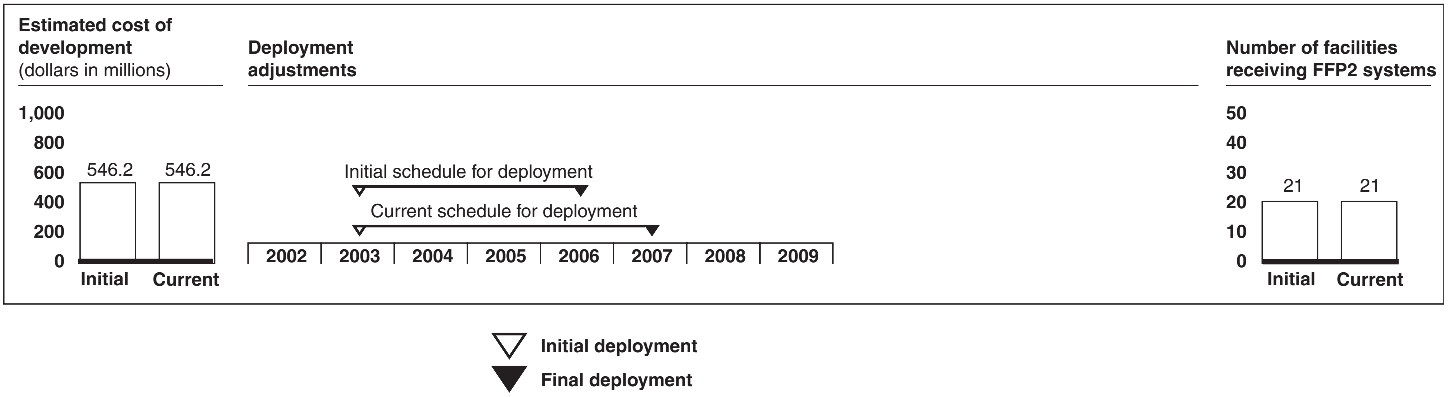
Source: Photo courtesy of FAA.

Note: Contractors for this system are Computer Sciences Corporation, ITT, Lockheed Martin, and Metron.

Purpose and Status

FFP2 builds on Free Flight Phase 1, which established the concept of managing air traffic in a way that enhances the safety, capacity, and efficiency of the NAS. Under FFP2, FAA expects air traffic control to move gradually from a highly structured system, based on elaborate rules and procedures, to a more flexible system that allows pilots, within limits, to change their route, speed, and altitude while keeping air traffic controllers informed of such changes. FFP2 will allow controllers to manage pilot requests for flight information in en route airspace, identify and resolve possible mid-air conflicts up to 20 minutes in advance, and develop arrival sequence plans.

Figure 16: Changes to FFP2 Schedule and Cost Targets



Source: GAO presentation of FAA data.

According to FAA officials, the schedule delay in FFP2's deployment from 2006 to 2007 because, among other things, the funding level received was less than the agency-approved funding level for the system acquisition. Since the transition from Free Flight Phase 1 to Phase 2, the program has received less than the expected level of funding. For example, in fiscal year 2003, FAA requested $107 million; however, due to external and internal budget cuts, the funding was reduced to $70 million.

FAA Telecommunications Infrastructure (FTI)

Figure 17: FTI Primary Network Operations Control Center

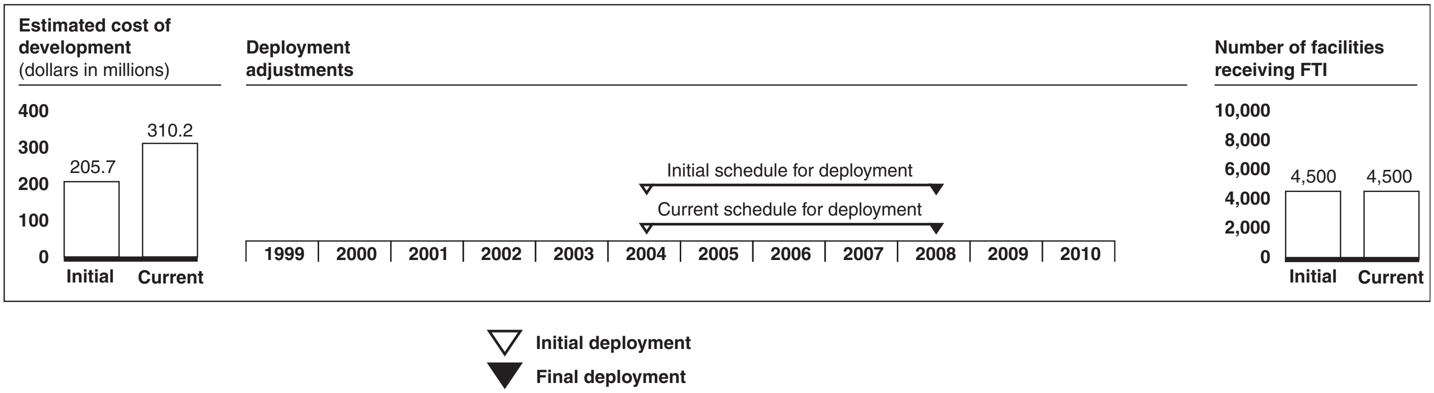
Source: Photo courtesy of FAA.

Note: Contractor for this system is Harris Corporation.

Purpose and Status

FTI will replace costly networks of separately managed systems and services—both leased and owned—by integrating advanced telecommunications services within the NAS and non-NAS infrastructures. FTI will provide FAA with commercial telecommunications services that can meet present and future telecommunications needs between facilities. Its modern and reliable consolidated network will furnish multi-service capabilities.

Figure 18: Changes to FTI Schedule and Cost Targets



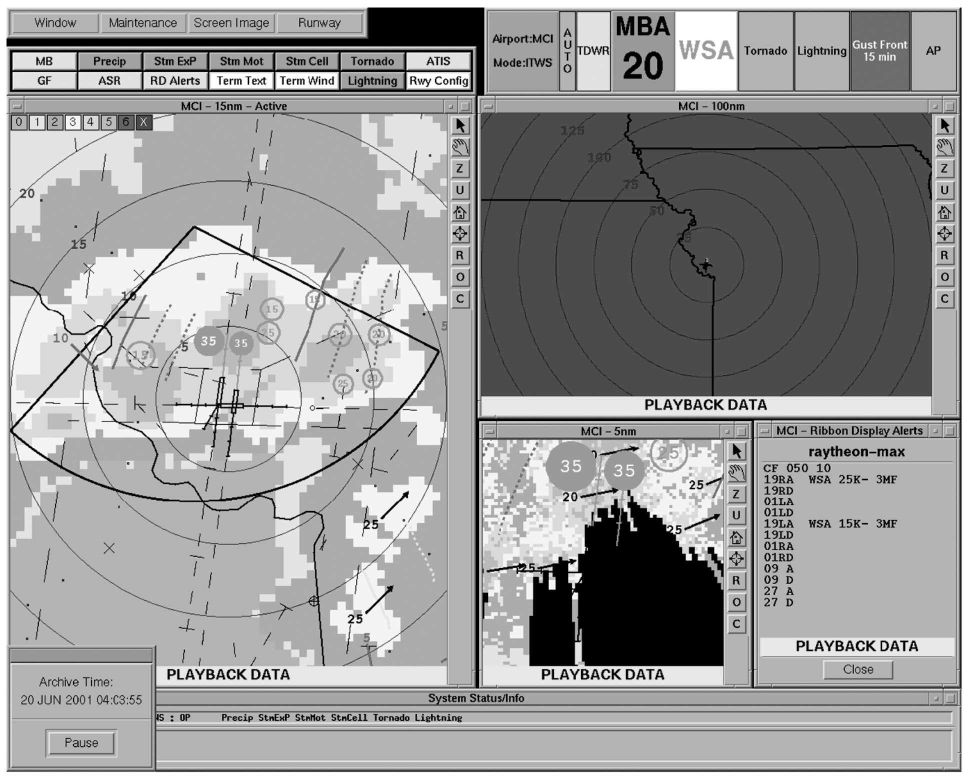
Source: GAO presentation of FAA data.

FTI's two-phase transition will take about 5 years to complete. Phase I was implemented at 21 Air Route Traffic Control Centers and 2 National Network Operations Control Centers. Deployment of Phase II, which is under way, will extend service to the remaining 4,477 NAS facilities.

In June 2003, the FTI program returned to the Joint Resources Council with a proposed revision to the baseline that was based on actual contract prices for NAS operational services and estimated prices for mission support services. The council deferred revising the baseline until the program negotiated prices for mission support services. A consolidated Acquisition Program Baseline package for the full scope of NAS operational and mission support services was then completed in December 2004. The Joint Resources Council approved the revised baseline on December 8, 2004.

Integrated Terminal Weather System (ITWS)

Figure 19: ITWS Situation Display



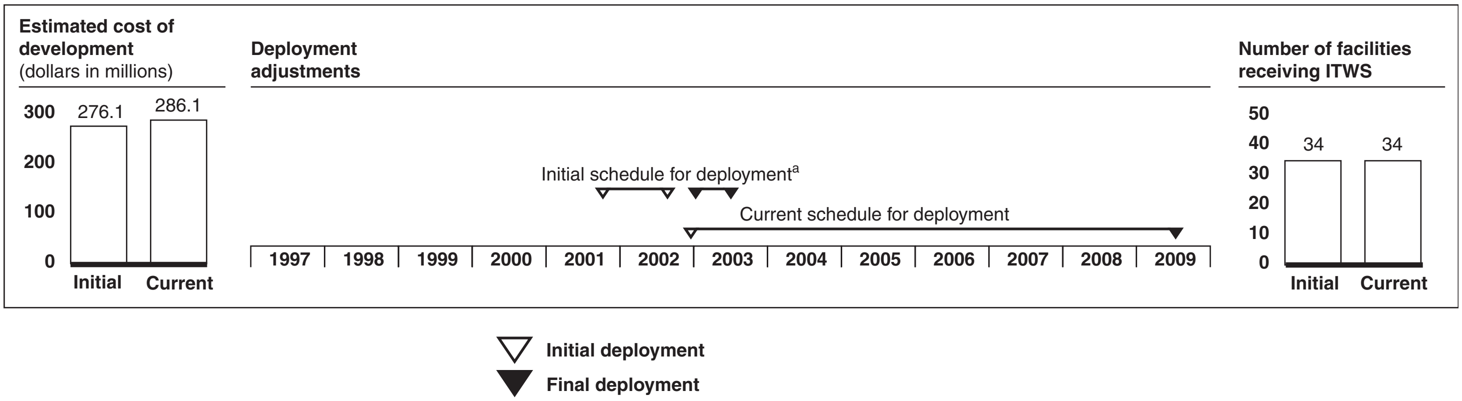
Source: Photo courtesy of FAA.

Note: Contractor for this system is Raytheon.

Purpose and Status

ITWS furnishes air traffic controllers and supervisors with full-color graphic displays of weather information concerning airport terminal airspace within a 60-mile radius. It provides a comprehensive current weather situation and precise forecasts of expected weather conditions for the next 60 minutes. ITWS requires no meteorological interpretation by air traffic controllers or pilots.

Figure 20: Changes to ITWS Schedule and Cost Targets



Source: GAO presentation of FAA data.

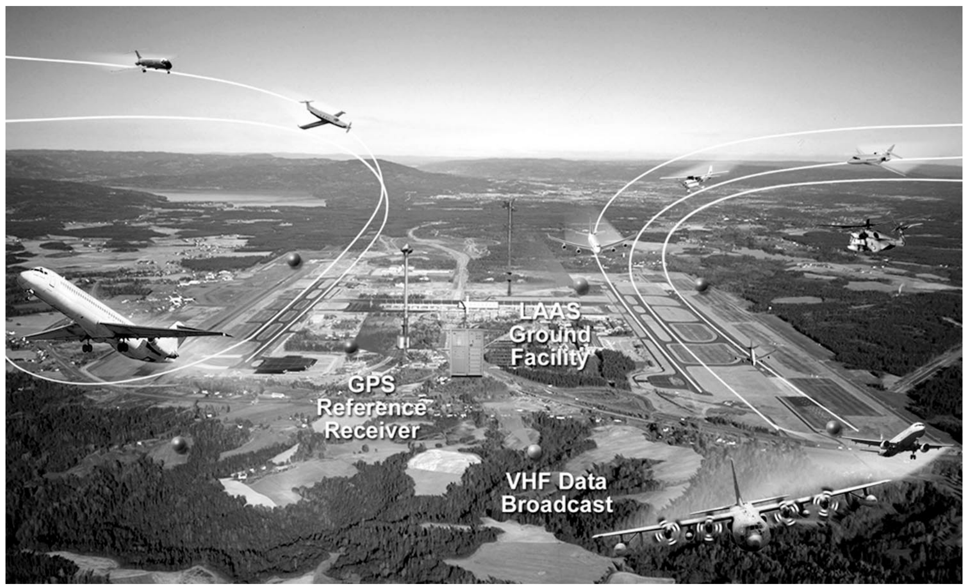
[a]FAA initially projected that its first ITWS deployment would occur between September 2001 and August 2002 and that final system deployment would occur between January 2003 and July 2003.

ITWS experienced delays because its software development was complex and the funding level received was less than the agency-approved funding level for the system acquisition. The program appeared to be progressing according to its baseline; however, immediately after the critical design review in September 1998, the contractor revealed that the program had exceeded the target cost by $4 million. Consequently, ITWS experienced schedule delays and cost increases, along with performance shortfalls.

In May 2004, FAA's Joint Resources Council revised the baseline for the ITWS program to include, in production, the capability to predict weather conditions 60 minutes into the future. Because of constrained funding, the ATO Executive Council froze funding for fiscal years 2005, 2006, and 2007. In addition, FAA postponed deploying 12 of the 34 systems until an undefined future date. In January 2005, FAA management decided that the ITWS program would use already-procured equipment to install the next six sites and transition to Airport Improvement Program grants for the remaining scheduled sites. The ITWS program office is currently studying the impact of the decision on the system's baseline. According to the contractor and the original acquisition plan, all systems were scheduled for delivery by December 2001, but that date has now been extended to after 2009.

Local Area Augmentation System (LAAS)

Figure 21: Key Components of LAAS



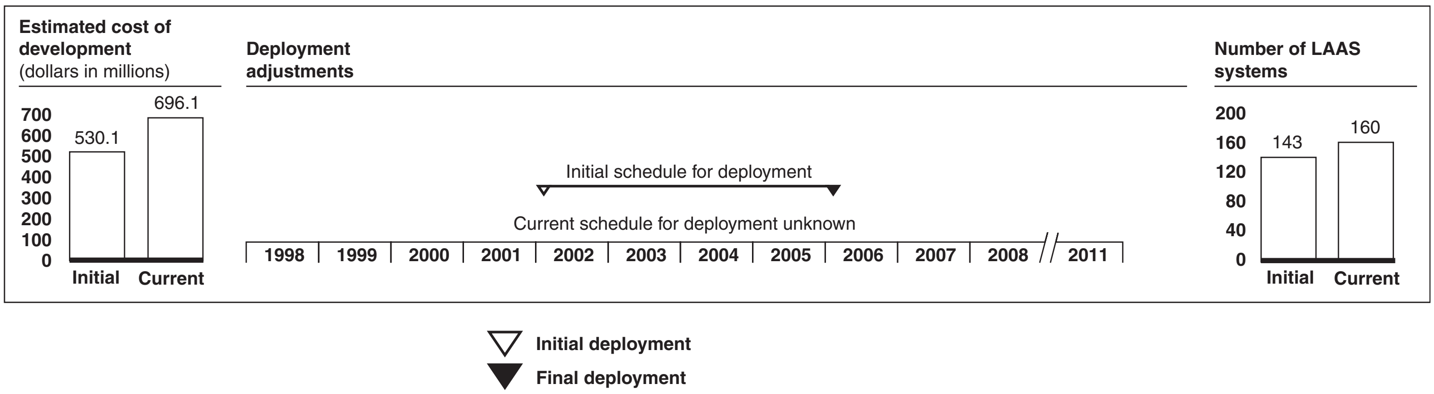
Source: Photo courtesy of FAA.

Note: Contractor for this system is Honeywell.

Purpose and Status

LAAS will allow aircraft to execute precision instrument approaches and landings in all weather conditions. Its global positioning system will broadcast highly accurate information to aircraft in a flight's final phases, providing more precise approach paths than the current instrument landing system, reducing the required separation between incoming aircraft, and increasing airspace capacity. LAAS will also provide airports with precision approach capability for all runways, eliminating the need for multiple-instrument landing system installations.

Figure 22: Changes to LAAS Schedule and Cost Targets



Source: GAO presentation of FAA data.

For LAAS, three of the four factors we discussed have contributed to the system's cost increases, schedule extensions, and performance problems. Specifically, poorly established requirements resulted in the addition of 113 new requirements to the initial specification, entailing unplanned work including significant software and hardware changes. In addition, FAA underestimated LAAS' software complexity because it inadequately assessed the system's technology maturity. In particular, the agency misunderstood the potential for radio interference through the atmosphere, which could limit LAAS' operations. FAA also did not fully engage technical experts early in the approval process of LAAS. According to the Department of Transportation Inspector General, although FAA has had a LAAS Integrity Panel in place since 1996 to assist with its research and development activities, the panel was not formally tasked with resolving the integrity requirement[4] early in the approval process, which might have enabled FAA to develop a quicker solution.[5] In 2003, FAA focused the LAAS Integrity Panel on developing a solution to meet the integrity requirement.

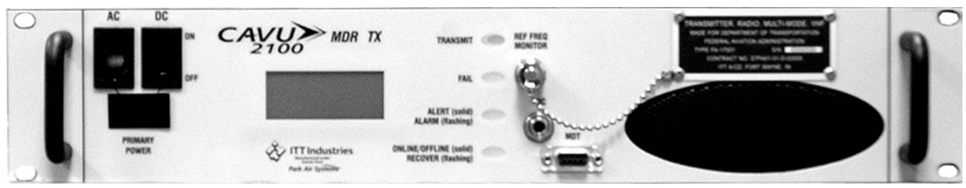
[4]The system's integrity requirement alerts pilots of erroneous information not more often than once every 47 years, or 10^{-7}.

[5]Department of Transportation's Inspector General, *FAA Needs to Reset Expectations for LAAS Because Considerable Work Is Required before It Can Be Deployed for Operational Use*, AV-2003-006 (Dec. 16, 2002).

The contractor has experienced difficulties ensuring that the system will alert pilots when it produces erroneous information. FAA and the contractor agree that these difficulties have resulted from a lack of communication. When the contract was awarded, FAA assumed that LAAS was 80-percent developed but later discovered that only about 20 percent was complete. FAA therefore suspended funding in fiscal year 2005 and used the remaining $18 million to resolve the integrity requirement problem, among other things, in fiscal year 2004. Although FAA had not requested funding, Congress did approve an additional $10 million for LAAS in fiscal year 2005. The FAA will continue to work on resolving LAAS integrity and safety assurance issues during fiscal year 2005. During fiscal year 2006, the program office will develop a business case justification on whether to continue the LAAS program.

Next Generation Air-to-Ground Communication (NEXCOM)

Figure 23: Multimode Digital Radio



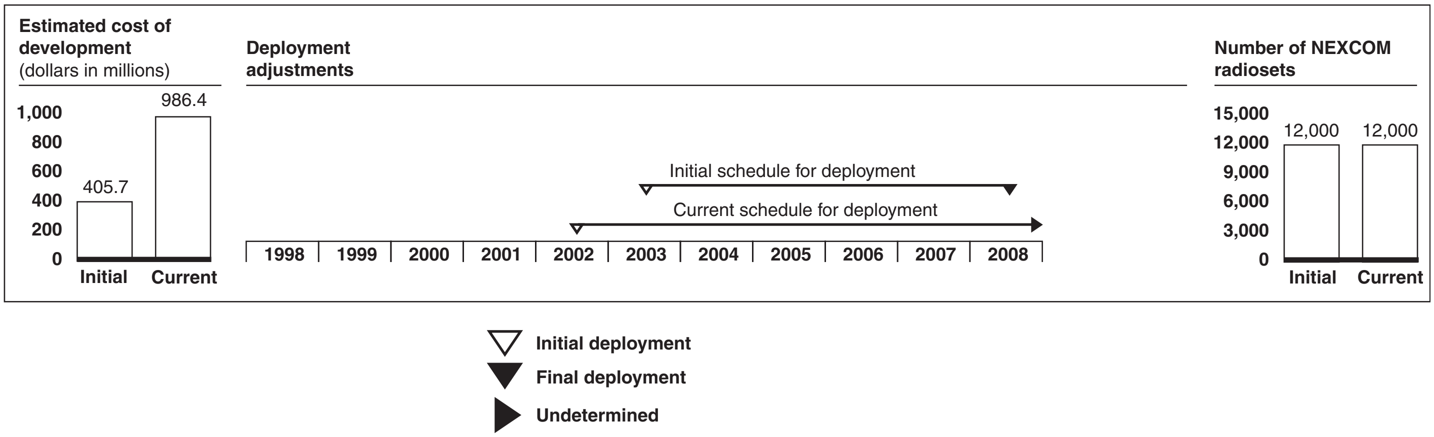
Source: Photo courtesy of FAA.

Note: Contracter for this system is ITT (segiment 1A).

Purpose and Status

NEXCOM will improve air traffic control communications by replacing controller-pilot analog communication with a state-of-the-art digital system. Consisting of multimode digital radios, avionics, and ground stations, NEXCOM will enhance security by requiring digital authentication and preventing "phantom controllers" from gaining access to the communications system. NEXCOM Segment 1A will replace 30- to 40-year-old radios, deploying 12,000 new radio sets that use analog and digital communications with aircraft. Segment 1B will create ground stations to communicate with aircraft equipped with digital capability.

Figure 24: Changes to NEXCOM Schedule and Cost Targets



Source: GAO presentation of FAA data.

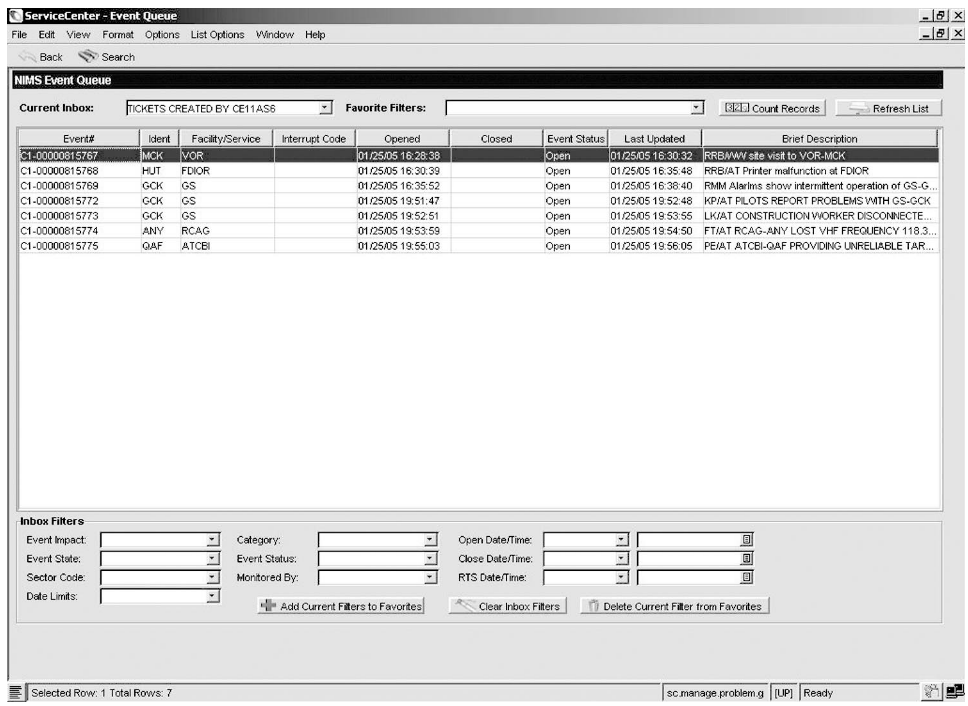
NEXCOM experienced schedule slippages in developing Segment 1A—the multimode radio sets—because the vendor failed to meet interference requirements and to perform additional tests to avoid risks associated with future upgrades. FAA's initial plans did require meeting interference requirements. The initial schedule assumed FAA could procure a nondevelopmental item (NDI) product that met the interference requirements. The vendor's product did not meet the established interference requirements. A solution had to be developed and tested. The project schedule had to be adjusted to accommodate additional development and testing. As a result, the system's approval was delayed by about 20 months. In September 2003, NEXCOM Segment 1A was initially deployed at Jacksonville, Florida. Segment 1A cost and schedule baseline is scheduled for a Joint Resources Council review in August 2005.

NEXCOM's cost growth has resulted from additional software and hardware requirements. Because the funding level received was less than the agency-approved funding level for the system acquisition, FAA postponed funding Segment 1B—the ground stations—until at least fiscal year 2008. FAA has no current estimate for the last deployment date.

FAA plans to develop and deploy NEXCOM Segment 2 between 2008 and 2013. This segment will provide a digital data link to aircraft at high and super-high altitudes. Segment 3, scheduled between 2011 and 2013, will provide digital voice and data link capabilities throughout the ATC system. FAA has not developed funding estimates for these two segments.

NAS Infrastructure Management System—Phase 2 (NIMS-2)

Figure 25: NIMS Infrastructure



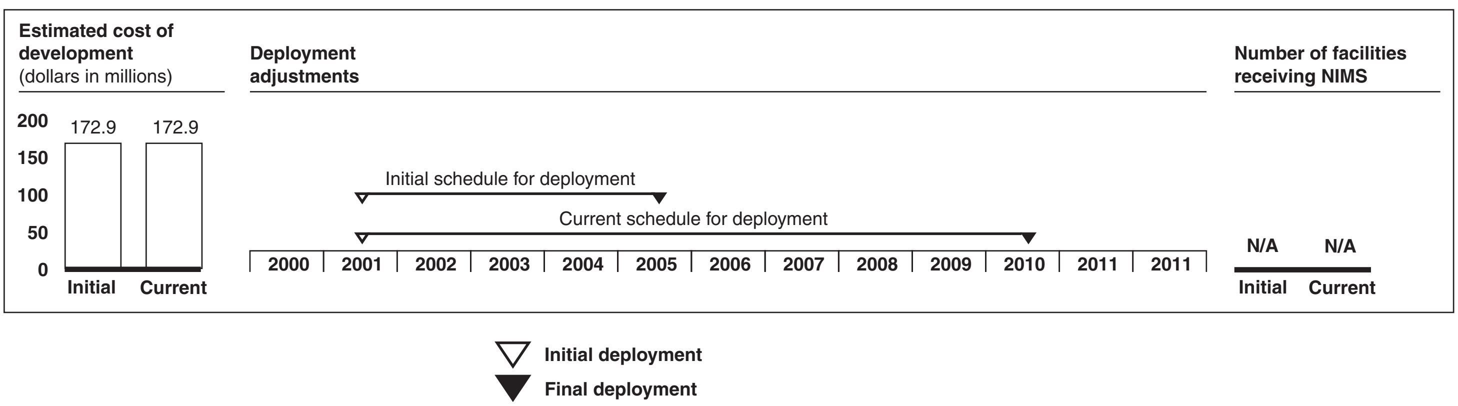
Source: Photo courtesy of FAA.

Note: Contractor for this system is Digicon.

Purpose and Status

NIMS, a centralized maintenance management system, will operate and maintain the NAS infrastructure, including its facilities, systems, and equipment (e.g., communications, radars, and navigational aids). NIMS will decrease the number of en route delays by reducing the time required to restore systems to full operation following maintenance. NIMS—Phase 1 currently provides initial Operational Control Center capability,[6] along with remote monitoring and control functionality, to 3,700 NAS facilities and 5,800 deployed maintenance data terminals. By fully implementing resource management and enterprise management software, NIMS—Phase 2 will focus on increasing workforce productivity in such priority activities as receiving orders and managing resources. Future NIMS phases will allow for information sharing that is in sync with NAS' technological improvements.

Figure 26: Changes to NIMS–Phase 2 Schedule and Cost Targets



Source: GAO presentation of FAA data.

According to FAA, the funding for NIMS–Phase 2 was $96.4 million below the approved amount in agency planning documents. Subsequently, FAA had to defer additional system requirements, extend the schedule by 5 years, and increase the system's cost estimate by $84.0 million. FAA is revising the baseline for Phase 2, as shown in figure 26; a Joint Resources Council decision is planned for August 2005.

[6]Operational Control Center capability, established in 2001, is a standard set of tools and procedures needed to open the control centers. The tools provide the initial enterprise management and resource management technical capabilities needed at Operational Control Centers.

Operational and Supportability Implementation System (OASIS)

Figure 27: OASIS Dual Screen Display

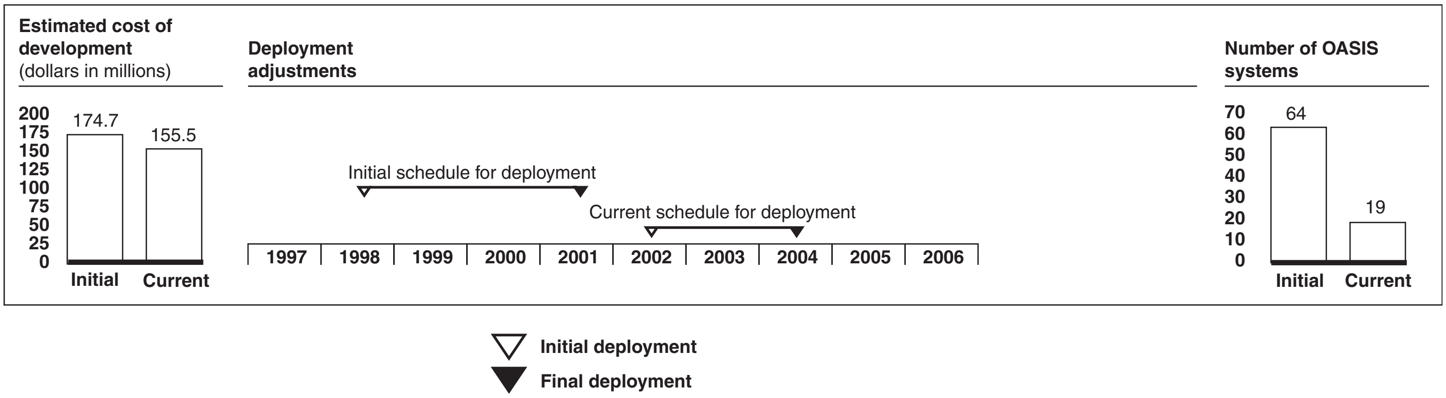
Source: Photo courtesy of FAA.

Note: Contractors for this system are Harris Corporation (OASIS workstations) and Evans Corporation (consoles), respectively.

Purpose and Status

OASIS, a modified commercial-off-the-shelf system, replaces workstation consoles, among other things, at automated flight service stations. It also replaces the Flight Services Automation system for which spare parts and hardware support have been difficult for FAA to maintain. OASIS furnishes up-to-the-minute weather graphics by integrating real-time weather and flight planning data with overlays of flight routes. It also provides operational support, retrieves reports, and supplies lightning data and icing images, among other things.

Figure 28: Changes to OASIS Schedule and Cost Estimates



Source: GAO presentation of FAA data.

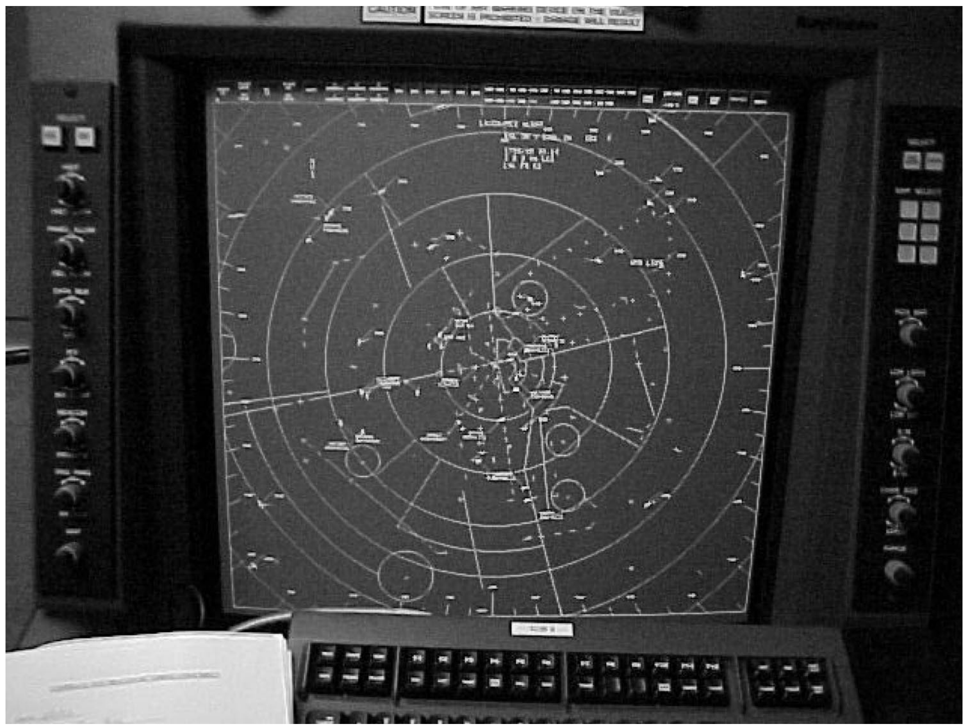
OASIS has experienced schedule extensions and cost increases because of unplanned work, insufficient stakeholder involvement, and funding that is less than the agency had approved as needed for meeting the system's schedule, cost, and performance targets. For example, the system acquisition schedule slipped because of a larger-than-planned development effort. FAA's 1998 review of the contractor system's architecture for OASIS revealed that the commercial-off-the-shelf solution was not as mature as FAA had envisioned when the contract was awarded and revealed that the contractor's commercial products did not fully satisfy its requirements. According to the Department of Transportation's Inspector General, FAA had identified a number of significant human factors concerns, such as inadequate weather graphics. This indicated that stakeholders were not sufficiently involved throughout the system's design and development. As a result, FAA eliminated the option of commercial-off-the-shelf procurement. In addition, the OASIS program was rebaselined in March 2000 due to fiscal year 2000 appropriations being reduced to $10 million from the $21.5 million baseline. The reduction in funding resulted in a reduced rate of software development, delayed and reduced the rate of planned hardware and console deployments, and resulted in the incremental deployment of operational software. This contributed to FAA's delay of its first-site implementation from July 1998 to 2002.

According to FAA officials, receiving less funding than the agency had approved for fiscal years 2004 and 2005 also resulted in a delay in OASIS' deployment to automated flight service stations. As of February 2005, FAA had deployed 19 systems: 16 at Automated Flight Service Stations (AFSS) and 3 at other sites. Software upgrades that are under way will be completed by June 2005. FAA had no plans for installations or software upgrades beyond those at the AFSS sites, pending an evaluation of private-sector bids to operate flight service stations. Until then, FAA had directed the program to remain within the funding levels of its Capital Investment Plan for fiscal years 2004 to 2006.[7] According to FAA, since completion of the evaluation of bids in February 2005, OASIS' implementation remains unchanged. FAA does not plan on additional OASIS funding for software enhancements or more installations. FAA plans to phase out OASIS between March 2006 and March 2007 in accordance with the new service provider's transition plan.

[7]The Capital Investment Plan, a 5-year financial plan, allocates funds to NAS projects on the basis of a detailed analysis of project funding by FAA functional working groups. The plan includes estimates for the current fiscal year budget and for 4 future year expenditures for each line item in the facilities and equipment budget.

Standard Terminal Automation Replacement System (STARS)

Figure 29: STARS Controller Workstation



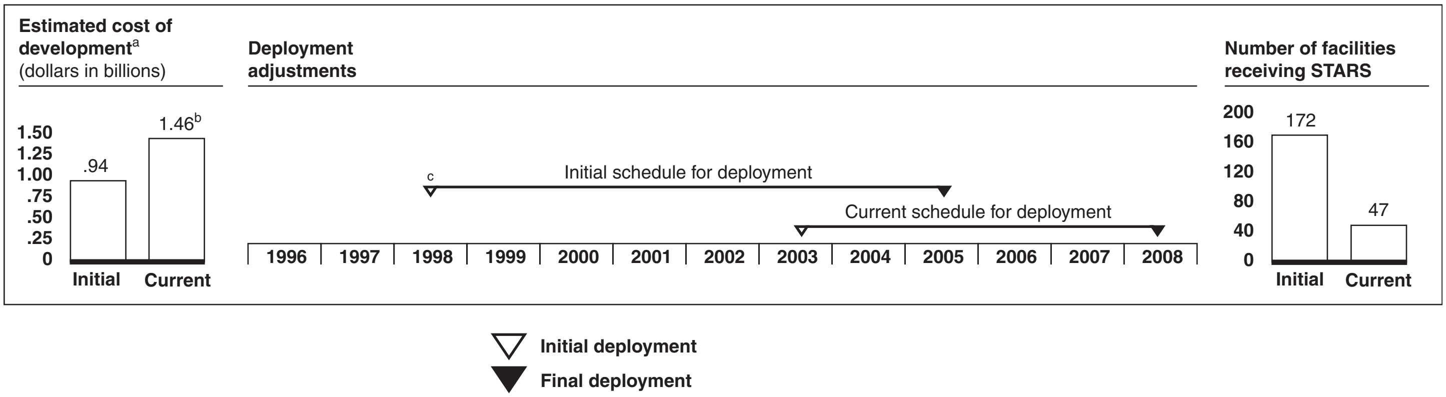
Source: Photo courtesy of FAA.

Note: Contractor for this system is Raytheon.

Purpose and Status

STARS—a joint program of FAA, the Department of Defense (DOD), and the Department of Transportation (DOT)—replaces aging FAA and DOD terminal systems with state-of-the-art terminal air traffic control systems. The system is designed to prevent duplication of development and logistic costs. Civil and military air traffic controllers use STARS to direct aircraft near major U.S. airports. Its open and expandable terminal automation platform can accommodate air traffic growth, as well as new hardware and software that promote safety, maximize operational efficiency, and improve controllers' productivity.

Figure 30: Changes to STARS Schedule and Cost Targets



Source: GAO presentation of FAA data.

[a]This estimate includes development costs only and does not include technology refresh and terminal automation enhancement.

[b]Based on the May 2004 FAA approved Acquisition Program Baseline for development and procurement estimates.

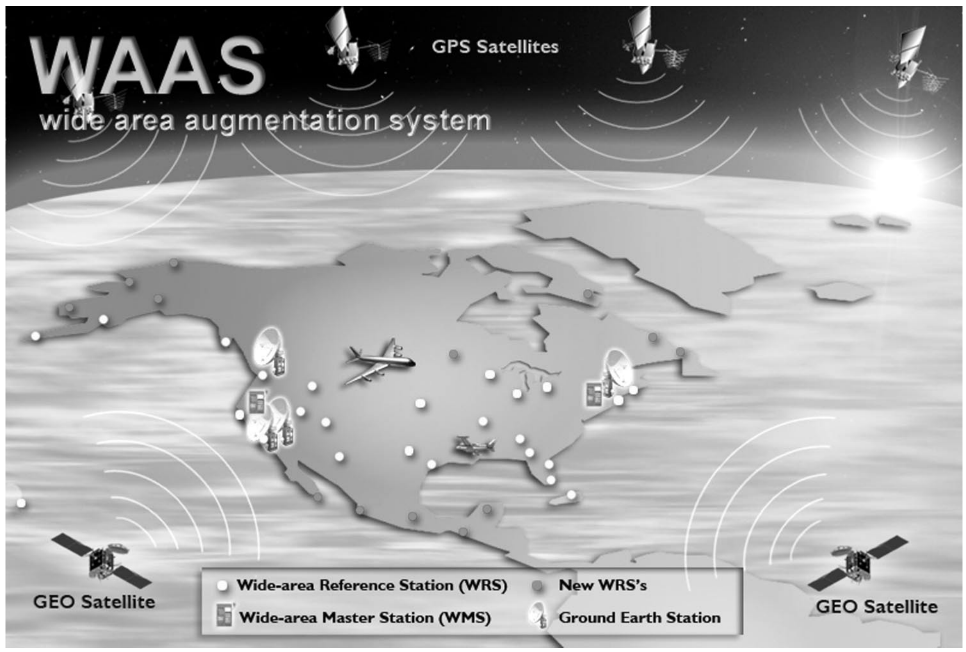
[c]The February 1996 baseline included limited human factor evaluations and a basic commercial-off-the-shelf configuration.

FAA revised its baseline for the STARS program in May 2004, changing the acquisition to a phased approach that divides large programs into smaller phases to allow the agency to evaluate other alternatives of system implementation. For Phase 1, STARS was approved for deployment to 51 Terminal Radar Approach Control (TRACON) facilities. Following the system's release and FAA's concurrence with the November 23, 2004, report from the DOT Inspector General, FAA reduced STARS' deployment to 47 TRACON facilities. STARS is fully operational at 29 FAA terminal radar control facilities and 21 DOD radar control facilities. If approved in 2005, DOD plans to deploy STARS to 106 Radar Approach and Control (RAPCON) facilities and 75 towers nationally and worldwide. With completion of DOD's transition in 2004 to FAA's new STARS' configuration, both DOD and FAA are operating together on a single national software and hardware configuration baseline.

During STARS' development, schedule slippages and cost increases occurred because the original commercial-off-the-shelf (COTS) acquisition strategy focused on early adoption of commercial technology by FAA and DOD could avoid the increasing cost of supporting legacy systems by quickly deploying STARS to the highest-priority air traffic control facilities, and then making further improvements. FAA had compressed STARS' original development and testing schedule from 32 to 25 months, leaving only limited time for human factors evaluations. Allowing insufficient time to involve stakeholders, FAA and the contractor had to restructure the contract to address technicians' and controllers' concerns, including an inconsistency in visual warning alarms and color codes between the old and the new systems. However, the STARS initial system configuration was satisfactory for use by DOD as deployed. The FAA modified the COTS strategy and suspended STARS deployments until FAA controller and technician requirements were developed. FAA estimates the COTS acquisition strategy, which limited involvement of controllers and maintenance technicians in the system's development added 3 years and $500 million to the development of more than 160 system requirements. The first phase of the three-phase deployment plan comprises 47 systems. FAA and the DOT are currently determining a safe, economical, and affordable site mix for follow-up phases.

Wide Area Augmentation System (WAAS)

Figure 31: Key Components of WAAS



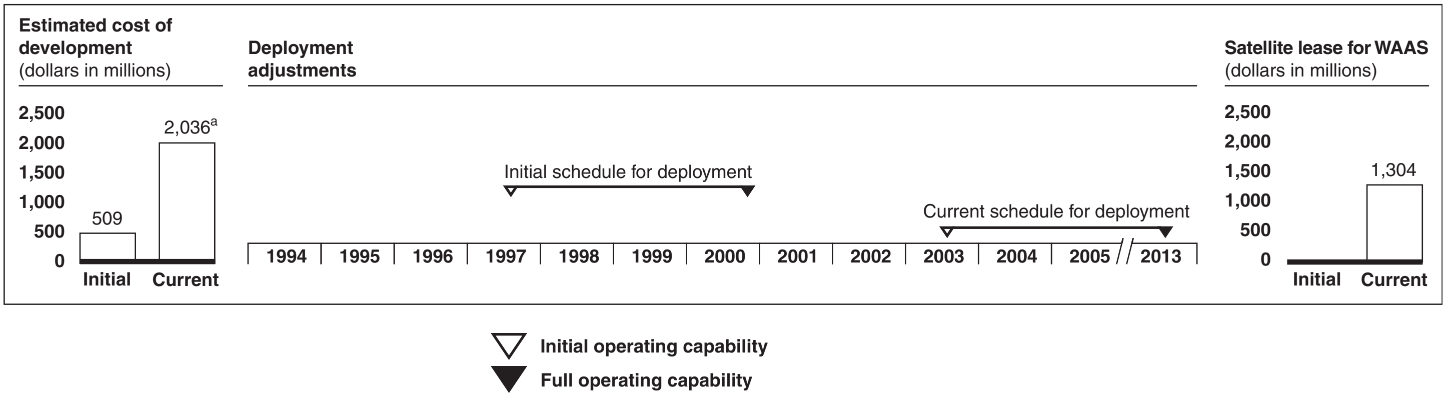
Source: Photo courtesy of FAA.

Note: Contractor for this system is Raytheon.

Purpose and Status

WAAS uses global positioning system satellites to provide precise navigation and landing guidance to aircraft at all airports, including thousands that have no ground-based instrument landing capability. WAAS also provides safer and more efficient arrival, en route, and departure operations by allowing user equipment to augment the global positioning system while increasing its position accuracy and reliability, among other things.

Figure 32: Change to WAAS Schedule and Cost Targets



Source: GAO presentation of FAA data.

[a]September 1999 and May 2004 estimates for WAAS development exclude $1.3 billion in satellite communications leases.

When WAAS has full operating capability, it will provide en route navigation guidance from the surface up to 100,000 feet and instrument landing guidance down to 200 feet. It currently provides full en route navigation up to 100,000 feet and instrument landing guidance down to 250 feet at all qualified airports in the continental United States. FAA has begun to publish WAAS instrument flight procedures for some runways; however, pilots cannot use WAAS for landing guidance on those runways for which FAA has not written guidance. To achieve full operating capability, a second civil aviation frequency must be added to new global positioning system satellites to allow aircraft to conduct precision runway approach operations during ionospheric interruptions, such as "solar storms." The Department of Defense, which is responsible for providing this frequency, plans to add it between 2013 and 2019.

FAA encountered cost, schedule, and performance problems because its scheduling was accelerated, coordination among its offices proved insufficient, and technical challenges delayed its meeting the integrity requirement—a requirement that pilots be alerted in a timely manner when the system should not be used. At the urging of government and aviation industry groups in the early 1990s, FAA accelerated WAAS' schedule by attempting to develop, test, and deploy the system within 28 months, even though software development alone was expected to take 24 to 28 months. Rather than shortening the total development time, these steps contributed to schedule delays. FAA also set development milestones before completing the research and development required to prove WAAS' capability. Since officials on WAAS' integrated product development team within the aircraft certification office did not participate regularly during design and development, FAA did not recognize its difficulty in meeting the integrity requirement or its lack of scientific and technical expertise. FAA eventually acquired the expertise, and a team of satellite navigation experts solved the problem. These actions resulted in unplanned work and contributed to the rise in WAAS's cost from the original estimate of $509 million in 1994 to $2.036 billion in 2005, and to a 6-year extension in its commissioning date. According to FAA, adding 6 years to the program's life cycle also contributed to increased costs.[8]

[8]FAA also transferred $1.3 billion--the cost of satellite leases--from the operations account to the facilities and equipment account, bringing the total estimate at completion cost to $3.3 billion.

Information on the 39 Additional Systems under the ATC Modernization Program

Table 4: Cost and Schedule Information for Nine Additional Major Systems under the ATC Modernization Program

Dollars in millions

Program/system description	Original cost target	Current cost target	1st year funded	Last year funding planned	Original schedule initial deployment target	Current schedule initial deployment target	Original schedule last deployment target	Current schedule last deployment target
HOST/Oceanic Computer System Replacement (HOCSR): Replaces the main ATC computer processor and some peripherals and ensures supportability of other peripherals until replaced by ERAM.	$424.10	$368.50	FY 97	FY 05	December 1998	December 1998	June 2004	April 2004
En Route System Modification: Will replace obsolete components, upgrade controllers' displays and supporting infrastructure, and configure consoles to accommodate additional processors.	$201.90	$201.90	FY 00	FY 09	N/A	N/A	May 2009	N/A
Initial Academy Training System (IATS): Enables the training of an increasing number of new air traffic controllers at the FAA Academy.	$23.35	$23.35	FY 03	FY 08	September 2005	September 2005	September 2005	September 2005
Ultra High Frequency (UHF) Radio Replacement: Replaces aging equipment used to communicate with Department of Defense aircraft in support of military operations.	$85.15	$85.15	FY 01	Beyond FY 09	FY 03	FY 10	FY 10	FY 10
Command Center Conference Control System (CCS) - Replace Operational Telephone Voice Switch (OTS): Replaces the existing telephone system at the FAA Air Route Control System Command Center in Herndon, Va. The existing telephone system is becoming unsupportable and can no longer perform required functions.	$12.70	$12.70	FY 02	FY 05	FY 05	FY 05	FY 05	FY 05

(Continued From Previous Page)

Dollars in millions

Program/system description	Original cost target	Current cost target	1st year funded	Last year funding planned	Original schedule initial deployment target	Current schedule initial deployment target	Original schedule last deployment target	Current schedule last deployment target
Capstone Phase I (a part of the Safe Flight 21 program): A demonstration program, intended to improve aviation system safety in Alaska through the introduction of new communications, navigation, and surveillance technologies, as well as improving aviation system capacity and efficiency.	$18.55	$18.55	N/A	N/A	FY 00	N/A	FY 03	N/A
Automated Surveillance Radar-Model 9 (ASR-9)/Mode Service Life Extension (SLEP): Extends the service life of the radar by replacing obsolete components to sustain existing system capabilities, such as providing aircraft detection and separation services to reduce aircraft delays and improve safety at congested airports.	$186.50	$186.50	FY 01	Beyond FY 09	TBD	TBD	TBD	TBD
Aviation Surface Weather Observation Network (ASWON): A suite of five weather systems that provides automated surface weather observation to meet the needs of pilots, operators, and air traffic controllers.	$350.90	$403.80	FY 98	Beyond FY 09	September 2002	N/A	September 2010	N/A
Precision Runway Monitor (PRM): An electronic scan radar that tracks and processes aircraft targets at a 1-second update rate and allows simultaneous approaches on runways spaced less than 4,300 feet apart, thereby increasing capacity and reducing delays during adverse weather conditions.	$145.80	$145.80	FY 88	FY 07	October 1997	October 1997	January 2007	January 2007

Source: GAO presentation of FAA data.

Table 5: Cost and Schedule Information for the 30 Buy-It-by-the-Pound Systems under the ATC Modernization Program

Dollars in millions

Program/system description	Appropriated funding for 1st year	Appropriated funding through FY 04	1st year funded	Last year funding planned	1st initial operating capability/ operational readiness date	Last initial operating capability/ operational readiness date
En Route Enhancements: Maintains current software systems and supports development, integration, and implementation of upgrades to, among other things, the Host software.	$5.30	$36.50	FY 01	Beyond FY 09	N/A	N/A
Terminal Sustainment: Will maintain the existing FAA terminal automation systems, such as Common Automated Radar Terminal System (CARTS) ARTS IIEs and IIIEs, until the Terminal Automation Modernization and Replacement program replaces or upgrades the systems.[a]	$6.30	$73.60	FY 00	Beyond FY 09	N/A	N/A
Current Enhanced Traffic Management System (ETMS) OPS: Maintains and supports mission-critical traffic flow management (TFM) operations in 85 ATC facilities and makes necessary upgrades to support enhanced traffic management services.	$13.40	$116.50	FY 98	FY 05	N/A	N/A
Traffic Flow Management Infrastructure (TFM-I) Modernization: Modernizes the TFM decision support systems and tools that help balance growing flight demands with NAS capacity within an environment.	$8.50	$30.40	FY 02	Beyond FY 09	February 2008	N/A
Departure Spacing Program (DSP): Assists controllers in the more efficient management of departures from multiple airports within the New York and Philadelphia metropolitan areas.	$7.50	$48.50	FY 01	FY 06	Prior to FY 03	Prior to FY 03
NAS Resources/Notice to Airmen (NOTAM): Provides an automated, centralized, standardized, and timely distribution system for NOTAMS using a dedicated telecommunications network.	$1.70	$10.90	FY 04	Beyond FY 09	N/A	N/A

(Continued From Previous Page)

Dollars in millions

Program/ system description	Appropriated funding for 1st year	Appropriated funding through FY 04	1st year funded	Last year funding planned	1st initial operating capability/ operational readiness date	Last initial operating capability/ operational readiness date
Voice Switching and Control System (VSCS)[b]: Upgrade and tech refresh to ensure that the air-to-ground and ground-to-ground communications capabilities are reliable and available for separating aircraft, coordinating flight plans, and transferring information between en route ATC facilities.	$13.60	$60.00	FY 01	Beyond FY 09	October 2006	N/A
Weather Message Switching Center Replacement (WMSCR) Transition: Will upgrade obsolete processors, output devices, display screens, backup systems and software. This will allow pilots quick and accurate access to weather data and NOTAMS.	$2.50	$8.50	FY 01	FY 05	N/A	N/A
Enhanced Terminal Voice Switch (ETVS): Replaces obsolete voice switches in the ATC Towers and Terminal Radar Approach Control facilities. Voice switches enable air traffic controllers to communicate with aircraft as well as other ATC facilities.	$2.00	$95.40	FY 95	FY 09	May 1998	N/A
Communications Facilities Expansion (CFE): Provides a vehicle for facilities to improve communications coverage to meet specific operational requirements based upon, among other things, air traffic demand.	$6.00	$53.00	FY 91	Beyond FY 09	N/A	N/A
Air/Ground Communications Radio Frequency Interference (RFI) Elimination: Provides equipment to improve air and/or ground communications and provides support for remote communication facilities. The equipment will reduce the need for inter-modulation products, thus eliminating the major source of radio frequency interference at congested sites.	$1.20	$26.40	FY 89	Beyond FY 09	1st delivery on current contract June 1996	Ongoing

(Continued From Previous Page)

Dollars in millions

Program/ system description	Appropriated funding for 1st year	Appropriated funding through FY 04	1st year funded	Last year funding planned	1st initial operating capability/ operational readiness date	Last initial operating capability/ operational readiness date
Critical Telecommunications Support (CTS): Enables FAA to nationally manage programmed, unprogrammed, and emergency telecommunications network requirements for the NAS.	$9.90	$63.00	FY 89	FY 05	N/A	N/A
Recovery Communications (RCOM) - Command and Control Communications (C3): Provides FAA with the minimum command-and-control communications capability necessary to direct the management, operation, and reconstruction of the NAS during regional or local emergencies when normal common carrier communications are interrupted. C3 also provides minimum capabilities for continuity of operations for FAA.	$6.30	$51.10	FY 92	Beyond FY 09	June 2003	N/A
Aeronautical Data Link (ADL) - Flight Information Service (FIS): Provides data link broadcasts of graphic and text flight information service data to the cockpit that are consistent with information available to air traffic controllers and flight service specialists in the NAS.	$3.30	$8.50	FY 99	FY 08	June 2000	N/A
Tower Data Link Services (TDLS): Displays the clearances received from Air Route Traffic Control Centers (ARTCC) to the tower, distributes flight plan data, weather information, and general information messages from the ARTCC National Airspace Center computer to ARTCC printers and Air Traffic Control Towers (ATCT) remote sites. In addition, the system displays weather information received via ATCT weather interface.	$2.30	$10.80	FY 00	FY 05	Tech refresh start May 2002	N/A

(Continued From Previous Page)

Dollars in millions

Program/ system description	Appropriated funding for 1st year	Appropriated funding through FY 04	1st year funded	Last year funding planned	1st initial operating capability/ operational readiness date	Last initial operating capability/ operational readiness date
Voice Recorder Replacement Program (VRRP): Replaces a total of 530 aging analog systems with modern digital systems that will reduce both life-cycle maintenance costs and maintenance staffing requirements.	$3.60	$24.80	FY 97	Beyond FY 09	January 1996	N/A
Houston Area Air Traffic System (HAATS): Provides the focal point and support for infrastructure, national airspace improvements, and implementation of the new procedures and airspace design for the Houston area.	$12.00	$52.10	FY 01	FY 08	N/A	N/A
Instrument Landing Systems (ILS):[c] Provides precision guidance (horizontal, vertical, and distance) information to allow category I, II, and III landing approaches at large and medium airports.	$5.70	$455.30	FY 89	Beyond FY 09	April 1995, February 2007	N/A
Visual Navaids for New Qualifiers: Procures and installs visual navigational aids approach lighting systems to enhance landing capabilities at designated airports throughout the United States.	$9.80	$40.90	FY 93	Beyond FY 09	June 2006	N/A
Approach Lighting System Improvement (ALSIP) Continuation: Retrofits rigid lighting systems with lightweight and low-impact resistant structures that collapse or break apart at impact, thereby reducing damage to aircraft that may strike these structures during departure or landing.	$5.80	$183.20	FY 93	Beyond FY 09	September 1996	N/A
Visual Navaids-Sustain, Replace, Relocate: Replaces aging, obsolete visual navigational aids and other ground-based navigation and landing aids to maintain current en route, approach, and landing capabilities at various airports throughout the United States.	$3.00	$6.00	FY 02	Beyond FY 09	N/A	N/A

(Continued From Previous Page)

Dollars in millions

Program/ system description	Appropriated funding for 1st year	Appropriated funding through FY 04	1st year funded	Last year funding planned	1st initial operating capability/ operational readiness date	Last initial operating capability/ operational readiness date
Very High Frequency Omni-directional Range (VOR) Collocated with Tactical Air Navigation (VORTAC): Replaces, relocates, or converts VORTAC facilities used for aerial navigation. General aviation, commercial carriers, and other groups use this navigation capability for en route navigation and approach operations into airports.	$1.60	$27.00	FY 93	Beyond FY 09	NA	N/A
Runway Visual Range (RVR) - Replacement/Establishment: Replaces aging, maintenance-intensive, and difficult-to-support RVR legacy systems. Pilots receive critical meteorological visibility data that are used to decide whether it is safe to take off or land when visibility is limited.	$2.80	$42.50	FY 98	Beyond FY 09	N/A	N/A
Sustain Distance Measuring Equipment (DME): Replaces older DME, which is difficult and expensive to maintain because replacement parts are largely unavailable, and provides current technology electronics to improve operations and facilities performance.	$1.20	$13.90	FY 99	Beyond FY 09	August 2003	N/A
Long Range Radars (LRR) Improvements - Infrastructure Upgrades: Sustains and improves LRRs, many of which are over 50 years old, and require upgrades to prevent outages and reduce maintenance costs.	$1.00	$20.20	FY 00	FY 09	N/A	N/A
Runway Incursion Reduction Program (RIRP) - ATDP: Provides research, development, and operational evaluation of technologies to improve runway safety.	$1.40	$35.40	FY 99	Beyond FY 09	N/A	N/A

(Continued From Previous Page)

Dollars in millions

Program/ system description	Appropriated funding for 1st year	Appropriated funding through FY 04	1st year funded	Last year funding planned	1st initial operating capability/ operational readiness date	Last initial operating capability/ operational readiness date
Automatic Dependent Surveillance-Broadcast (ADS-B): Broadcasts derived aircraft position data from an onboard navigation system such as global navigation satellite system thereby allowing pilots and air traffic controllers to "see" location of nearby aircraft and engage in collaborative decisionmaking.	$3.50	$14.30	FY 99	FY 09	N/A	N/A
Next Generation Weather Radar (NEXRAD) Open Systems Upgrades: Detects, processes, distributes, and displays hazardous and routine weather information on air traffic controller consoles.	$2.00	$32.90	FY 98	FY 06	February 2000	N/A
Terminal Doppler Weather Radar (TDWR) – Service Life Extension Program (SLEP): Maintains the current level of service until 2020 and improves deteriorating system reliability. The service provides air traffic controllers with reports of hazardous windshear and other severe weather in and near an airport's terminal approach and departure zone at higher-density airports with high occurrences of thunderstorms.	$3.30	$3.30	FY 03	FY 09	September 2004	N/A
Corridor Integrated Weather System (CIWS): Will improve airspace capacity during adverse weather in congested airspace. The key approach is to provide accurate and timely prediction of hazardous weather activity.	$5.00	$9.10	FY 02	Beyond FY 09	N/A	N/A

Source: GAO presentation of FAA data.

[a]Terminal Automation Modernization and Replacement program is intended to replace aging automation and display systems at the Nation's terminal air traffic control facilities.

[b]The VSCS tech refresh does not have a baseline; an investment analysis is pending.

[c]The April 1995 operational readiness data (ORD) is under the original contract, while the new contract will be in effect in fiscal year 2006. Additional systems added in appropriations may affect the last ORD.

Objectives, Scope, and Methodology

We examined (1) FAA's experience in meeting cost, schedule, and/or performance targets for major system acquisitions under its ATC modernization program, (2) the steps FAA has taken to address long-standing challenges with the ATC modernization program and additional steps that are needed, and (3) the potential effects of the constrained budget environment on FAA's ability to modernize the ATC system.

To address the first objective, we selected 16 of the 55 system acquisitions in the ATC modernization program to review in detail.[1] We selected these 16 systems in July 2004, when this review was still a part of our broader work on FAA's efforts to modernize the National Airspace System (NAS).[2] Specifically, we selected the 16 ATC system acquisitions with the largest life-cycle costs that met the following criteria: each system had cost, schedule, and/or performance targets, was discussed in our prior and Department of Transportation Inspector General reports, had not been fully implemented or deployed by 2004, and received funding in 2004. We reviewed this list with FAA officials to ensure that we did not exclude any significant system.[3] (See app. I for additional information on these 16 systems.) FAA does not have a formal definition of major systems under its Acquisition Management System; however, agency officials told us that if a system acquisition has a formally approved baseline, we could consider it "major." Using this definition, we determined that 25 of the 55 system acquisitions under the ATC modernization program are major. The remaining 30 system acquisitions are generally what FAA refers to as buy-it-by-the-pound systems that are commercially available and ready to use without modification, such as those to replace a system that has reached the end of its useful life.

For fiscal year 2005, the 55 systems accounted for about 55 percent of FAA's facilities and equipment (F&E) budget, or $1.38 billion of the $2.52 billion appropriated for the F&E budget. The 16 major systems accounted for 36 percent ($917.3 million), and the other 39 system acquisitions accounted for about 19 percent ($460 million). The remaining 45 percent of

[1]According to FAA officials, the number of system acquisitions in the ATC modernization program can vary annually, when Congress earmarks funds for a specific system acquisition. As of March 2005, the number of system acquisitions under the program was 55.

[2]Our review of FAA's NAS modernization efforts will be issued later this year.

[3]To make the report as current as possible, we have used fiscal year 2005 funding levels where appropriate, including the status sheets for each of the 16 systems in appendix I.

the F&E budget will be spent on facilities, mission support, and personnel-related activities ($1.14 billion).

To assess the 16 major system acquisitions, we relied largely on data collected from FAA and contracting officials for two engagements we issued in November 2004 on FAA's acquisition and certification processes.[4] In turn, we updated this information and collected data on the remaining 39 systems under the modernization program, primarily through interviews with FAA officials and analyses of the data they provided, including key acquisition documents. (See app. II for additional information on these 39 system acquisitions.) In addition, we reviewed our past reports and those of the Department of Transportation's Inspector General. Furthermore, we interviewed FAA officials within the recently created ATO and collected and analyzed the documents they provided. We also interviewed officials with the Aircraft Owners and Pilots Association, Air Transport Association, Department of Defense, National Air Traffic Controllers Association, and RTCA.[5] Furthermore, we convened a panel of international aviation experts[6] to obtain their views on, among other things, the factors that have affected the cost, schedule, and/or performance of FAA's ATC modernization program.

In addition, we assessed the reliability of FAA's cost and schedule estimates. Through interviews with FAA officials about their data system and quality controls, we determined that the cost and schedule estimates were appropriate for use in our report. Specifically, the estimates are sufficiently authoritative, appropriate, and reliable to allow us to use them without conducting any further assessment. The estimates appear to be based on reasonable assumptions. Our review did not focus on FAA's efforts to modernize its facilities.

[4]GAO, *Air Traffic Control: FAA Needs to Ensure Better Coordination When Approving Air Traffic Control Systems*, GAO-05-11 (Washington, D.C.: Nov. 17, 2004); GAO, *Air Traffic Control: FAA's Acquisition Management Has Improved, but Policies and Oversight Need Strengthening to Help Ensure Results*, GAO-05-23 (Washington, D.C.: Nov. 12, 2004).

[5]Organized in 1935 and once called the Radio Technical Commission for Aeronautics, RTCA is today known just by its acronym. RTCA is a private, not-for-profit corporation that develops consensus-based performance standards for ATC systems. RTCA serves as a federal advisory committee, and its recommendations are the basis for a number of FAA's policy, program, and regulatory decisions.

[6]GAO, *Experts' Views on Improving the U.S. Air Traffic Control Modernization Program*, GAO-05-333SP (Washington, D.C.: April 2005).

To address the second objective, we interviewed FAA officials, primarily within the recently created ATO, and collected and analyzed the documents they provided. We also interviewed officials with the Aircraft Owners and Pilots Association, Air Transport Association, Department of Defense, National Air Traffic Controllers Association, and RTCA.

We also reviewed past GAO reports and those of the Department of Transportation's Inspector General. In addition, we obtained the views of the international aviation experts who participated in our panel on what steps the ATO could take in the short term to address the factors that have affected the cost, schedule, and/or performance of FAA's ATC modernization program.

To address the third objective, we interviewed officials within FAA's ATO and obtained and analyzed data on FAA's capital investments and annual budgets. We also interviewed officials with other organizations cited above. In addition, we obtained the views of the international aviation panelists on how federal budget constraints have affected ATC modernization and what steps the ATO could take in the short term to address these constraints. We conducted our review from November 2004 through May 2005 in accordance with generally accepted government auditing standards.

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