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Report to Congressional Requesters

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AIR TRAFFIC CONTROL

Status of FAA's Modernization Program

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Congressional Requesters

In late 1981, the Federal Aviation Administration (FAA) began a modernization program to replace and upgrade the National Airspace System's (NAS) equipment and facilities to meet the expected increase in traffic volume, enhance the margin of air safety, and increase the efficiency of the air traffic control system—the principal component of the NAS. Historically, the modernization program has experienced many problems in meeting cost, schedule, and performance goals. As a result, many of the promised benefits from using new equipment have been delayed, and the aviation community's confidence in FAA's ability to manage the modernization program has been weakened. Because of the complexity, cost, and problem-plagued past of FAA's modernization program, we designated it a high-risk information technology initiative in 1995 and again in 1997.[1]

In light of past problems and continuing concerns about key projects being funded under this program, you asked us to provide current information on the status of the modernization program. As agreed with your offices, this report provides information on the (1) status of the overall modernization program, including its cost; (2) status of 18 key modernization projects; and (3) challenges facing the overall modernization program. (See app. I for specific information on these 18 projects. A listing of projects completed from 1983 through August 1998 is included in app. II.)

Results in Brief

Over the past year, FAA, in collaboration with the aviation community, has taken steps to restructure its multibillion-dollar modernization program in order to achieve a more gradual and cost-effective approach by, among other actions, limiting the scope of projects to more manageable segments. This contrasts with the approach of the past, where the agency sought to develop highly complex software-intensive systems all at once and often established unrealistic cost, schedule, and performance goals. Under FAA's new incremental approach, the agency plans to implement a new way of managing air traffic, known as "free flight," in order to provide immediate

[1]FAA's modernization program is one of four high-risk system development and modernization efforts. See High-Risk Series: An Overview (GAO/HR-95-1, Feb. 1995) and High-Risk Series: Information Management and Technology (GAO/HR-97-9, Feb. 1997).

improvements for the system's safety, efficiency, and capacity.[2] Under its most recent financial plan, FAA estimates that the total cost of modernization will be nearly $42 billion from fiscal year 1982 through fiscal 2004—a $3.8 billion increase since the agency's last financial plan in February 1998.[3,4] This increase in planned spending (1) is attributed to new funding levels that were provided by the Office of Management and Budget and (2) allows for the acceleration of the NAS' modernization. Through fiscal year 1998, the Congress appropriated over $25 billion of the $42 billion for modernization (funded through FAA's Facilities and Equipment account), and FAA's latest financial plan indicates that $17 billion will be needed from fiscal year 1999 through fiscal 2004.

We have identified 18 projects that are key to FAA's efforts to replace NAS' aging infrastructure and that provide a platform for improving the system's safety, efficiency, and/or capacity. Total estimated Facilities and Equipment funding for each of these projects exceeds $100 million, and, collectively, these projects account for about 41 percent of the Facilities and Equipment funds requested for fiscal year 1999. FAA's progress in meeting cost and schedule goals for these 18 key projects has been mixed. Under FAA's new phased approach to modernization, two projects in our review—Aeronautical Data Link and Air Traffic Management—have been revised, resulting in new cost and schedule estimates for those components that are planned for implementation under free flight. Including these two projects, approximately two-thirds of the 18 projects are operating within cost and schedule estimates. Of the remaining projects, several have incurred cost increases and delays due, in part, to changes in requirements, difficulties in developing software, and changes designed to allow human operators to work better with new computer systems. However, despite the delays with some projects, FAA has fielded new air traffic control equipment. For example, since 1996, FAA has commissioned 38 of 43 planned Air Route Surveillance Radar-4s.[5,6] Additionally, since early 1997, FAA has commissioned 238 Automated

[2]Under "free flight," FAA will begin implementing new technologies and procedures that will allow the agency to move to a more collaborative system of managing traffic under which pilots, within limits, will be allowed to choose routes to save them time and money.

[3]FAA's financial plan, which is based on the national airspace architecture—FAA's blueprint for defining the long-range needs of the NAS—takes into account the funding required for the service life of a project, including the amounts needed for upgrades (refreshments) to technology. Previously, these amounts were not included in the financial plan.

[4]Estimated costs may not add because of rounding.

[5]The term "commissioned" is defined as the formal approval of the equipment for operational use.

[6]The Air Route Surveillance Radar provides data on the movement of aircraft and weather and is used for the separation of aircraft, drug interdiction, and defense of the U.S. borders.

Surface Observing Systems at new sites, bringing the total commissioned systems to 371 out of 597.[7]

While FAA has taken action to address some of its long-standing problems, the agency still faces many challenges in effectively managing its multibillion-dollar investment in modernization:

- FAA's internal evaluations and our reviews have identified shortcomings in FAA's current process used to manage its investments in validating and prioritizing mission needs analyses, in establishing and monitoring baseline measurements for all projects, and in communicating and coordinating among cross-functional teams. Improvements in these areas, among others, will help ensure that FAA (1) selects those investments that best meet its mission needs; (2) monitors all investments using accurate and reliable cost, schedule, and other performance data; (3) evaluates investment projects after they are implemented to measure outcomes and incorporate lessons learned to improve its decision-making for new investment projects; and (4) facilitates effective partnerships among teams responsible for acquisitions.
- While FAA has begun to address some of the root causes of long-standing modernization problems that hinder its achievement of desired mission goals, these efforts are not yet complete. For example, we found that FAA lacked reliable cost-estimating processes and cost-accounting practices needed to effectively manage investments in information technology, leaving it at risk of making ill-informed decisions on critical and costly air traffic control systems.[8] FAA has begun to improve its cost-estimating practices and to acquire a cost-accounting system, but these efforts are not complete. We have also identified problems with the agency's systems architecture, software acquisition processes, and organizational culture among those responsible for acquisitions. FAA has actions under way to implement our recommendations in all of these areas.
- FAA has more work to do to ensure that its mission-critical air traffic control systems will work through the year 2000 date change and to determine how it will ensure the continuity of critical operations in the event of some systems' failures when January 1, 2000, arrives. While FAA has completed critical steps in identifying which systems need to be fixed and repairing them, it must still test many of its mission-critical systems and implement needed fixes. Also, the agency still needs to resolve a

[7]The Automated Surface Observing System equipment automates the observation and dissemination of selected weather data.

[8]See Air Traffic Control: Improved Cost Information Needed to Make Billion Dollar Modernization Investment Decisions (GAO/AIMD-97-20, Jan. 22, 1997).

number of cross-cutting risks that threaten aviation operations, such as risks associated with exchanges of data with external partners—including airports and airlines—that are integral to managing air traffic operations.

- FAA also has weaknesses in its computer security that will require action to ensure that air traffic control systems on which it depends are sufficiently resistant to intrusion. Disruptions to the nation's air traffic control system could result if these systems are not adequately protected. We identified shortcomings in four areas: physical security of air traffic control facilities, operational system security, the security of future air traffic control systems, and management structure and security policy implementation. We recommended that FAA build detailed security requirements into its design of future air traffic control systems and that the agency enforce computer security policy. The agency has acknowledged weaknesses but has not yet formulated a plan to strengthen security.

Background

FAA's mission is to promote the safe, orderly, and expeditious flow of air traffic in the national airspace. To accomplish its mission, FAA provides air traffic control services 24 hours a day, 365 days a year. The air traffic control system, which is the principal component of the NAS, comprises a vast network of radars; automated data processing, navigation, and communications equipment; and air traffic control facilities.

Through its modernization program, FAA is upgrading and replacing equipment and facilities—such as controller workstations and airport towers—and developing new technologies—such as digital communications—to help improve the safety, efficiency, and capacity of the NAS. FAA's air traffic services are provided primarily through four service areas—air traffic control towers, terminal-area facilities, en route centers, and flight service stations. The functions of each type of service area are described below.

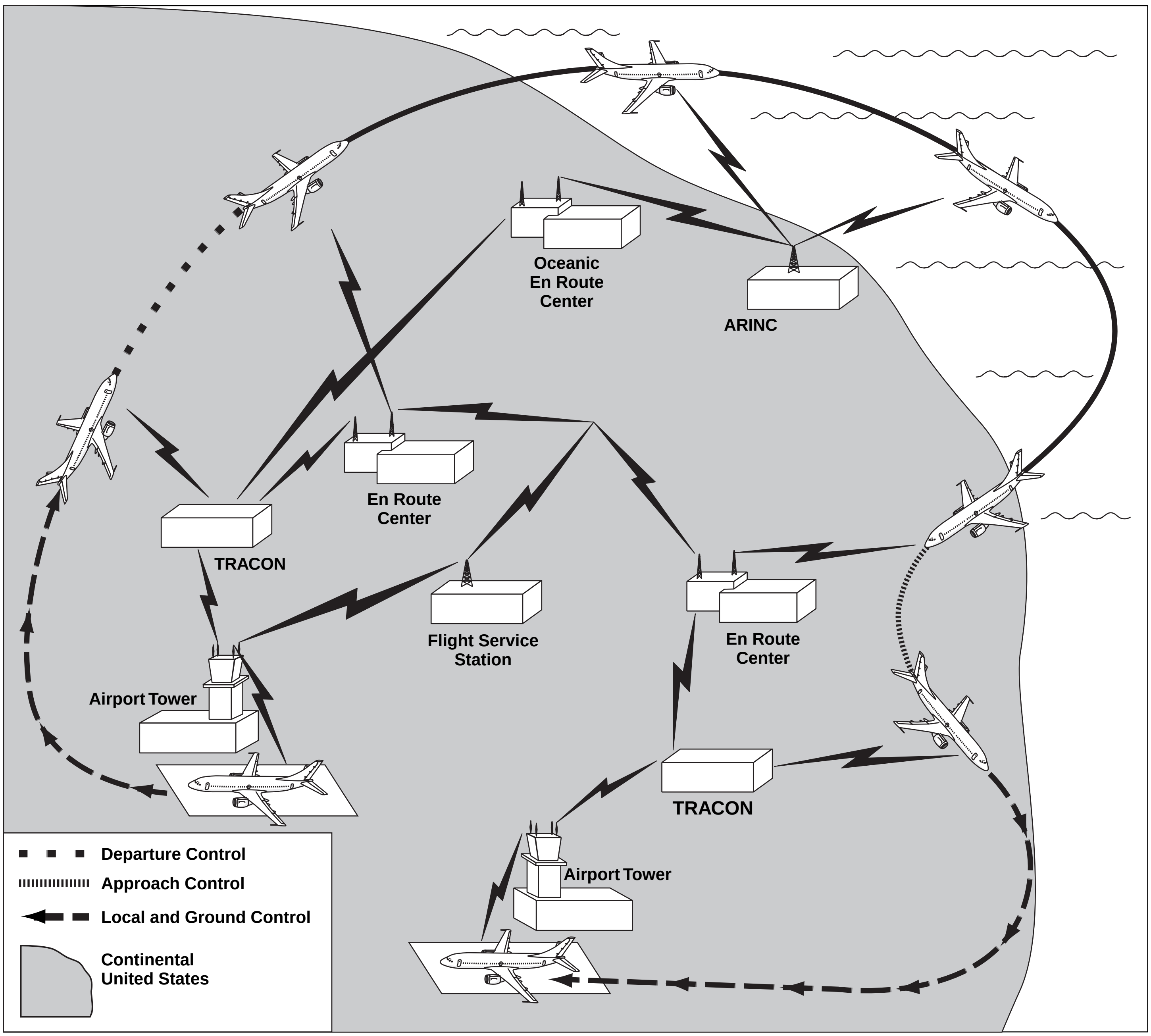
- Airport towers control the flow of aircraft—before landing, on the ground, and after takeoff—within 5 nautical miles of the airport and up to 3,000 feet above the airport.
- Terminal area facilities—known as Terminal Radar Approach Control (TRACON) facilities—direct aircraft in the airspace that extends from the point where the tower's control ends to about 50 nautical miles from the airport. A TRACON can be located at or outside an airport.
- En route centers—known as air route traffic control centers—control aircraft in air routes outside of terminal airspace. Planes are controlled through regions of airspace by en route centers responsible for the

regions. Control is passed from one center to another as a plane moves across a region until it reaches terminal airspace. Two en route centers—Oakland and New York—also control aircraft over the ocean. Because radar coverage over the ocean is limited, beyond the radars' sight, controllers must rely on periodic radio communications through a third party—Aeronautical Radio Incorporated (ARINC), a private organization funded by the airlines and FAA to operate radio stations—to determine aircraft locations.

- Flight Service Stations provide weather and flight plan services primarily for general aviation pilots.

(See fig. 1 for a visual summary of air traffic control over the continental United States and oceans.)

Figure 1: Summary of Air Traffic Control Over the Continental United States and Oceans



The 18 key modernization projects will help upgrade the air traffic services provided through one or more of the four service areas that FAA uses. Table 1 depicts the air traffic service areas that will be modernized by these projects. (App. I describes the functions of each of these projects.)

Table 1: Air Traffic Services That Will Be Modernized by 18 Major Air Traffic Control Projects

	Service areas			
Project's title	Tower	Terminal	En route center	Flight service station
Aeronautical Data Link	X	X	X	
Air Route Surveillance Radar-4			X	
Airport Surface Detection Equipment-3	X			
Air Traffic Control Beacon Interrogator			X	
Air Traffic Management/Free Flight Phase 1 Program		X	X	
Automated Surface Observing System	X		X	X
Display System Replacement			X	
Global Positioning System Program: Wide Area Augmentation System	X	X	X	
Global Positioning System Program: Local Area Augmentation System	X	X		
Host and Oceanic Computer System Replacement Program			X	
Integrated Terminal Weather System	X	X		
Oceanic Automation Program			X	X
Operational and Supportability Implementation System				X
Standard Terminal Automation Replacement System		X		
Terminal Digitization, Replacement, and Establishment Program/Airport Surveillance Radar-11 Project		X		
Terminal Doppler Weather Radar	X	X		
Voice Switching and Control System			X	
Weather and Radar Processor			X	

Note: "X" denotes service areas where projects are utilized.

Overall Status of Modernization Program

The NAS modernization program has undergone many changes since it was established in 1981. Initially, the program comprised only about 80 projects, but in December 1990, it was redefined and expanded as the Capital Investment Plan (hereafter, referred to as the financial plan). Over the past year, FAA and industry have worked together to develop a new approach to managing the program, which now includes 124 active projects funded through FAA's Facilities and Equipment appropriation account. Eighty-nine projects have been completed since the modernization program began.

FAA and Industry Have Agreed to a Phased Approach to Modernization

Over the past year, FAA and industry, working through the RTCA,[9] have agreed on a phased approach to modernizing the NAS—including a new way of managing air traffic, known as "free flight."[10] A central tenet of this approach is the "build a little, test a little" concept of technology development and deployment—intended to limit development efforts to a manageable scope, identify and mitigate risks, and deploy technologies prior to their full maturity so they can provide immediate improvements to the system's safety, efficiency, and/or capacity. This approach contrasts with the former approach, where FAA sought to build highly complex systems, many of which required the extensive development of software. In several cases, FAA underestimated the technical complexity of the development efforts, and, as a result, the systems were more costly and took longer to develop than anticipated.

Under the first phase of the modernization program, FAA plans to accelerate the development and deployment of certain technology projects that have the potential to provide immediate benefits to users.[11] Additionally, the agency plans to continue to develop and deploy critical infrastructure replacement projects like the Standard Terminal Automation Replacement System and Display System Replacement, which provide new workstations and functionality to controllers in terminal and en route centers, respectively. Furthermore, other modernization projects, particularly those related to communication, navigation, and surveillance, will be tested under the agency's planned demonstration program.[12]

[9]RTCA serves in an advisory capacity to FAA. It was organized as the Radio Technical Commission for Aeronautics in 1935 to provide a forum where industry and government representatives could discuss aviation issues and develop consensus-based recommendations. In November 1991, it reorganized and shortened its name to RTCA.

[10]In September, we issued a report on the status of FAA's efforts to implement free flight and the challenges that lie ahead. See National Airspace System: FAA Has Implemented Some Initiatives, but Challenges Remain (GAO/RCED-98-246, Sept. 28, 1998).

[11]Under this phase, FAA would implement new technologies and procedures to allow the agency to gradually move to a "free flight" operating system, where decisions for conducting flight operations would be based increasingly on the collaborative efforts of FAA and users. Components of two projects in our review—Aeronautical Data Link and Air Traffic Management—are a part of the agency's free flight effort.

[12]FAA has proposed to change the name of the demonstration from Flight 2000 to "Safe Flight 21."

Total Cost of Modernization Through Fiscal Year 2004 Is Estimated to Be $42 Billion

FAA, in its current financial plan, dated July 1998, estimated that the cost of the modernization program for fiscal years 1982 through 2004 will total nearly $42 billion—a $3.8 billion increase over the estimate included in the February 1998 plan.[13] Of the estimated $42 billion required, the Congress appropriated over $25 billion for fiscal years 1982 through 1998. Of this amount, FAA has reported spending $5.7 billion on 89 completed projects and $15.2 billion on 124 ongoing projects. Of the remaining amount, FAA has reported spending about $2.8 billion on projects that have been canceled or restructured and $1.6 billion for personnel-related expenses associated with the acquisition of systems. The financial plan estimates that approximately $17 billion will be required for fiscal years 1999 through 2004.

The $3.8 billion increase in the estimated cost of modernization since February 1998 results from new spending levels provided by the Office of Management and Budget for accelerating the NAS' modernization. This consists of $1.9 billion for existing projects to allow for acceleration, new approaches (Free Flight Phase 1), and cost growth. The remaining $1.9 billion increase results from the addition of new projects identified in the architecture that could not be accommodated under the old funding levels.

Cost, Schedule, and Risks Associated With 18 Major Projects

The 18 projects represent the agency's priority projects in the areas of communication, navigation and landing, surveillance, automation, and weather. Total estimated spending for each of these projects exceeds $100 million, and, collectively, they represent about 41 percent of the Facilities and Equipment funding requested for fiscal year 1999. FAA's progress in meeting cost and schedule goals for these 18 projects has been mixed. Under FAA's new phased approach to modernization, two projects in our review—Aeronautical Data Link and Air Traffic Management—have been revised, resulting in new cost and schedule estimates for those components that are planned for implementation under free flight. Including these two projects, approximately two-thirds are meeting cost and schedule estimates, while several of the remaining projects have incurred cost increases and delays due, in part, to changes in

[13]For the purposes of this report, the "cost of modernization" means all actual and projected Facilities and Equipment appropriations from fiscal year 1982 through fiscal 2004 for projects in FAA's financial plan. This plan contains funding primarily for projects, including prime contract costs; costs for personnel compensation, benefits, and travel; and contract costs for technical support service activities. The plan also includes estimated future costs for some projects that have not yet been funded but are part of the NAS architecture.

requirements, difficulties in developing software, and changes designed to allow human operators to work better with new computer systems.

The net estimated Facilities and Equipment cost of the 18 major modernization projects has increased by $482 million since the original estimate was made.[14] This includes an increase of about $530 million for six of these projects. Projects experiencing the largest increase—due primarily to new requirements for additional equipment and technical and siting problems—include the Airport Surveillance Radar-11, Automated Surface Observing System, and Terminal Doppler Weather Radar. The estimated cost for one project—Oceanic Automation Program—decreased by about $48 million, 10 projects showed no change, and 1 project's original estimate was too recent for comparison purposes. (See app. I.)

Schedules for completing implementation were delayed for 5 of the 18 projects. The delays ranged from 5 months to over 6 years.[15] For example, the date for implementing the last of the Airport Surface Detection Equipment-3 has slipped by over 3 years primarily because of delays in completing towers or other structures at locations that will receive the radars.[16] Of the remaining 13 projects, 9 had no schedule delays, the schedules for 2 were accelerated, and the original and current schedules for 2 could not be compared. For one of these projects, the original implementation date had not been established when the contract was signed. For the second project, the agency established the schedule in October 1998. As an example, the Display System Replacement project is still scheduled to be completely implemented by May 2000.[17] FAA accelerated the schedule for implementing the Oceanic Automation Program by 8 months when it canceled four of five planned phases and

[14]The original estimate, representing when the investment decision was made or the contract was signed—whichever is relevant—was compared with the 1998 estimate to determine changes in costs. The date of this estimate varies among projects.

[15]Implementation signifies that a system has been fielded and that the personnel who will use and maintain it are satisfied that it is ready for operation. Usually, commissioning soon follows implementation. "Last-site implementation" is the date when the last planned unit is scheduled to become operational.

[16]The Airport Surface Detection Equipment-3 is a primary radar designed to provide tower controllers with surveillance information—a video display—of all aircraft and other vehicles on an airport's surface.

[17]The Display System Replacement project will modernize en route center equipment by replacing 20- to 30-year-old display channels, controller workstations, and network infrastructure.

significantly reduced the requirements for the one remaining phase.[18] (See app. I.)

However, despite delays with some projects, FAA has fielded new air traffic control equipment. For example, since 1996, FAA has commissioned 38 of 43 planned Air Route Surveillance Radar-4s. Additionally, since early 1997, FAA has commissioned 238 Automated Surface Observing Systems at new sites, bringing the total commissioned systems to 371 out of 597.

Several of the 18 projects face challenges and risks that could lead to further cost increases and delays. For example, the Wide Area Augmentation System was initially designed to serve as the only means of navigation for civil aviation, thus allowing FAA to decommission its existing, costly ground-based navigation system. However, the future of the project is uncertain because of vulnerability concerns—related to both intentional and unintentional interference with the satellite signal—and congressional concerns about whether FAA's program, as currently planned, is cost-effective.[19] FAA is revisiting the program's cost, schedule, and performance baselines and will incorporate the results of the vulnerability assessment, expected in January 1999, into its analyses.[20]

FAA Faces Challenges in Managing This Multibillion-Dollar Investment

Long-standing problems, including cost increases in the overall modernization program and in many of the individual projects as well as difficulty in meeting project schedules, demonstrate the difficulty of managing an investment of this size. Although FAA is taking actions to address many of these problems, the agency faces several challenges in seeking to improve its management of the modernization program in order to deliver promised benefits and thereby restore its credibility. Included among these challenges is FAA's need to (1) implement an effective process for selecting, controlling, and evaluating its air traffic control investments; (2) sustain its commitment to addressing the root causes of its modernization problems; (3) address the Year 2000 problem; and (4) correct its computer security weaknesses.

[18]The Oceanic Automation Program project is designed to provide a platform for improving air traffic control over the oceans where radar coverage is limited. Among other capabilities, the one segment that FAA is implementing will provide pilots and controllers with data link technology.

[19]Department of Transportation and Related Agencies Appropriations Act for 1999 (P.L. 105-277, Division A, sec. 101 (g)(1998)).

[20]FAA, the Air Transport Association, and the Aircraft Owners and Pilots Association have initiated a risk assessment of using satellite navigation as the only means of navigation in the NAS.

Managing Modernization Requires a Disciplined Investment Management Process

Recent federal management reforms have introduced requirements emphasizing federal agencies' need to significantly improve their management processes for selecting, monitoring, and evaluating investments.[21] Our reviews and FAA's internal evaluation of its acquisition management system identified shortcomings in two of these areas: mission analyses (selection) and baseline management (monitoring).[22,23] FAA's and our work also identified problems with FAA's cross-functional team structure, which is key to successfully acquiring new modernization systems and technology. It is critical that FAA has processes in place to help ensure that its modernization projects are being implemented at acceptable costs, within reasonable and expected time frames, and are contributing to observable improvements in mission performance. FAA's acquisition management system, implemented on April 1, 1996, is intended to provide high-level acquisition policy and guidance and to establish rigorous investment management practices to guide modernization efforts. We are currently reviewing FAA's investment management approach as carried out through its acquisition management system.

First, the mission analysis process is intended to enable FAA to determine and prioritize its most critical capability shortfalls and its best technological opportunities for improving the safety, security, capacity, and efficiency of the NAS. FAA's internal evaluation identified major shortcomings relating to validating and prioritizing all critical needs, evaluating mission needs statements to ensure that needs were still valid, implementing the mission analysis process across the entire agency, and coordinating the mission analysis process among internal organizations. As a result of these shortcomings, FAA's evaluation team found that the agency cannot ensure that some of its most critical needs are being met, that it is not duplicating efforts in identifying mission needs, and that resources are being used in the most cost-effective manner.

Addressing shortcomings in mission analysis capabilities, among other areas, would put FAA in a better position to effectively plan for its needs and avoid crisis situations that result from inadequate planning. At least two such situations arose during fiscal year 1998. FAA reprogrammed $37.7 million to cover expenses associated with activities aimed at

[21]Included among these legislative reforms are revisions to the Paperwork Reduction Act, the Government Performance and Results Act, and the Chief Financial Officers Act.

[22]See Air Traffic Control: Observations on FAA's Modernization Program (GAO/T-RCED/AIMD-98-93, Feb. 26, 1998).

[23]Evaluation of Acquisition Reform—The First Two Years: April 1996-March 1998, FAA Program Evaluation Branch, Office of Systems Architecture and Investment Analysis, May 29, 1998.

ensuring that the agency's critical air traffic control-related computer systems will function properly at the turn of the century (Year 2000 computer problem). Although FAA recognized the Year 2000 initiative as a critical need and began addressing it, the agency did not document the need in a mission needs statement. The discipline associated with mission analysis—identifying the shortfall, the impact of not satisfying the shortfall, and an estimate of the resources the agency should commit to resolve the need—might have eliminated the need to reprogram funds to meet this priority. Additionally, the agency reprogrammed $28.9 million for additional requirements for its new automation system for terminal controllers. Included in this amount were funds to implement solutions to address design concerns identified by human operators of the system. As a result of the reprogramming, the schedule for some projects may have to be pushed out several years, increasing the likelihood that costs for these projects will also increase.

Second, in the area of baseline management, the acquisition management system requires that each program has a baseline, which establishes performance, cost, schedule, and benefits parameters within which the program is authorized to operate. These baselines assist managers in monitoring the performance of projects. FAA's internal evaluation identified numerous shortcomings in baseline management, including the fact that only 54 percent of the 94 programs funded by the Facilities and Equipment account had some form of approved baseline documentation.[24] Furthermore, the approved baselines did not always include enough information to measure and monitor the program's performance. For example, while documentation related to Facilities and Equipment funding for a project was usually complete, funding for research and development and operations was not always included in the baseline document. Even when operations data were included, questions existed about the reliability of these cost estimates. We found, as did the FAA evaluation team, that poor or inaccurate cost estimates could limit FAA's ability to make sound investment decisions about modernization projects on the basis of economic merits.[25] FAA has taken steps to improve its cost-estimating capabilities; these steps are not yet complete. In a related

[24]FAA's evaluation team also found that the agency had not established definitions for or designations of "program," "substantial acquisition program," and "major systems acquisition." Such definitions and designations are important because P.L. 104-264 (Air Traffic Management System Performance Improvement Act of 1996) requires the Administrator to consider terminating substantial acquisition programs that fail to meet defined goals. Office of Management and Budget circulars require designation and reporting on major systems acquisitions. FAA's team defined "program" for purposes of the evaluation and identified 94 programs that should have had an acquisition baseline.

[25]See GAO/AIMD-97-20.

area, an FAA official indicated that the agency has begun to baseline a number of projects. In this regard, future changes in cost and schedule estimates will be measured against these new baselines. Although the requirement for the Administrator to consider terminating a project that fails to meet defined goals applies only to acquisitions initiated after October 1996, this official indicated that the agency plans to subject its ongoing projects to these requirements. Completing efforts under way to improve cost-estimating capabilities and tracking and monitoring the performance of projects against approved baselines would be a step in the right direction as FAA seeks to improve its management of projects and avoid past problems associated with cost increases and delays.

Finally, the agency faces a continuing challenge in effectively implementing its cross-functional integrated product development team structure.[26] Our recent work relating to FAA's implementation of free flight initiatives found continuing problems with communication and coordination across program lines.[27] Some team members were motivated primarily by the priorities and management of the offices that they represented rather than the goals of a given team. FAA's internal evaluation findings were similar, in that conflicts between horizontal organizational structures (teams) and vertical organizational structures (operating divisions, such as air traffic) created a constraint to the team structure by, among other things, delaying decisions that could affect a team's ability to support successful acquisitions. As we noted in our September 1998 report, FAA is attempting to improve cross-agency communication and coordination through such initiatives as developing incentives for staff to work toward the agency's goals and priorities. Because FAA's successful implementation of the modernization program is tied to the effective partnership among offices responsible for various acquisition-related activities, it will be important for the agency to continue its efforts to forge effective partnerships.

[26]The integrated product development team structure was designed as the implementing arm for the acquisition management system. Integrated product teams are responsible for developing or procuring equipment. The goals of these teams are to improve accountability and coordination and infuse a more strategic, mission-oriented focus into the acquisition process. Team members include contractors, FAA's engineering division, and the FAA divisions that operate and maintain air traffic control equipment.

[27]These findings were consistent with earlier findings in our work on FAA's culture and how it affects acquisition management. See GAO/RCED-98-246 and Aviation Acquisition: A Comprehensive Strategy Is Needed for Cultural Change at FAA (GAO/RCED-96-159, Aug. 22, 1996).

Improving the Management of the Modernization Program Will Require Sustained Commitment to Address Root Causes

Our reviews have identified some of the root causes of long-standing problems that jeopardize the effective use of modernization resources. These problems included unreliable cost information, incomplete architecture, weak software acquisition capabilities, and an organizational culture that did not reflect a strong commitment to the agency's mission focus, accountability, coordination, and adaptability. FAA has ongoing actions under way to address these shortcomings.

In January 1997, we reported that FAA lacked reliable cost-estimating processes and cost-accounting practices needed to effectively manage investments in information technology, which leaves it at the risk of making ill-informed decisions on critical and costly air traffic control systems.[28] Without reliable cost information, the likelihood of poor investments is increased. We recommended that FAA improve its cost-estimating processes and fully implement a cost-accounting system. FAA has begun to institutionalize defined cost-estimating processes and to acquire a cost-accounting system as required by legislation. According to officials responsible for the new cost accounting system, the agency had planned to have the first phase of the system—accumulating data for domestic and oceanic air traffic services—operational by October 1998, but this milestone has been delayed by complications associated with the method used to allocate costs. These officials stated that it is too soon to tell how this delay may affect other planned milestones.

With respect to the new system, the Department of Transportation's Inspector General has identified design issues that call into question whether the planned cost-accounting system can accurately account for FAA's full cost of operations.[29] For example, among its major findings, the report noted that FAA had yet to establish a systematic method to identify and reflect the (1) cost for all development projects, (2) correct labor charged to appropriate projects, and (3) cost incurred by other agencies for air traffic services.[30] Additionally, decisions had not been made on how to allocate Facilities and Equipment costs among operating facilities

[28]GAO/AIMD-97-20.

[29]See Implementation of Cost Accounting System: Federal Aviation Administration, U.S. Department of Transportation, Office of Inspector General (Rpt. No. FE-1998-186, Aug. 10, 1998).

[30]The issue of allocating costs incurred by other agencies is relevant to a discussion of moving to a cost-based fee system. The Department of Defense provides military and civilian users with air traffic control services, and its costs may be relevant to determining user fees. However, for fiscal years 1998 and 1999, FAA is constrained by the Office of Management and Budget's guidance from recognizing air traffic service costs incurred by the Department of Defense. For a discussion of issues related to cost allocation, see National Airspace System: Issues in Allocating Costs for Air Traffic Services to DOD and Other Users (GAO/RCED-97-106, Apr. 25, 1997).

throughout FAA. According to a senior FAA finance official, the agency has made a change in program management and has assigned additional resources to the cost-accounting effort to address problems cited by the Inspector General's report. For example, FAA has developed and tested the capability to capture and report all of a project's developmental costs. In addition, with respect to decisions about how to allocate Facilities and Equipment costs among operating divisions, this official noted that FAA had new procedures for allocating property depreciation costs for fiscal year 1998. Taking steps to ensure that its cost-accounting system is complete—by correcting known design and allocation issues—will put FAA in a better position to provide managers and other decisionmakers with accurate information for use in determining and controlling the agency's costs.

In February 1997, we reported that FAA attempted to modernize the NAS without a complete systems architecture, or blueprint, to guide development and evolution.[31] The result has been unnecessarily higher spending to buy, integrate, and maintain hardware and software. We recommended that FAA develop and enforce a complete systems architecture and implement a management structure for doing so that is similar to the Chief Information Officers provision of the Clinger-Cohen Act of 1996. FAA has initiated activities to develop a complete systems architecture, and project officials estimated in May 1998 that it would take 18 to 24 months to complete the development. Also, FAA is in the process of hiring a Chief Information Officer that will report directly to the Administrator.

Furthermore, in March 1997, we reported that FAA's processes for acquiring software for air traffic control systems are ad hoc, sometimes chaotic, and not repeatable across projects.[32] As a result, FAA is at great risk of acquiring software that does not perform as intended and is not delivered on time and within budget. We recommended that FAA improve its software acquisition capabilities by establishing a mature acquisition process throughout its entire organization. While FAA has initiated efforts to improve its software acquisition process, these efforts have not been implemented agencywide.

[31] Air Traffic Control: Complete and Enforced Architecture Needed for FAA Systems Modernization (GAO/AIMD-97-30, Feb. 3, 1997).

[32] See Air Traffic Control: Immature Software Acquisition Processes Increase FAA System Acquisition Risks (GAO/AIMD-97-47, Mar. 21, 1997).

Finally, we have reported that an underlying cause of FAA's air traffic control acquisition problems is its organizational culture—the values, beliefs, attitudes, and expectations shared by an organization's members that affect their behavior and the behavior of the whole organization.[33] We found that FAA's acquisitions were impaired because employees acted in ways that did not reflect a strong commitment to mission focus, accountability, coordination, and adaptability. We recommended a comprehensive strategy for cultural change that (1) addresses specific responsibilities and performance measures for all stakeholders throughout FAA and (2) provides the incentives needed for promoting the desired behaviors to achieve cultural change.

In response to our recommendations, FAA issued a report outlining its overall strategy for changing its acquisition culture and describing its ongoing actions to influence organizational culture.[34] For example, the Acquisition and Research organization has restructured its personnel system to tie pay to performance based on achievement of organizational goals. The Administrator has approved the Acquisition and Research organization as the pilot for the new compensation program that FAA plans to implement agencywide. Additionally, the Acquisition and Research organization has developed an organizational assessment process that identifies culture-related factors that inhibit full achievement of organizational objectives. The centerpiece of this process is the Acquisition and Research organization's culture survey. The results of the 1998 survey showed that while employees are motivated in their current job and are pleased with the variety within and complexity of their job, a number of opportunities for improvement still exist. For example, the data showed that employees (1) do not believe that accurate information is disseminated downward to work groups or teams, (2) believe that decisionmakers are not able to anticipate problems before they occur, (3) feel that training is an area needing improvement, and (4) do not feel that they have a clear understanding of organizational and job-specific goals. While recognizing that cultural change is a complex and time-consuming undertaking, the Acquisition and Research organization's management team has developed a set of actions to begin addressing the shortcomings identified in the culture survey and is proceeding with other initiatives.

[33]GAO/RCED-96-159.

[34]Strategy for Acquisition Culture Change, FAA (June 1997).

Serious Challenges Remain Unresolved for Year 2000

To perform its mission, FAA is dependent on an extensive array of information-processing and communications technologies. Without these specialized systems, the agency cannot effectively control traffic or provide pilots and controllers with up-to-date weather information, among other functions. FAA has identified 225 mission-critical NAS systems.[35] Examples of such systems include the primary computer system used in en route centers (known as Host computer), which processes radar and other data, and the long-range radar systems, which allow controllers to monitor and separate aircraft at higher altitudes. The implications of FAA's not meeting the Year 2000 deadline are enormous and could affect hundreds of thousands of people—through customer inconvenience, increased airline costs, grounded or delayed flights, or degraded levels of safety. Although FAA has made progress in managing its Year 2000 problem and has completed critical steps in defining which systems need to be repaired and fixing them, the agency must still test many of its mission-critical systems and implement needed changes.

In August 1998, we reported that, with less than 17 months left before 2000, it was doubtful that FAA could do all of this in the time remaining.[36] Accordingly, FAA must determine how to ensure the continuity of critical operations in the event of some systems' failure. FAA is preparing a NAS continuity plan to ensure that critical operations continue, should its mission-critical systems fail. We are currently reviewing FAA's business continuity plan. Additionally, we noted that FAA must mitigate other critical, cross-cutting risks, such as data exchanges with external entities; international coordination to ensure safe, reliable aviation services for U.S. travelers; and cooperation with contractors to ensure that the telecommunications upon which FAA relies are dependable. FAA is taking steps to address all of these issues.

Weak Security Practices Degrade Safety

In May 1998, we reported that FAA cannot ensure that the air traffic control systems upon which it depends are sufficiently resistant to intrusion.[37] The failure to adequately protect these systems threatens to disrupt the nation's air traffic. We found weaknesses in four areas: physical security of air traffic control facilities, operational system security, the development

[35]These 225 systems are included among the 430 FAA-wide mission-critical systems.

[36]See FAA Systems: Serious Challenges Remain in Resolving Year 2000 and Computer Security Problems (GAO/T-AIMD-98-251, Aug. 6, 1998).

[37]See Air Traffic Control: Weak Computer Security Practices Jeopardize Flight Safety [unclassified version] (GAO/AIMD-98-155, May 18, 1998).

of new systems, and FAA's management structure and implementation of security policy.

First, FAA's management of physical security at its air traffic control facilities that control aircraft has been ineffective. We found that FAA had inspected some facilities and was aware of physical security weaknesses at these facilities but was unaware of weaknesses that might exist at other facilities because many had not been inspected. Since our review, FAA officials indicated that they have inspected all applicable facilities and have accredited over half (199 out of 368) of these facilities.

Second, FAA has not assessed, certified, or accredited most of its operational air traffic control systems as required by its policy.[38] As a result, FAA does not know how vulnerable those operational systems are and, consequently, has no basis for determining how to protect them. In addition, FAA has assessed only one of nine FAA-owned or -leased air traffic control telecommunications systems despite acknowledging that vulnerabilities in this area could threaten property and public safety. FAA's 1997 Telecommunications Strategic Plan continues to identify the security of telecommunications systems as an area in need of improvement.

Third, FAA is not effectively incorporating security features into new air traffic control systems. The agency does not consistently include well-formulated security requirements in specifications for all new modernization systems. Without security requirements that are based on sound risk assessments, FAA lacks assurance that future air traffic control systems will be protected from attack.

Finally, FAA's management structure is not effectively implementing or enforcing computer security policy. Security responsibilities are distributed among three different organizations, all of which have been remiss in their air traffic control security duties. Until existing computer security policy is effectively implemented and enforced, operational and developmental air traffic control systems will continue to be vulnerable to the compromise of sensitive information and interruption of critical services.

To improve security for the future in the most efficient and cost-effective manner, we recommended that FAA build detailed security requirements

[38]System certification is the technical evaluation that is conducted to verify that FAA's systems comply with FAA's security requirements, identify security deficiencies, specify remedies, and justify exceptions. Accreditation is the formal declaration from management that the appropriate security safeguards have been properly implemented and that residual risk is acceptable.

into its design for new air traffic control systems. We also recommended that FAA enforce its computer security policy for air traffic control. FAA has acknowledged that major improvements are needed in all areas of its computer security program but has not yet formulated a plan to strengthen security.

Agency Comments

We provided copies of a draft of this report to FAA for its review and comment. We met with FAA officials, including the Deputy Director, Program Office, Free Flight Phase 1, and the Program Director, NAS Programming and Financial Management, who generally agreed with the contents of the report and provided clarifying comments, which have been incorporated as appropriate.

Scope and Methodology

We reached agreement on the major projects to be included in our review after discussions with officials from the office of the Program Director, NAS Programming and Financial Management, within FAA's Associate Administrator for Research and Acquisition organization. We obtained the information on the overall costs of air traffic system modernization as well as on appropriations and obligations from documents provided by representatives of FAA's Research and Acquisition organization and the Office of Financial Services. Cost, schedule, and performance information on the 18 key projects came from project officials within the Research and Acquisition organization. We also obtained information from the Office of Independent Operational Test and Evaluation. We did not independently verify the accuracy of the cost data but did compare it with past cost data for consistency. We developed the list of challenges primarily from past reviews by us and others and from our knowledge of FAA's progress in implementing past recommendations. We conducted our review from July through October 1998 in accordance with generally accepted government auditing standards.

We are providing copies of this report to the Secretary of Transportation; the Administrator, FAA; and other interested parties. We will make copies available to others on request.

If you or your staff have any questions or need additional information, please call me at (202) 512-3650. Major contributors to this report are listed in appendix III.

Gerald L. Dillingham
Associate Director,
Transportation Issues

Congressional Requesters

The Honorable Richard C. Shelby
Chairman
The Honorable Frank R. Lautenberg
Ranking Minority Member
Subcommittee on Transportation
Committee on Appropriations
United States Senate

The Honorable Frank R. Wolf
Chairman
The Honorable Martin O. Sabo
Ranking Minority Member
Subcommittee on Transportation and
Related Agencies
Committee on Appropriations
House of Representatives

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Figures

Abbreviations

AMASS	Airport Movement Area Safety System
ARINC	Aeronautical Radio Incorporated
ARSR	Air Route Surveillance Radar
ARTS	Automated Radar Terminal System
ATCBI	Air Traffic Control Beacon Interrogator
ATM	Air Traffic Management
ASDE	Airport Surface Detection Equipment
ASOS	Automated Surface Observing System
ASR	Airport Surveillance Radar
AWOS	Automated Weather Observing System
CTAS	Center Terminal Radar Approach Control Automation System
DSR	Display System Replacement
FAA	Federal Aviation Administration
F&E	Facilities and Equipment
GAO	General Accounting Office
GPS	Global Positioning System
ITWS	Integrated Terminal Weather System
LAAS	Local Area Augmentation System
NAS	National Airspace System
NATCA	National Air Traffic Controllers Association
OASIS	Operational Supportability and Implementation System
STARS	Standard Terminal Automation Replacement System
TDWR	Terminal Doppler Weather Radar
TRACON	Terminal Radar Approach Control
TRDRE	Terminal Radar Digitization, Replacement, and Establishment
VHF	very high frequency
VSCS	Voice Switching and Control System
VTABS	VSCS Training and Backup Switch
WAAS	Wide Area Augmentation System
WARP	Weather and Radar Processor

Information on the Status of 18 Major Modernization Projects

This appendix provides detailed information on changes in the costs and schedules as well as challenges and risks for 18 of the Federal Aviation Administration's (FAA) major acquisitions. Collectively, these projects account for about 41 percent of the Facilities and Equipment (F&E) funding requested by FAA for fiscal year 1999.

In our past reports on the status of FAA's modernization program, we used cost and schedule estimates that were developed when the projects were approved for inclusion in the modernization plan.[1] Instead in February 1998, we began measuring FAA's progress against revised baselines that represent the date of the contract, the contract's revision, or the investment decision. This appendix uses this benchmark.[2] However, where relevant, we provide historical cost and schedule information in the project summaries to give a context for current developments.

On the basis of the revised baselines, the net estimated F&E cost of the 18 major modernization projects has increased by $482 million. Six of these projects increased by a total of about $530 million. Three projects experiencing the largest increase—due primarily to new requirements for additional equipment and technical and siting problems—include the Airport Surveillance Radar-11, Automated Surface Observing System, and Terminal Doppler Weather Radar. One project—the Oceanic Automation Program—decreased by about $48 million, 10 projects showed no change, and 1 had no basis for comparison because FAA recently established baselines for it. (See table I.1.)

[1]Since estimates for many projects were developed in the 1980s, FAA officials asserted that the dates in the early modernization plans did not represent a realistic baseline for measuring progress for a variety of reasons, including changes to requirements for a number of projects as well as to the number of systems being developed. As a result, these officials suggested that we measure progress against the contract date or the date of the investment decision.

[2]FAA officials informed us that they are currently baselining many of their older projects in accordance with acquisition management policy. According to these officials, this effort will facilitate the agency's ability to report major variances in the achievement of cost, schedule, and performance goals. (For the most part, FAA officials indicated that the new baseline will be the cost and schedule estimate as of 1998. As a result, in future years, the baselines that we report, on the basis of the criteria indicated above, may differ from those that FAA uses for external reporting).

Table I.1: Changes in Cost Estimates for 18 Major Modernization Projects

Dollars in millions

Project	Date of original F&E cost estimates	Original F&E cost estimates[a]	Current F&E cost estimates[a]	Change in F&E cost estimates	Original planned units	Current planned units	Change in units
Aeronautical Data Link Program: En Route Controller/Pilot Data Link Communications	1998	$163.7	$163.7	N/A[b]	22 units	22 units	N/A[b]
Air Route Surveillance Radar-4	1988	349.4	415.8	+66.4	43 radars	44 radars	+1
Airport Surface Detection Equipment-3	1993	191.0	249.1	+58.1	40 radars	40 radars	None
Air Traffic Control Beacon Interrogator	1998	282.8	282.8	None	127 systems	127 systems	None
Air Traffic Management Program: Center Terminal Radar Approach Control Automation System	1997	251.1	251.1	None	N/A[c]	N/A[d]	None
Automated Surface Observing System	1991	151.3	287.5	+136.2	537 units	597 units	+60
Display System Replacement	1994	1,055.3	1,055.3	None	22 systems	22 systems	None
Global Positioning System Augmentation Program: Wide Area Augmentation System	1998	1,006.6	1,006.6	None	[e]	[e]	[e]
Global Positioning System Augmentation Program: Local Area Augmentation System	1998	535.8	535.8	None	143 systems	143 systems	None
Host and Oceanic Computer System Replacement Program	1998	424.1	424.1	None	24 systems	24 systems	None
Integrated Terminal Weather System	1997	276.1	276.1	None	37 systems	37 systems	None
Oceanic Automation Program	1995	236.5	189.0	–47.5	3 systems	3 systems	None
Operational and Supportability Implementation System	1997	174.7	190.5	+15.8	64 systems	64 systems	None
Standard Terminal Automation Replacement System	1996	940.2	940.2	None	171 systems	173 systems	+2
Terminal Doppler Weather Radar	1988	322.2	393.5	+71.3	47 radars	47 radars	None

(continued)

Dollars in millions

Project	Date of original F&E cost estimates	Original F&E cost estimates[a]	Current F&E cost estimates[a]	Change in F&E cost estimates	Original planned units	Current planned units	Change in units
Terminal Radar Digitization, Replacement, and Establishment Program: Airport Surveillance Radar-11 Project	1996	561.3	743.3	+182.0[f]	48 radars	112 radars	+64
Voice Switching and Control System	1994	1,452.9	1,452.9	None	23 units	23 units	None
Weather and Radar Processor	1996	125.6	125.6	None	23 systems	23 systems	None
Total estimated costs		$8,500.6	$8,982.9	+$482.3			

Legend

N/A = not applicable.

[a]For this report, all dollars are expressed in current-year dollars, unless otherwise noted, because they are a better indication of the dollar amount that the Congress may have to appropriate.

[b]There is no basis for comparing original and current cost estimates and planned units because the investment decision for the En Route Controller/Pilot Data Link Communications project (of the Aeronautical Data Link Program) was made by FAA on October 30, 1998.

[c]The number of original planned units for the Air Traffic Management Program is not applicable because its primary purpose was to prototype technologies for future use under “free flight.” Under free flight, FAA will gradually deploy a range of new technologies and procedures and work collaboratively with users to manage air traffic operations.

[d]The number of current planned units is not applicable because under the Free Flight Phase I Program, FAA plans to deploy technologies developed under the Air Traffic Management Program for early user benefits.

[e]The initial Wide Area Augmentation System consists of 25 reference stations, 2 master stations, and 4 ground stations joined by a telecommunications network.

[f]The increase in costs is largely attributed to FAA’s decision to replace older radars rather than upgrade them, thus, more than doubling the number of planned units.

On the basis of the revised baselines, the date for completing implementation was delayed from 5 months to more than 6 years for 5 of the 18 projects. Of the remaining 13 projects, the schedule for 2 was accelerated, 9 had no schedule delays, and 2 project’s original and current schedules had no basis for comparison. (See table I.2.)

Table I.2: Changes in Schedule for 18 Major Modernization Projects

	Last-site implementation		
Project	Original estimate	1998 estimate	Changes in months/years
Aeronautical Data Link Program: En Route Controller/Pilot Data Link Communications	Dec. 2005	Dec. 2005	N/A[a]
Air Route Surveillance Radar-4	Nov. 1996	May 1999	+2 years, 6 months
Airport Surface Detection Equipment-3	July 1996	Nov. 1999	+3 years, 4 months
Air Traffic Control Beacon Interrogator	Sept. 2004	Sept. 2004	None
Air Traffic Management Program: Center Terminal Radar Approach Control Automation System	2006[b]	2006[b]	None
Automated Surface Observing System	Sept. 1996	Dec. 2002	+6 years, 3 months
Display System Replacement	May 2000	May 2000	None
Global Positioning System Augmentation Program: Wide Area Augmentation System	Aug. 1999[c]	Aug. 1999[c]	None
Global Positioning System Augmentation Program: Local Area Augmentation System	2006	2006	None
Host and Oceanic Computer System Replacement Program	Oct. 1999[d]	Sept. 1999[d]	–1 month
Integrated Terminal Weather System	July 2003	July 2003	None
Oceanic Automation Program	June 2000	Oct. 1999	–8 months[e]
Operational and Supportability Implementation System	Aug. 2001	Aug. 2001	None
Standard Terminal Automation Replacement System	Feb. 2005	Feb. 2005	None
Terminal Doppler Weather Radar	Aug.1996	July 2001	+4 years, 11 months

(continued)

Project	Last-site implementation: Original estimate	1998 estimate	Changes in months/years
Terminal Radar Digitization, Replacement, and Establishment Program: Airport Surveillance Radar-11 Project	Not determined	Sept. 2005	N/A
Voice Switching and Control System	May 2000	May 2000	None
Weather and Radar Processor	Feb. 2000	July 2000	+5 months

Legend

N/A = not applicable

[a]There is no basis for comparing changes to last-site implementation because the investment decision for the En Route Controller/Pilot Data Link Communications project (of the Aeronautical Data Link Program) was made by FAA on October 30, 1998.

[b]FAA expects to accelerate the schedule of this project under the Free Flight Phase 1 Program.

[c]Implementation date represents when the project is expected to achieve the system's initial capability.

[d]Implementation date for completing the project is for phase 1 of a planned four-phase system.

[e]Implementation date for completing the project has been accelerated by 8 months because FAA canceled four of the five phases and significantly reduced requirements for the one remaining phase.

Aeronautical Data Link

Background

Aeronautical Data Link is designed to provide digital data communications between ground and airborne automation systems. It is expected to give pilots direct access to weather and air traffic control information and reduce voice communication errors. FAA has been developing Aeronautical Data Link since the early 1980s. An original National Airspace System (NAS) plan modernization program, Aeronautical Data Link was designed to construct an En Route Data Link Processor and associated software utilizing Mode-S.[3] In addition, Tower Data Link Services were planned to

[3]Mode-S is a secondary surveillance radar. A secondary surveillance radar identifies, locates, and tracks aircraft by using its signals to interrogate equipment (transponders) on board the aircraft.

provide airlines with predeparture clearances. Other components, such as Terminal Data Link and Oceanic Data Link were also planned.

The program has experienced a number of changes to cost and schedule estimates since its inception. Several factors have led to the changes, including the addition of new projects, restructuring of existing projects, and international agreements. The most significant change to the program was the decision to cancel the En Route Data Link Processor and transmit controller-pilot messages via a service provider—very high frequency (VHF) Digital Link Mode 2. This decision was reached for various reasons, including spectrum and user equipage concerns. The En Route Data Link Processor equipment will now be used for other FAA programs. FAA reports that it spent $175.9 million of F&E funding on the Aeronautical Data Link Program from its inception through fiscal year 1998. According to FAA officials, funds were used primarily to establish Tower Data Link Services and test and demonstrate the En Route Data Link Processor and associated software.

The program currently comprises one major project—the En Route Controller/Pilot Data Link Communications project—which will provide a two-way digital exchange of controller-pilot messages via VHF Digital Link Mode 2—and six other projects. In October 1998, FAA approved the En Route Controller/Pilot Data Link Communications project's baseline—the only active project to have a formerly approved baseline. This project will be developed in two phases—Build 1 and Build 1A. Build 1 will allow a limited number of messages between pilots and controllers to be automated for use at the Miami en route center. Build 1A will enhance this capability by increasing the number of automated messages exchanged and will be implemented at 20 en route centers, and one each at the FAA Technical Center and the FAA Academy. Both builds will consist of Aeronautical Telecommunication Network-compliant messages using VHF Mode 2.[4]

The six other Aeronautical Data Link projects include (1) Tower Data Link Services, (2) the Host Interface Device/National Airspace System Local Area Network, (3) Traffic Information Service, (4) Terminal Weather Information for Pilots, (5) Flight Information Services, and (6) Decision Support System Services. Other programs, such as Free Flight Phase 1,

[4]The Aeronautical Telecommunications Network is a data network being developed in accordance with internationally accepted standards to provide a link between many U.S. and international airlines and civil aviation authorities for the exchanging of flight plans, weather data, distress messages, and other data.

will use some of the services provided under this program. Terminal Data Link and Oceanic Data Link are still in the planning stages.

Tower Data Link Services enables data link communications between air traffic controllers and aircraft. For example, it provides aircraft with predeparture clearances and pilots with weather and facility conditions at major airports. FAA has completed the installation of Tower Data Link Services at 57 airports and one each at the FAA Technical Center and the FAA Academy. FAA is considering requests from additional airports for this service.

The Host Interface Device will provide the interface for digital communications between the Host computer system, En Route Controller/Pilot Data Link Communications project, and other automation systems and tools. FAA plans to implement a Host Interface Device at 20 en route centers, two at the FAA Technical Center, and one at the FAA Academy.

Traffic Information Service will display information on traffic and potential conflict situations to pilots via data link. The information will be a graphic depiction of radar traffic similar to information received over voice radio. This information is intended to improve the safety and efficiency of flight under visual flight rules. FAA plans to implement the Traffic Information Service at 119 locations throughout the NAS with Mode-S radars.

Terminal Weather Information for Pilots will provide pilots with weather information obtained through the Terminal Doppler Weather Radar on conditions such as microbursts, gust fronts, wind shear, and heavy precipitation within 15 miles of an airport. FAA plans to deploy this function at all 47 Terminal Doppler Weather Radar sites.

Flight Information Services will provide pilots with general aeronautical information, including weather and the status of special use airspace to assist in flight planning. Currently, a pilot must obtain this information on the ground before flight or in the cockpit via voice. Using data link, a pilot will be able to read this information on a cockpit display unit. One example of a flight information service is Graphical Weather Services, which will provide pilots with a map that shows real-time precipitation conditions throughout the nation. FAA plans to implement Graphical Weather Services at three sites that will provide NAS coverage as well as systems at the FAA Technical Center and at the FAA Academy.

Decision Support System Services will allow pilots to plan more optimal flight paths and to adhere more closely to controller-approved flight paths by providing wind and air temperature information via data link. This service will also provide controllers with more accurate information on flight paths using data obtained via data link from aircraft about their location, speed, direction, intended flight paths, and performance characteristics. Ultimately, FAA plans for this service to provide automated negotiations and clearances of conflict-free flight paths between pilots and controllers.

Data Link's Cost and Schedule

Table I.3 summarizes the Controller/Pilot Data Link Communications' cost and schedule.

Table I.3: En Route Controller/Pilot Data Link Communications' Cost and Schedule

Dollars in millions

Vendors: Computer Sciences Corporation, Calverton, Md.; Aeronautical Radio Incorporated, Annapolis, Md; Lockheed Martin Corporation, Bethesda, Md.; and Universal Systems and Technology, Inc. Fairfax, Va.

Financial information	Oct. 1998	Oct. 1998	Change in dollars
Total estimated F&E cost	$163.7	$163.7	N/A[a]
Cumulative F&E appropriations through fiscal year 1998		None	
Schedule	**Oct. 1998**	**Oct. 1998**	**Change**
Estimated first-site implementation (Controller/Pilot Data Link Communications Build 1)	Sept. 2002	Sept. 2002	N/A[a]
Estimated last-site implementation (Controller/Pilot Data Link Communications Build 1A)	Dec. 2005	Dec. 2005	N/A[a]

[a]There is no basis for comparison of original and current cost estimates and first- and last-site implementation because the investment decision for the En Route Controller/Pilot Data Link Communications project (of the Aeronautical Data Link Program) was made by FAA on October 30, 1998.

Data Link's Challenges and Risks

The En Route Controller/Pilot Data Link Communications project has aggressive development and implementation schedules for Build 1 and Build 1A. The project also has a major schedule interdependency with Aeronautical Telecommunications Network Systems, Inc.-developed software. Any software development delays by the company will likely jeopardize FAA's ability to meet the project's baselined schedule. Additionally, FAA has assumed that the service provider message costs of VHF Data Link Mode 2 will be shared between FAA and industry. However, FAA has yet to formalize this arrangement with industry.

Air Route Surveillance Radar-4

Background

Air Route Surveillance Radar-4 (ARSR-4) is a long-range primary surveillance radar that tracks en route aircraft and weather by emitting radio signals that are reflected back to the radar.[5] (See fig. I.1.) Data from this radar on the movement of aircraft and on weather are used for keeping aircraft separated, drug interdiction, and the defense of U.S. borders. Radar data are merged with data from a collocated secondary beacon system and then transmitted to FAA's en route air traffic control centers, Air Force Air Defense Sectors, and the Customs Service. ARSR-4 is a part of FAA's Long Range Radar Replacement Program—a multiyear program funded jointly by FAA, the Air Force, and the Navy.

This project replaces some of the obsolete FAA and military air route surveillance radars and aging long-range radars. FAA has acquired 44 ARSR-4s. Forty-two of these will be placed along the perimeter of the continental United States, Hawaii, Guam, and Guantanamo Bay, Cuba, and will be owned and maintained by FAA for the agency's and the Air Force's use. One radar will be used exclusively by the Air Force at Vandenberg Air Force Base, California. The remaining radar is to be used for field support and training in Oklahoma City, Oklahoma, and will not be commissioned.

Changes to ARSR-4's Cost and Schedule

The estimated cost of the ARSR-4 has increased by $66.4 million to $415.8 million since the contract was awarded in 1988. About $50 million of this increase occurred in the early-to-mid-1990s because of the relocation of eight sites and the addition of one radar. The remaining $16 million increase, which occurred in 1997, is due in part to (1) technical corrections required for the system, (2) an increase in the costs of spare parts, (3) an increase in the length of depot repair service from 3 to 5

[5]A primary surveillance radar system tracks aircraft and weather by emitting radio signals that are reflected by all of the aircraft and weather conditions present in the area covered by the system.

years, (4) the installation of uninterruptible power systems at all sites, and (5) software upgrades.

The project's first-site implementation date was delayed by 2 years and 7 months, from September 1993 to April 1996 by several technical issues—that were eventually resolved—and by new requirements. However, within the last 2 years, FAA has made progress with implementing the ARSR-4. As of October 1998, the agency had commissioned 38 of 43 ARSR-4s and had 3 additional sites planned for commissioning by December 1998. Commissioning at the last two sites—Guam and Ajo, Arizona—is planned in 1999. Guam's original implementation date for ARSR-4 was delayed because new equipment had to be replaced after being damaged by a typhoon. Ajo will be the last site installed. This site alone has contributed 5 months to the total last-site implementation delay because of environmental issues. However, FAA recently signed a Memorandum of Understanding with the U.S. Fish and Wildlife Service to mitigate the environmental issues at or near the site, and construction at the site has started. Table I.4 summarizes the changes to ARSR-4's cost and schedule since 1988.

Table I.4: Changes to ARSR-4's Cost and Schedule

Dollars in millions

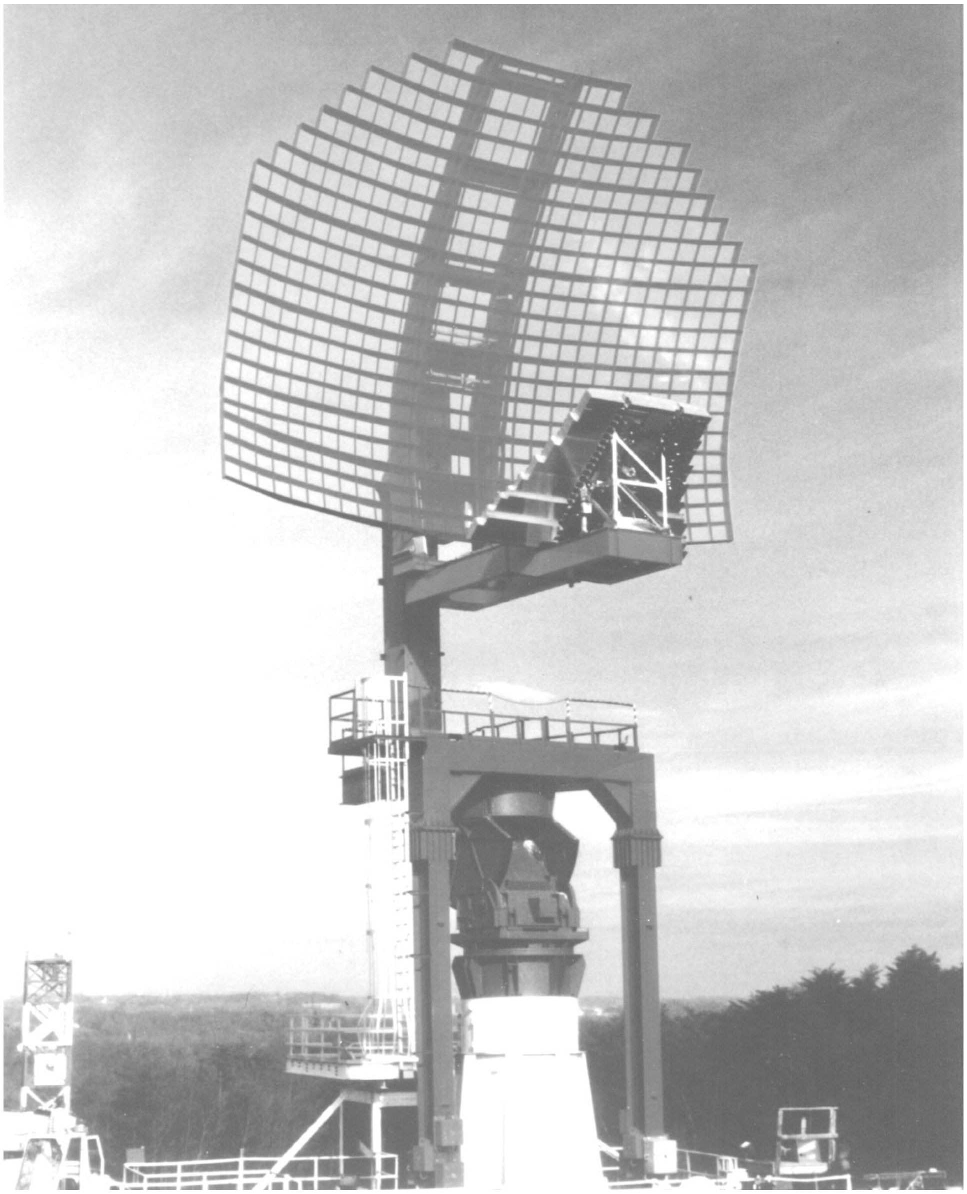
Vendor: Northrup-Grumman Corporation, Linthicum, Md.

Financial information	1988	1998	Change in dollars
Total F&E cost	$349.4	$415.8	+$66.4
Cumulative F&E appropriations through fiscal year 1998		$408.8	
Schedule	**1988**	**1998**	**Change in years/months**
First-site implementation	Sept. 1993	Apr. 1996	+2 years, 7 months
Estimated last-site implementation	Nov. 1996	May 1999	+2 years, 6 months

ARSR-4's Challenges and Risks

Total funding for this project could increase by about $2.5 million because of the reprogramming of the project's fiscal year 1998 funds. The program office had planned for fiscal year 1999 to be the final year of F&E funding for the ARSR-4 project. However, FAA reprogrammed $1.3 million of the project's fiscal year 1998 funds for other modernization activities, including the Standard Terminal Automation Replacement System and Year 2000 computer problems. The restoration of these funds—which the program office planned to use to complete modifications to enhance the system—is not expected until 2001. This action will most likely force the program office to let a new contract for system modifications and, as a result, spend an additional $2.5 million on the project's costs.

Figure I.1: ARSR-4



Source: FAA.

Airport Surface Detection Equipment-3

Background

The Airport Surface Detection Equipment-3 (ASDE-3) is a primary radar designed to provide tower controllers with surveillance information—a video display—of all aircraft and other vehicle operations on an airport's runways and taxiways. ASDE-3 will help prevent accidents by allowing controllers to efficiently move traffic, especially during low visibility, such as in fog or during night operations. (See fig. I.2.) FAA developed these radars to replace the aging and less reliable ASDE-2 radars. While ASDE-3 provides a video display for controllers to assist them in preventing potential runway collisions, controllers are not able to watch the display at all times. As a result, FAA is developing an Airport Movement Area Safety System (AMASS) to provide automated aural and visual warnings (conflict alerts) to alert controllers of potential runway collisions.

FAA has procured a total of 40 ASDE-3 systems—33 under the original contract and 7 under a contract with the same contractor (Northrup Grumman-Norden Systems)—that was signed in September 1993. Thirty-eight of the systems are for airport use, and two systems are for support and training use in Oklahoma City, Oklahoma.

In the 1983 financial plan, ASDE-3's F&E cost was $83.2 million, and the first- and last-site implementation dates were 1987 and 1990, respectively. Cost increases from 1983 through 1993 were due to increases in the number of systems being acquired and software and hardware changes. Slips in implementation dates through 1993 were due in part to performance problems with ASDE-3's ability to accurately track targets and conflicts with ongoing construction projects at airports that were scheduled to receive these radars.

Changes to ASDE-3's Cost and Schedule

Since the project was expanded in 1993, the cost of ASDE-3 increased by $58.1 million to procure and install additional equipment items needed for remote site operation, additional radar displays, spare parts, test equipment, and modifications to enhance the reliability and maintainability of component parts for the system (such as bearings and transmitters) that were deteriorating more quickly than anticipated.

ASDE-3's first-site implementation was delayed in part because of technical problems at the first site. The last-site implementation has been delayed by more than 40 months—from July 1996 to November 1999—primarily because of delays in the completion of towers or structures at locations receiving ASDE-3 systems. Other factors contributing to delays include problems associated with the buildup of cadmium dust that was generated by components needed to operate ASDE-3 antenna heaters. A project official stated that although FAA has resolved this problem, the agency has delayed the project's installation schedule by 9 months.

As of September 1998, 37 of the 40 systems had been delivered to FAA, and the last 3 were planned for delivery in 1999. Thirty of the 37 systems have been commissioned, and 2 are being used as support systems. Of the remaining five systems at operational sites, four are awaiting commissioning, and one is undergoing implementation. Table I.5 summarizes the changes to ASDE-3's cost and schedule since 1993.

Table I.5: Changes to ASDE-3's Cost and Schedule

Dollars in millions

Vendor: Northrup Grumman-Norden Systems, Inc., Norwalk, Conn.

Financial information	1993	1998	Change in dollars
Total F&E cost	$191.0	$249.1	+$58.1
Cumulative F&E appropriations through fiscal year 1998		$241.1	
Schedule	**1993**	**1998**	**Change in years/months**
First-site implementation	Mar. 1993	Dec. 1993	+ 9 months
Estimated last-site implementation	July 1996	Nov. 1999	+ 3 years, 4 months

ASDE-3's/AMASS' Challenges and Risks

Achieving the full safety benefits from ASDE-3 hinges on AMASS. FAA plans to install an AMASS system at each of the 40 ASDE-3 sites; as of September 1998, three AMASS systems had been delivered to FAA, and the first of these is planned for implementation in October 1999. Additionally, FAA plans to take delivery of the remaining 37 systems by March 2000 and have the last site implemented by August 2000. There are several challenges to meeting this schedule.

Preliminary tests have shown that AMASS can provide accurate and timely warnings of potential conflicts. Additionally, AMASS is designed to place symbols on real targets so controllers can visually distinguish them from false targets caused by multipath problems from the ASDE-3 radar.[6] However, during early testing of AMASS, false alerts from multipath were considered a challenging issue. For example, if excessive levels of false alerts continued, controller confidence in AMASS could be eroded and could affect the flow of air traffic. FAA has made system changes to address these problems and continues to evaluate software algorithms and other technical enhancements to mitigate false alerts. Operational testing is expected to be completed in 1999.

Implementing AMASS could also prove to be operationally challenging. For example, AMASS' performance in accurately detecting conflicts is directly affected by each airport's physical layout, local procedures for traffic flow, and ASDE-3's performance during inclement weather. Consequently, cooperation within FAA to optimize each system on the basis of sight-specific parameters is key to the system's implementation. Standards and procedures will need to be developed to address such issues as the acceptable AMASS performance rates for accurately detecting conflicts and how controllers will use the tool in an operational setting. To use AMASS in an operational setting, FAA will also have to resolve issues surrounding controllers' actions based on AMASS data, such as disruptions caused by false alerts. According to an FAA official, the agency has begun to address these issues.

[6]Multipath problems occur when radio-frequency energy radiates off buildings or other aircraft, thus creating a momentary false target on the ASDE-3 radar's display. All radars experience multipath problems, but radars like ASDE-3, which radiate energy downward, are especially prone to such problems.

Figure I.2: Rotodome Containing ASDE-3 Radar on Top of Air Traffic Control Tower

Source: FAA.

Air Traffic Control Beacon Interrogator

Background

The Air Traffic Control Beacon Interrogator (ATCBI) project will replace 30-year-old model 4 and 5 secondary surveillance radars—located mainly at en route sites—with a new model 6 radar. The existing model 4 and 5 radars are extremely vulnerable to outages as well as critical part shortages, since they were planned to have only a 20-year life.

In August 1998, after a 10-month evaluation of potential vendors, FAA awarded Raytheon a contract for up to 150 model 6 secondary surveillance radars. As of November 1998, FAA is committed to purchasing 127 systems. FAA expects to begin testing two preproduction systems in January 1999 and to begin fielding the new model 6 radar no later than March 2001.

ATCBI's Cost and Schedule

Table I.6 summarizes ATCBI's costs and schedule since August 1998.

Table I.6: ATCBI's Cost and Schedule

Dollars in millions

Vendor: Raytheon Systems Company, Marlborough, Mass.

Financial information	Aug. 1998	Oct.1998	Change in dollars
Total F&E cost	$282.8	$282.8	None
Cumulative F&E appropriations through fiscal year 1998		$8.4	
Schedule	**Aug. 1998**	**Oct. 1998**	**Change**
Estimated first-site implementation	Sept. 2001	Sept. 2001	None
Estimated last-site implementation	Sept. 2004	Sept. 2004	None

ATCBI's Challenges and Risks

The project faces both technical and schedule risks related to interface requirements. ATCBI-6 must interface with existing and future automation systems as well as all primary radars collocated with the existing equipment that ATCBI-6 will replace. According to project officials, the contractor has limited experience with known interfaces and no experience with those interfaces that are not yet defined. Project officials plan to develop interfaces in the order of "easiest" to "most difficult." The interfaces to existing en route automation systems will be the first to be developed. Next, interfaces to existing primary radars will be developed, and, finally, ATCBI-6 interfaces will be developed for future automation systems.

Because some of ATCBI-6's interface requirements are "moving targets," the ATCBI-6 project officials will need to maintain close coordination with other project teams to help ensure that the ATCBI team meets its schedule. The procurement, delivery, and installation of government equipment must also be monitored closely to ensure that all ancillary equipment required for complete installation and testing is available to the contractor.

Air Traffic Management Program/Free Flight Phase 1 Program

Background

The Air Traffic Management (ATM) program integrated the development and prototyping of automated tools designed to improve the management of air traffic control. Traffic flow management tools included the Enhanced Traffic Management System and Collaborative Decision Making. Air traffic control tools included the User Request Evaluation Tool, Center Terminal Radar Approach Control Automation System (CTAS), and Surface Movement Advisor. FAA has been developing these new capabilities to support the agency's efforts to implement a new, more flexible system of air traffic management known as "free flight." Under free flight, FAA will gradually deploy a range of new technologies and procedures and work collaboratively with users to manage air traffic operations.

As of September 30, 1998, the ATM program was completed—including all of its prototyping efforts in support of Free Flight Phase 1—and the program's structure was eliminated. Under the ATM program, FAA estimates that it spent $405 million on F&E through fiscal year 1998, including funding for the Enhanced Traffic Management System. On October 1, 1998, the recently established Free Flight Phase 1 program commenced operations under a new charter to move these former ATM prototypes into full-scale development.[7] Projects under this program include CTAS, Surface Movement Advisor, User Request Evaluation Tool, and Collaborative Decision Making. While not officially a part of Free Flight Phase 1, Enhanced Traffic Management System will be managed by the program office. FAA estimates the cost of Free Flight Phase 1 through its completion in 2002 at $633 million.

CTAS has two components that are planned for use under Free Flight Phase 1—Traffic Management Advisor Build 2 and Passive Final Approach Spacing Tool. Traffic Management Advisor will provide en route/terminal controllers with automation tools to schedule aircraft to enter or depart from airspace that is between 5 and 50 miles from an airport. Similarly, the Passive Final Approach Spacing Tool is an automated device that provides terminal controllers with sequence numbers and runway assignments during final approach and landing. The Surface Movement Advisor is intended to enhance the efficiency of aircraft movements on the airport surface by facilitating the sharing of real-time information among airspace users and airport operators. User Request Evaluation Tool is an automated device that assists en route controllers in identifying and resolving potential conflicts between aircraft up to 20 minutes before their occurrence. Collaborative Decision Making provides a real-time exchange of information on flight plans and system constraints to assist airline and air traffic control personnel in making decisions about NAS resources. Finally, Enhanced Traffic Management System provides the current traffic management system with software and hardware upgrades to convert it to an open system platform that is Year 2000 compliant.

ATM Program's Cost and Schedule

According to an FAA program official, CTAS is the only project to have a formally approved baseline. The current baseline was approved under the former ATM program, but FAA plans to request a revised baseline in January 1999. At the same time, project officials plan to request the approval of baselines for the remaining projects. FAA plans to deploy all of these projects by 2002. Table I.7 summarizes CTAS' cost and schedule since 1997.

[7]FAA plans to move Free Flight Phase 1 technologies to full-scale development using an evolutionary spiral development approach to the development and deployment of technology, as appropriate. Under such an approach, the agency plans to limit the scope of project segments so that it can deploy, test, evaluate, and refine a given technology in a cyclical manner until it can perform at the desired level.

Table I.7: CTAS' Cost and Schedule

Dollars in millions

Vendors: Computer Science Corporation; Lockheed Martin; NASA Ames; Massachusetts Institute of Technology/Lincoln Laboratory; Wyndemer and EDS.

Financial Information	1997	1998	Changes in dollars
Total F&E cost	$251.1	$251.1	None
Cumulative F&E appropriations through fiscal year 1998		$69.0	
Schedule	**1997**	**1998**	**Change**
Estimated first-site implementation	2002[a,b]	2002[a,b]	None
Estimated last-site implementation	2006[b]	2006[b]	None

[a]First-site implementation date is for both components of CTAS—Traffic Management Advisor Build 2 and Passive Final Approach Spacing Tool.

[b]FAA expects to accelerate this schedule under Free Flight Phase I.

Free Flight Phase 1's Challenges and Risks

In a recent report on FAA's free flight implementation efforts, we reported that FAA and the aviation community face numerous challenges in their efforts to implement free flight—including Phase 1—in a cost-effective manner.[8] Among the challenges, we identified the need for FAA to (1) provide effective leadership and management of modernization efforts both within and outside the agency, including effective collaboration with stakeholders and improvements to cross-program communication and coordination within FAA; (2) work collaboratively with the aviation community to develop goals and sufficiently detailed plans for what it intends to achieve and develop measures for tracking progress; and (3) address outstanding issues related to the development of technology, such as identifying and addressing the impacts of modernization on human operators, including maintenance staff, controllers, and pilots.

FAA recently identified similar challenges, such as its need to provide strong leadership and accountability for implementing Free Flight Phase 1. A senior FAA official told us that the key challenge facing the agency in implementing free flight—including Phase 1—will be maintaining a consensus between FAA and the aviation community as implementation efforts move forward. Other challenges highlighted by FAA include

[8]See National Airspace System: FAA Has Implemented Some Free Flight Initiatives, but Challenges Remain (GAO/RCED-98-246, Sept. 28, 1998).

(1) managing the expectations of the aviation community on the expected benefits of free flight capabilities, in part, by taking care not to overstate expected benefits; (2) taking steps to ensure that vendors and research organizations focus on Phase 1 from a system's perspective rather than on their individual products; (3) holding to the number of sites selected and the agreed upon locations—to keep the program manageable and affordable; (4) coordinating with projects on which Phase 1 is dependent; and (5) managing an aggressive schedule for deploying Phase 1's capabilities by 2002 as planned.

According to FAA, the structure of the Free Flight Phase 1 program office is designed to facilitate communication and coordination with other FAA organizations and the aviation community. For example, the office includes a stakeholder council to help assure adequate involvement of key FAA and aviation community stakeholders in its implementation efforts. This council will be responsible for maintaining consensus agreement and addressing global issues related to the implementation of free flight. The office also has a team that is working directly with the airlines to build baseline performance data needed for measuring progress under free flight and is addressing human factors issues, among other tasks.

Automated Surface Observing System

Background

The Automated Surface Observing System (ASOS) automates the observation and dissemination of data on temperature and dew point, visibility, wind direction and speed, pressure, cloud height and amount, and the types and amounts of precipitation. (See fig. I.3.) ASOS is intended to improve the weather services at the nation's large airports and provide smaller airports used by general aviation pilots with new service. ASOS is intended to replace some of the human observers who provide FAA with similar services under contract. According to FAA's Air Traffic officials, it is estimated that $18 million a year can be avoided by replacing human observers.

Under ASOS—a joint program administered by the National Weather Service—597 ASOS units will be procured, installed, and maintained by FAA at both towered and nontowered airports. Prior to fiscal year 1998, FAA provided ASOS with funds under the umbrella of the Automated Weather

Observing System (AWOS) program, which also included AWOS, AWOS Data Acquisition System, and the Automated Lightning Detection and Reporting System projects.[9] AWOS filled an immediate need for automated weather information during the development of the more sophisticated ASOS. The last of 200 AWOS sites was implemented in April 1998. Each AWOS Data Acquisition System acquires weather information from up to 137 AWOS and ASOS units, disseminates this information via FAA's National Weather Network, and archives weather data products. According to project officials, all 22 operational AWOS Data Acquisition Systems, located primarily at en route centers, have been commissioned. Three additional support systems are also operational.

Changes to ASOS' Cost and Schedule

As of October 1998, FAA had commissioned 371 of the 597 ASOSs—238 new sites since early 1997. FAA plans to commission an additional 79 systems by the end of December 1999 and the remaining 147 sites by the end of December 2002. Currently, FAA cannot commission 70 nontowered sites because it placed a moratorium on their commissioning as a result of contract weather observers' concerns. According to FAA project officials, the agency may place a moratorium on an additional 40 nontowered sites. Contract weather observers claim that ASOS provides a lower level of service than they provide, and, as a result, they should not be replaced by ASOSs at these sites. The estimated total cost of ASOS has increased by $136.2 million since the contract was awarded in February 1991, and the project's last-site implementation schedule has slipped by more than 6 years. Five major factors caused changes to the project's cost and schedule baselines.

First, at the time of the contract's award, the scope of ASOS' commissioning process was still under development. The schedule was extended once the scope was fully defined to allow for such activities as the evaluation of planned sites. The schedule also slipped because of limited manpower resources in FAA's regional offices responsible for commissioning ASOS equipment. These events caused the first-site and last-site implementation to slip by 27 and 8 months, respectively. Also contributing to the schedule slippage was the shifting of telecommunications costs from the operations and maintenance budget to the F&E budget. This change in policy regarding telecommunications funding also resulted in an increase of $10.5 million to the project's F&E cost.

[9]The Automated Lightning Detection and Reporting System will provide AWOS and ASOS with data on lightning via AWOS' Data Acquisition System.

Second, FAA added new requirements to the ASOS project from 1994 through 1998 because it determined that the original requirements were unacceptable. As a result, FAA added requirements for freezing rain sensors, backup equipment, and a new tower display—ASOS Controller Equipment.[10] This additional equipment caused the project's cost to increase by $47.8 million and the project's last-site implementation date to slip by 13 months.

Third, FAA reduced the project's 1994 funding by $10 million, causing the National Weather Service to restructure the ASOS contract. As a result, the project's cost increased by $14.6 million, and its last-site implementation date slipped by 18 months.

Fourth, in 1994 and 1995, the National Weather Service imposed a moratorium on commissioning any ASOSs until the systems' technical deficiencies and logistic problems were resolved. FAA also agreed to halt commissioning because the National Air Traffic Controllers Association (NATCA) has similar concerns about the system. As a result, this caused the project's cost to increase by $10 million and the last-site implementation date to slip by 1 year.

Fifth, the conferees for the fiscal year 1997 and 1998 Department of Transportation Appropriations Acts directed the purchase of additional systems in 1997 and 1998. This caused the project's cost to increase by $20 million, which FAA plans to use to purchase 60 additional systems—30 of which FAA has already purchased. The 1997 congressional direction caused the last-site implementation date to slip by 1 year. In addition, the 1998 direction will cause the last-site implementation date to slip from December 2001 to December 2002.

Additionally, an increase of $33.3 million in the cost baseline from 1991 through 1998 can be attributed to several other factors. These include spare parts, congressionally directed ASOS augmentation for Alaska, special site considerations in Alaska, equipment relocations, earthquake anchoring, an ASOS assessment study, initial maintenance, preplanned product improvements, and the procurement of modems. Table I.8 summarizes the changes to ASOS' cost and schedule since 1991.

[10]This equipment consists of a local area network located in air traffic control towers and associated terminal radar approach control facilities that are used for displaying ASOS-generated weather data at controllers' workstations in easily understood graphical displays. This equipment allows multiple controllers to access similar ASOS data at the same time in both the terminal radar approach control facility and tower.

Table I.8: Changes to ASOS' Cost and Schedule

Dollars in millions

Vendor: SMI Corporation, Hunt Valley, Md.

Financial information	1991	1998	Change in dollars
Total F&E cost	$151.3	$287.5	+$136.2
Cumulative F&E appropriations through fiscal year 1998		$215.8	
Schedule	**1991**	**1998**	**Change in years/months**
First-site implementation	Aug. 1991	Nov. 1993	+2 years, 3 months
Estimated last-site implementation	Sept. 1996	Dec. 2002	+6 years, 3 months

ASOS' Challenges and Risks

The ASOS project faces two primary challenges. First, FAA has experienced reliability problems with ASOS' temperature/dew point sensor. This faulty sensor accounts for more than 50 percent of all ASOS data errors, thereby limiting FAA's ability to utilize ASOS to its full potential. FAA and the National Weather Service are attempting to resolve this problem.

Second, as stated above, FAA has placed a moratorium on ASOS' commissioning as a result of contract weather observers' concerns. After a reassessment of ASOS' performance, which was conducted during 1997-98, FAA determined that it should continue commissioning ASOS at selected sites. However, in September 1998, in response to congressional concerns about the contract weather observers' opinions on ASOS' performance, FAA requested that the Air Force conduct an independent assessment to validate the results of the first study. The Air Force plans to complete its assessment by December 1998. FAA hopes to have closure on this matter by year's end to prevent further schedule slips.

Figure I.3: ASOS

Source: FAA.

Display System Replacement

Background

The Display System Replacement (DSR) project will modernize en route center equipment by replacing 20- to 30-year-old display channels, controllers' workstations, and network infrastructure. (See fig. I.4.) DSR will also provide a platform for FAA to implement planned capabilities, such as the User Request Evaluation Tool, which will allow airlines to request more direct routings, thereby providing them with benefits including fuel and time savings. DSR is a scaled-back version of the Initial Sector Suite System—a segment of the former Advanced Automation System, which FAA restructured in 1994 to solve long-standing cost, schedule, and technical problems. In 1994, the Initial Sector Suite System was estimated to cost $3 billion, and, at the time of the restructuring, FAA had sunk $1.8 billion into the project. The Initial Sector Suite System's first- and last-site implementation dates were 1996 and 1998, respectively.

Changes to DSR's Cost and Schedule

Table I.9 summarizes the changes to DSR's cost and schedule since 1994.

Table I.9: Changes to DSR's Cost and Schedule

Dollars in millions

Vendor: Lockheed Martin Corporation, Rockville, Md.

Financial information	1994	1998	Change in dollars
Total F&E cost	$1,055.3	$1,055.3	None
Cumulative F&E appropriations through fiscal year 1998		$771.0	
Schedule	**1994**	**1998**	**Change in months**
Estimated first-site implementation	Oct. 1998	Dec. 1998	+1.5 months
Estimated last-site implementation	May 2000	May 2000	None

DSR's Challenges and Risks

According to project officials, FAA achieved initial operational capability of the system as scheduled at its first site, Seattle, Washington, on June 1, 1998. However, full implementation of DSR was suspended for a few months in response to 19 computer-human interface issues expressed by NATCA. On June 16, 1998, FAA and NATCA agreed to solutions for these 19 issues, and, in October 1998, full implementation of DSR in Seattle resumed in accordance with the terms of the June 16 agreement. The project office estimates that activities associated with modifications to DSR could result in a 1- to 3-month slip in Seattle's original first-site implementation date of October 31, 1998.[11] However, the project office is only currently projecting a 6-week slip to December 15, 1998. Moreover, according to project officials, although FAA's agreement with NATCA resulted in adjustments to DSR's schedule, the estimate last-site implementation date scheduled for May 2000 at Indianapolis, Indiana, is not projected to change.

The Professional Airways Systems Specialists—the union for airway facilities personnel—has also expressed some concerns regarding the fielding of DSR. Chief among these is the ease of access for maintaining Voice Switching and Control System electronics equipment located within the DSR controller workstation. FAA reached an agreement in May 1998 to cooperate with the union to identify acceptable solutions to these concerns. However, until these solutions have been identified and implemented, a risk to the DSR schedule remains.

Figure I.4: DSR

Source: FAA.

[11]In accordance with the agreement with NATCA, FAA incorporated a generic keyboard layout and the use of color for display attributes along with software and hardware modifications.

Global Positioning System Augmentation Program: Wide Area Augmentation System/Local Area Augmentation System

Background

FAA's current policy is to transition from its present ground-based navigation and landing system to a satellite-based system using signals generated by the Department of Defense's Global Positioning System (GPS).[12] However, GPS, by itself, does not satisfy all aviation requirements, such as the one requiring the system to be available virtually all of the time and another requiring the system be accurate enough to support landings in the worst weather conditions. To satisfy these requirements, FAA has taken a two-pronged approach to augmenting GPS through its Wide Area Augmentation System (WAAS) and Local Area Augmentation System (LAAS) projects.

WAAS is expected to support the navigation for all phases of flight from nonprecision through category I precision approaches.[13] LAAS is needed to support the more stringent category II and III precision approach requirements.[14] LAAS is also expected to complement WAAS and provide a category I precision approach at airports where WAAS does not provide sufficient coverage or where there is a higher requirement for availability. FAA and the aviation industry expect that these systems will result in major benefits, including a reduction in landing accidents, by providing more precision-landing capabilities than currently exist and a reduction in flight

[12]There are currently 27 GPS satellites (24 in operation and 3 in reserve) located in six orbits at approximately 11,000 miles above the earth. These satellites are positioned so that a user will have at least four satellites in view at any given location.

[13]On a nonprecision approach, an aircraft receives electronic guidance for flying toward the runway's center line. On a precision approach, an aircraft not only receives this guidance but also guidance on the slope of descent to the runway. As a result, on a precision approach, an aircraft can safely descend closer to the ground while attempting to land in bad weather. FAA currently categorizes precision-landing systems according to their ability to safely guide an aircraft to a runway in poor weather conditions. A category I system provides aircraft with safe vertical guidance to a height of not less than 200 feet with runway visibility of at least 1,800 feet.

[14]A category II system provides aircraft with a safe vertical guidance to a height of not less than 100 feet with runway visibility of not less than 1,200 feet. A category III system provides aircraft with safe vertical guidance all the way to touchdown under conditions where a runway's visibility is extremely limited, for example, where a runway's visibility is not less than 150 feet.

times, fuel consumption, and delays due to bad weather. WAAS and LAAS are eventually expected to serve as "sole means" navigation systems that would enable FAA to phase out its costly network of ground-based navigation aids.[15]

In August 1995, after several years of research, FAA contracted with Wilcox Electric to develop WAAS. However, because of concerns about the contractor's work, FAA terminated the contract in April 1996. In May 1996, FAA entered into an interim contract with Hughes Aircraft Company (now Raytheon Systems), and the contract became final in October 1996. FAA rebaselined the project in January 1998 to reflect safety changes that occurred since Wilcox's contract termination. Operations and Maintenance costs were also included in the January 1998 baseline.[16]

At the time of the original baseline for WAAS in 1994, FAA estimated the project's cost at $509 million. Also at this time, FAA expected that the initial and full system could be completed by June 1997 and December 2000, respectively. From 1994 through 1998, baseline costs increased because of higher development costs to build greater redundancy into the system's ground components and higher-than-originally-estimated satellite-leasing costs. In addition to an already aggressive schedule, such factors as the need to build greater reliability into the systems and certify system software further contributed to the schedule's slippage.

Currently, the initial WAAS network consists of 25 reference stations, 2 master stations, and 4 ground stations joined by a telecommunications network. The initial system, still in testing, also uses two leased geostationary communication satellites to provide signals for making corrections and for transmitting information to aircraft.[17] In September 1998, FAA decided to add an interim step between the initial and full system. During this interim step, FAA plans to add additional ground stations and make performance upgrades to the initial system's software in order to evaluate operational experience before moving ahead to complete the full system. For the full system, FAA envisions a design consisting of up

[15]A "sole means" navigation system must, for a given operation or phase of flight, allow the aircraft to meet all performance requirements for the navigation system.

[16]During the January 1998 rebaselining, the agency conducted an economic analysis to reevaluate whether WAAS was still a sound investment. The analysis assessed how such events as the range of satellite costs and the inclusion of the costs of decommissioning ground-based navigation aids would affect the investment. FAA found that WAAS' benefits still outweighed costs.

[17]Unlike GPS satellites, the WAAS geostationary satellites are located at fixed positions in orbit 22,000 miles above the earth.

to 54 reference stations, 8 master stations, and 14 ground earth stations. (See fig. I.5.)[18]

LAAS is a joint research effort with industry. In January 1998, FAA approved the first LAAS baseline and anticipates moving to full-scale development by December 1998. During full-scale development, some systems will be built to test and evaluate the capabilities of meeting category I, II, and III precision-landing requirements. After full-scale development, FAA anticipates acquiring 143 systems. About 42 systems will be installed at airports and will provide a category I capability, where WAAS cannot.[19] The remaining 101 systems will provide category II and III capabilities. LAAS will consist of precisely surveyed reference stations for receiving GPS signals, detecting malfunctions, calculating corrections, and transmitting corrections to aircraft. The system will also consist of a ground station, known as a "pseudolite," which will broadcast an additional signal to aircraft for making corrections. (See fig. I.6.)

WAAS' and LAAS' Cost and Schedule

Table I.10 summarizes WAAS' and LAAS' costs and schedules since January 1998.

[18]Neighboring countries may field additional ground stations and reduce the need for FAA to invest in as many ground stations as originally envisioned.

[19]WAAS may not provide sufficient coverage for precision landing guidance in remote areas, such as in parts of Alaska. Also, some airports (e.g., Miami International) have higher availability requirements than WAAS can provide. Availability is the probability that, at any given time, the system will meet the accuracy and integrity requirements for each phase of flight.

Table I.10: WAAS' and LAAS' Cost and Schedule

Dollars in millions

Vendors: WAAS-Raytheon Systems Company, Fullerton, Calif.;
COMSAT/Mobile Communications, Bethesda, Md.
Partners: LAAS-Honeywell, Minneapolis, Minn.; Raytheon Systems Company, Fullerton, Calif.

Financial information	Jan. 1998[a]	Oct. 1998	Change in dollars
Total WAAS F&E cost	$1,006.6	$1,006.6	None
F&E appropriations through fiscal year 1998		$400.4	
Total LAAS F&E cost	$535.8	$535.8	None
F&E appropriations through fiscal year 1998		$11.2	
Schedule	**Jan. 1998**	**Oct. 1998**	**Change**
WAAS' initial capability	Aug. 1999	Aug. 1999	None
WAAS' interim capability	N/A	Dec. 2001	N/A
WAAS' full capability	Dec. 2001	TBD	N/A
LAAS' first-site implementation[b]	2003	2003	None
Last-site implementation[b]	2006	2006	None

Legend

N/A = not applicable

TBD = to be determined

[a]The revised WAAS baseline also includes $2.043 billion for operations and maintenance through 2016. In 1997, FAA estimated these costs at $1.5 billion. LAAS' operations and maintenance costs are estimated to reach $296 million.

[b]These dates reflect the first- and last-site implementation dates for full production of LAAS.

WAAS'/LAAS' Challenges and Risks

Several uncertainties—related to cost, performance, and technical issues—surround FAA's satellite navigation program. While FAA's revised baseline recognizes that WAAS' estimated costs have grown significantly, questions persist about whether the WAAS program is cost-effective. Closely related to the issue of whether the expected benefits justify the cost are several performance and technical issues, including the vulnerability of the GPS signal to interference, the selection of a second broadcast frequency for civilian use, and the acquisition of additional geostationary satellites for WAAS. FAA's current efforts to identify alternatives to satisfy its future satellite navigation needs and the resolution of the outstanding issues could affect the cost, schedule, and delivery of benefits to users and to FAA.

Questions Persist About the Cost and Benefits of WAAS

In the Department of Transportation Appropriations Acts for fiscal years 1998 and 1999 and their accompanying legislative histories, congressional concerns were expressed about certain aspects of the WAAS program, including its cost, schedule, performance, and risks.[20] For example, in the conference report accompanying the fiscal year 1999 appropriations, the conferees noted that proponents of the WAAS program have not been able to provide compelling assurance that the program will be cost-effective beyond the initial phase, which is expected to become operational in 1999. The conferees further asserted that serious and persistent technical concerns await resolution by the FAA at an unknown cost and in unknown time frames. The fiscal year 1999 appropriations act includes a provision which prohibits the use of funds for any WAAS activity beyond phase 1.

FAA's analyses of WAAS have shown the project to be cost beneficial. In fact, during the January 1998 rebaselining of the project, FAA conducted an economic analysis to reevaluate whether WAAS was still a sound investment. The analysis assessed how such events as the range of satellite costs and the inclusion of the costs of decommissioning ground-based navigation aids would affect the investment. At that time, FAA found that benefits still outweighed costs. However, since then questions have arisen about the WAAS investment and in particular, the conferees for the fiscal year 1999 Transportation Appropriations Act expressed concern that the benefits of WAAS may be overstated.

It is expected that FAA will identify its future needs for satellite navigation and analyze a range of alternatives for meeting those needs. In fact, the conferees for the fiscal year 1999 Transportation Appropriations Act directed FAA to complete an alternatives analysis which looks at various combinations of existing and new, ground-based and satellite-based technology. In response, FAA has completed a draft alternative analysis plan, which calls for the identification of possible alternatives by early 1999. Once possible alternatives have been identified, the Center for Advanced Aviation System Development of the Mitre Corporation is expected to do a technical evaluation of the alternatives.[21] Following Mitre's evaluation, FAA's investment analysis team will analyze the costs,

[20] Senate Report 105-55, Department of Transportation and Related Agencies Appropriations, Fiscal Year 1998 (July 22, 1997), and House of Representatives Conference Report 105-313, Department of Transportation and Related Agencies Appropriations, Fiscal Year 1998 (Oct. 7, 1997) and House of Representatives Conference Report 105-825, Department of Transportation and Related Agencies Appropriations Act, Fiscal Year 1999 (Oct. 19, 1998).

[21] Mitre Corporation operates, under a memorandum of agreement with funding from FAA, the Center for Advanced Aviation System Development. The Center carries out a continuing program of research, development, system architecture, and high-level system engineering to support FAA's NAS needs.

benefits, schedule, performance, and risks of each alternative and expects to recommend a proposed alternative to FAA's senior acquisition managers by the end of May 1999. The Congress is expected to use the results of various analyses of WAAS in determining the level of appropriations needed for FAA's future navigation program including both WAAS and LAAS.

GPS Signals Are Vulnerable to Interference

GPS provides low-power signals that are susceptible to both unintentional and intentional radio frequency interference.[22] For example, accidental or inadvertent interference by extraneous radio transmissions on the GPS frequency could cause the loss of service. Also, the potential exists that an individual or organization could disrupt the GPS navigation signals by jamming them.

FAA has recognized that the interference issue must be addressed and that appropriate measures must be in place before satellite navigation can become a "sole means" system. One mitigation strategy that FAA may employ includes retaining a portion of its existing ground-based navigation aids as a backup. Also, during the transition from ground-based navigation aids to WAAS, which would last for about a decade, both would be available to users and FAA. During this period, users would have time to equip their aircraft, and FAA would have time to test several countermeasures, including the use of the existing air traffic control and surveillance networks to safely control traffic in areas where there is interference and the use of flight inspection aircraft to detect interference events.

In recent months, vulnerability concerns about whether satellite navigation should be used as the "sole means" of providing aircraft landing guidance have been reemphasized. Consequently, FAA has begun assessing whether, and to what extent, it may have to maintain some portion of existing ground-based navigation aids as a backup navigation service.[23] As part of this effort, in July 1998, FAA, in a joint effort with industry, contracted with Johns Hopkins University Applied Physics Laboratory to conduct a detailed risk assessment of using GPS along with WAAS' and LAAS' augmentations as a "sole means" system for aircraft navigation. FAA expects to have the final report of this assessment by January 1999.

[22]These vulnerabilities are common to ground-based navigation aids. However, because GPS broadcasts its signal at a very low power level, its signal may be somewhat more vulnerable to interference.

[23]The issue of satellite navigation's vulnerability to interference was raised by the President's Commission on Critical Infrastructure Protection of October 1997. The purpose of this commission was to study the nation's infrastructure, which constitutes the life support system of the United States; determine the vulnerability of these support systems; and propose a strategy for protecting them in the future. Also, in October 1997, a group of independent experts from outside FAA, and called together by the agency, also raised concerns about the intentional jamming of GPS signals.

FAA Asserts That the Selection of a Second Frequency Would Benefit the WAAS Program

The present GPS satellites broadcast position data for the Department of Defense's use on two frequencies referred to as L1 and L2. WAAS will use data on the L1 frequency in conjunction with limited data available from the L2 frequency to make corrections. LAAS will rely solely on the L1 frequency for making corrections. According to FAA, providing full access to a second frequency can provide significant benefits in the long term for both these systems. A second frequency could provide another risk mitigation strategy to counteract these systems' vulnerability to electronic interference (mainly unintentional interference). If one frequency were lost because of interference, a second frequency could be used to provide service.

With a second frequency, FAA could build WAAS so that aircraft operators would be able to use receivers that could function on a single frequency now and on a dual frequency in the future. Building this type of "forward" compatibility into WAAS could cut down on users' investment in new receivers and FAA's future investments in WAAS to accommodate aircraft with single- and dual-frequency receivers. Another potential advantage is that FAA would need fewer WAAS ground stations and a smaller ground communications network in the future if dual frequency receivers are used to correct position data that may be distorted as GPS signals pass through the ionosphere. Also, dual-frequency receivers could be used by LAAS to detect and mitigate multipath problems caused when radio frequencies radiate off objects and create data errors.

However, challenges need to be resolved before these benefits can be realized. While the Interagency GPS Executive Board, together with its joint chairs, the Department of Defense and the Department of Transportation, has agreed that a second frequency protected for civil air navigation's safety of life function will be provided, there is still ongoing discussion within the executive board to identify the protected frequency.[24] The executive board has tentatively set December 1998 as the date for selecting this frequency. Furthermore, once the executive board agrees upon the second frequency, the United States will have to gain concurrence from the International Telecommunications Union at the next World Radio Conference. According to FAA officials, the next World Radio Conference is scheduled for 2000, and there have been earlier proposals

[24]The Interagency GPS Executive Board manages the dual civil and military use of GPS. The board is made up of representatives from the Departments of Transportation, Defense, Agriculture, Commerce, the Interior, Justice, and State, and the National Aeronautics and Space Administration.

that the conference is studying to share the spectrum used by GPS with nonaviation users.[25]

Beyond the challenge of identifying an additional frequency, funding issues need resolution. The Department of Transportation has agreed to fund the implementation of an additional frequency on the next generation of GPS satellites. While it may not be until 2010 before a significant number of these satellites will be placed in orbit, the Department of Transportation believes it has to begin making the investment soon in order to allow the manufacturer to build the second frequency into the design for next-generation satellites. According to the Department of Transportation, the amount that the agency has to invest can be established only once an agreement is reached on the additional frequency to be provided for civil air navigation use. Finally, current-generation GPS satellites still in production could be retrofitted to provide a second frequency capability and potentially bring about the expected benefits before 2010. However, because of concerns about the potential high costs of this solution—estimated to be about $130 million—the Department of Transportation has not agreed to fund this solution.

Acquisition of Additional WAAS Satellites Presents Significant Challenges

We reported in April 1998 that the acquisition of geosatellites for WAAS present some of the most significant cost, funding, and schedule challenges to the project.[26] Today, these challenges remain and have led to FAA's decision to delay the full implementation of the system to a date that has not yet been determined.

The greatest degree of uncertainty about the cost of WAAS surrounds the costs of satellites. This uncertainty exists because FAA does not know exactly how many additional satellites will be needed and how much the per-unit costs will be.[27] Although FAA had initially planned to award a contract in July 1998 for additional satellites, it did not meet this target date. FAA is currently analyzing various options to identify additional satellites, which include obtaining them from the existing provider. However, according to FAA officials, since the need for additional satellites and the timing for acquiring these satellites hinges on the outcome of the

[25]Every 2 years, the International Telecommunications Union of the United Nations holds a World Radio Conference to develop policy and decide major international telecommunications and radio spectrum issues affecting navigation and transportation systems.

[26]National Airspace System: Status of Wide Area Augmentation System Project (GAO/RCED-98-79, Apr. 30, 1998).

[27]According to FAA officials, if more GPS satellites and a second civil frequency were available along with deactivation of selective availability, the quantity of additional WAAS geostationary satellites and life-cycle costs for the geostationary satellites could be reduced.

previously mentioned risk assessment, they opted to wait for the results of the assessment, which is expected in January 1999, before deciding on a procurement strategy.

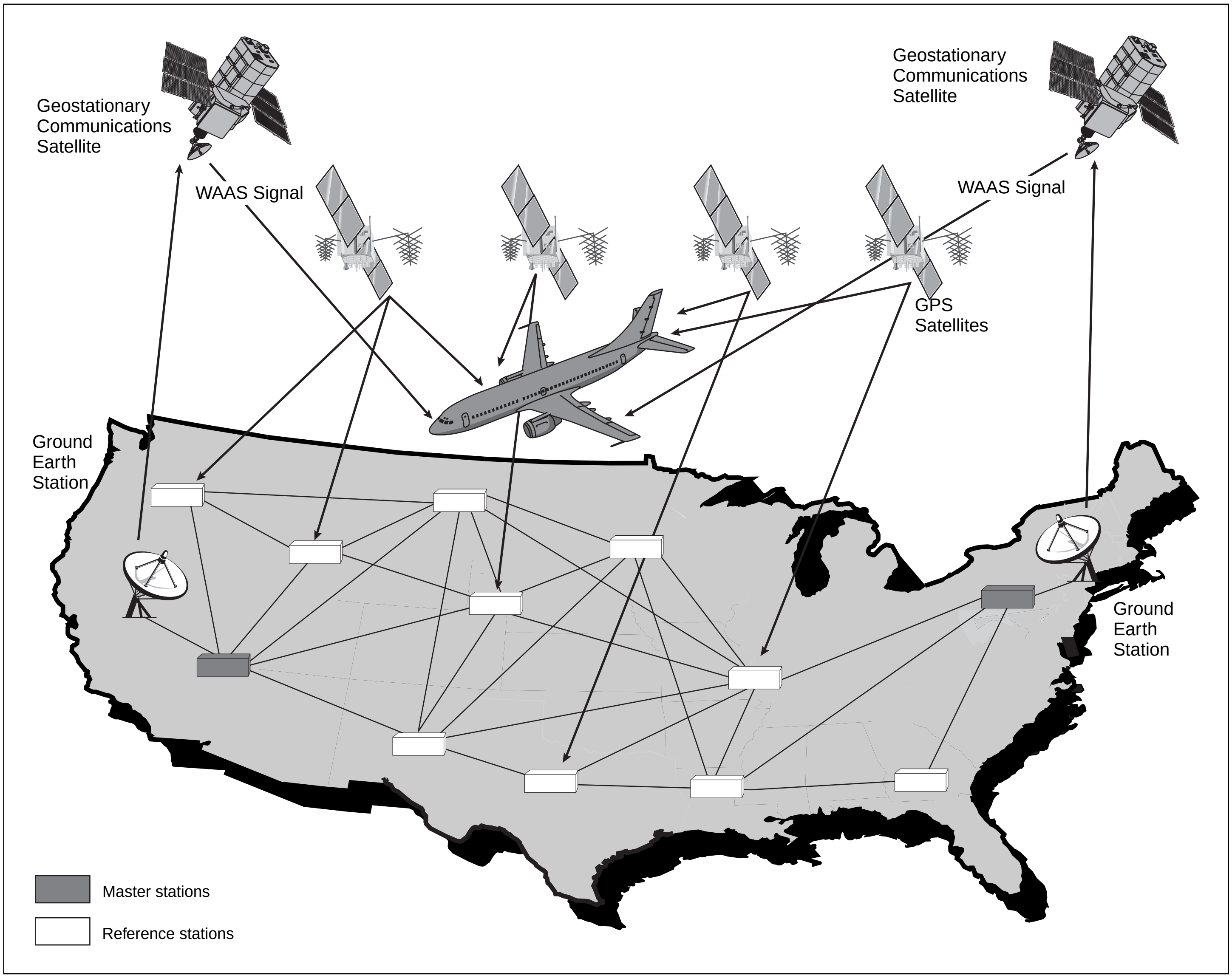
While the outcome of the risk assessment has postponed any decision to lease additional satellites, FAA officials stated that entering into any leasing negotiations with vendors has also been deferred for two other reasons. First, they stated that during this period of uncertainty, negotiations with satellite vendors would be precarious, at best. Since vendors are expected to absorb most of the costs associated with building and leasing the satellites, they may require huge premiums on leasing fees or large cancellation fees to cover their investment in case FAA subsequently decides against adding the satellites. Second, while FAA officials believe that they could not afford to purchase the satellites from the agency's F&E appropriation without significantly reducing other capital projects, the House mandated that the agency not sign a lease for WAAS satellites services until it evaluates whether a lease versus purchase acquisition will result in the lowest overall cost to the agency.[28]

In our April 1998 report, we questioned whether FAA would find a vendor willing and able to complete the launching and testing of satellites in time to meet FAA's December 2001 date for implementing the full WAAS capability. In this report, we stated that potential vendors pointed to 2002 or 2003 as a more realistic schedule for putting the satellites in orbit. Since our report, FAA's decision to postpone satellite acquisition activity, pending the outcome of the current risk assessment, coupled with the agency's efforts to evaluate operational experience with WAAS before moving to full capability and the need to resolve the lease versus purchase issue, will likely result in delays to the schedule. FAA officials recognize that the original date must change to allow enough time to address the above issues, and they stated that they did not expect to make this decision on the additional satellites until September 1999.[29] Notwithstanding this decision date, officials stated that a more realistic schedule for putting satellites in orbit would be around 2003 or 2004.

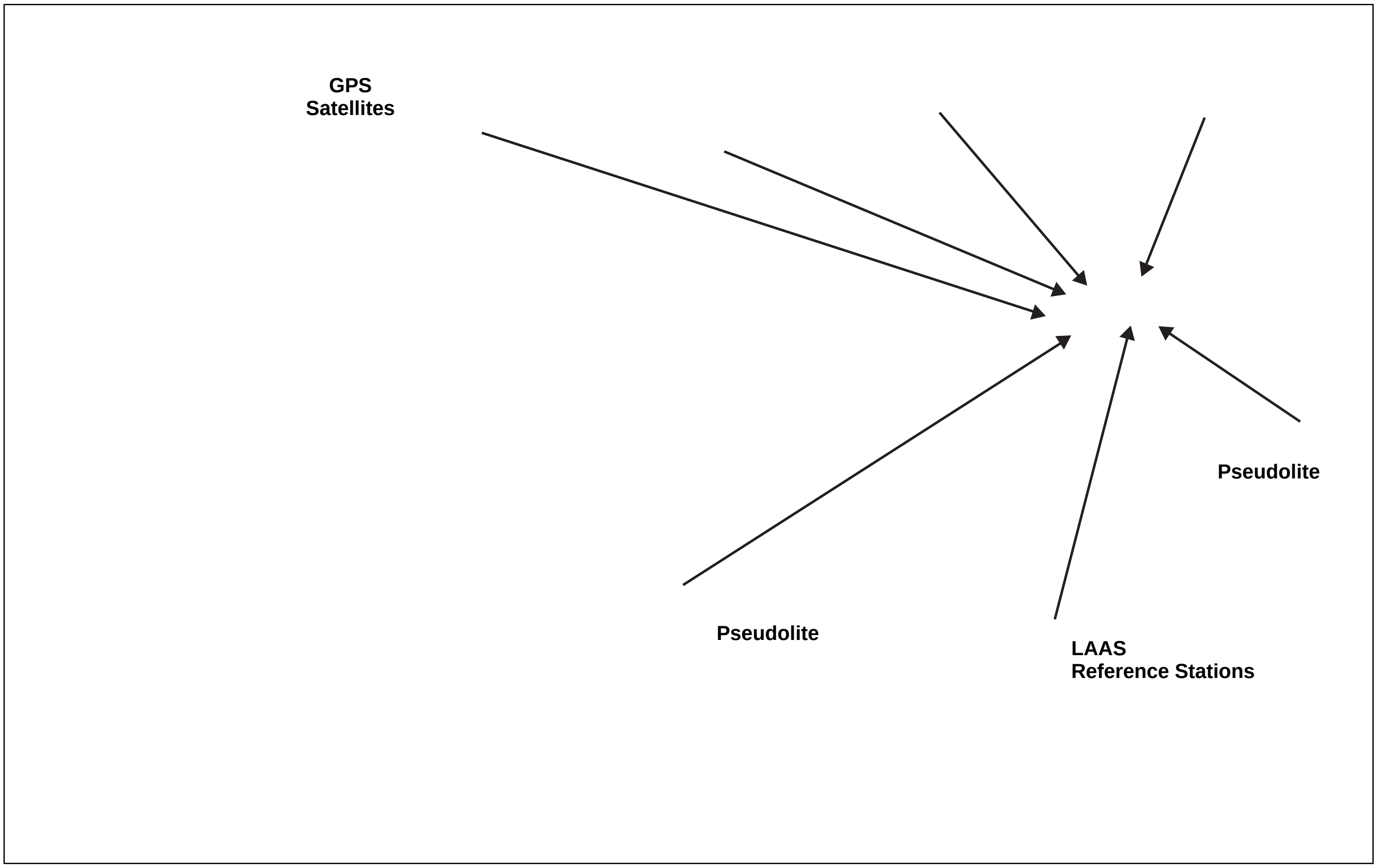
[28]The Department of Transportation and Related Agencies Appropriations Act for 1999, P.L. 105-277, Division A, sec. 101, (g)(1998).

[29]FAA's ongoing alternatives analysis may impact the decision regarding the need for the additional satellites. The results of this analysis is expected in May 1999.

Figure I.5: WAAS' Architecture



Source: FAA.



Source: FAA.

Host and Oceanic Computer System Replacement

Background

Many of the hardware components of the En Route and Oceanic automation systems have reached or are near the end of their service life, and are no longer supportable. Additionally, concerns existed that these systems would suffer potential Year 2000 problems. Therefore, an immediate need exists for FAA to ensure that current and planned service levels can be maintained until the replacement system is fully operational. The Host and Oceanic Computer System Replacement program replaces existing En Route and Oceanic automation hardware and software over a 4-year period. The project is structured into four phases to help minimize schedule and funding risks. Phase 1 of the project replaces existing En Route and Oceanic hardware, but it does not replace the existing software's functionality. Phase 2 provides new software, which basically duplicates the existing software functionality. Phases 3 and 4 replace peripheral equipment and add new software functionality. According to project officials, in June 1998, FAA awarded Lockheed Martin a contract for up to 24 operational systems and 7 support systems. The project's total F&E cost is estimated at $424.1 million, over an 8-year period that includes technology refreshment. To date, only Phase 1 of the project has a schedule baseline.

Changes to the Host and Oceanic Computer System Replacement Program's Cost and Schedule

Table I.11 summarizes the changes to the Host and Oceanic Computer System Replacement program's cost and schedule since June 1998.

Table I.11: Changes to Host and Oceanic Computer System Replacement Program's Cost and Schedule

Dollars in millions

Vendor: Lockheed Martin, Rockville, Md.

Financial information	June 1998	Oct. 1998	Change in dollars
Total F&E cost	$424.1	$424.1	None
Cumulative F&E appropriations through fiscal year 1998		$86.4	
Schedule	**June 1998**	**Oct. 1998**	**Change in months**
Estimated first-site implementation[a]	Jan. 1999	Jan. 1999	None
Estimated last-site implementation[a]	Oct. 1999	Sept. 1999	–1 month

[a]The implementation dates are only for Phase 1 of the program.

Host and Oceanic Computer System Replacement Program's Challenges and Risks

According to project officials, the project's schedule is the primary risk. Because the project's schedule is aggressive and coincides with other en route and oceanic modernization activities, the project office must maintain close coordination with other project teams and operational sites. The procurement, delivery, and installation of government-furnished equipment must also be monitored closely to ensure that all ancillary equipment required for complete installation and testing is available to the contractor. Project officials report that all Phase 1 hardware deliveries and site implementation plans are on or ahead of schedule.

According to project officials, the project's technical risk is low because the contractor is utilizing commercial-off-the-shelf equipment for this procurement. Moreover, the lead contractor is experienced at installing existing software on new equipment. In addition, the Host and Oceanic Computer System Replacement team successfully completed a "proof of concept" that showed that the existing software could run on the new platform in a demonstration at the FAA Technical Center.

Integrated Terminal Weather System

Background

Air traffic personnel in tower and terminal facilities rely on a number of sensors to obtain weather data. The interpretation of these data is performed manually and is labor-intensive. The main shortcoming of the present system is that it cannot anticipate short-term changes in ceilings, visibility, winds, and precipitation.

The Integrated Terminal Weather System (ITWS) is designed to automatically integrate data from terminal weather sensors to provide current weather conditions—as well as forecasts out to about 30 minutes in the future—in easily understood graphical and textual form to air traffic supervisors and controllers. ITWS will integrate information originating from several sources, such as next-generation weather radar products, Terminal Doppler Weather Radar, aircraft weather systems, surveillance radars, or weather-observing systems, and present it on displays located in the tower and Terminal Radar Approach Control (TRACON) facilities. ITWS' products include wind shear and microburst predictions, storm cell and lightning information, terminal area winds aloft, runway winds, and short-term ceiling and visibility predictions. FAA intends to deploy 37 ITWSs, including 34 at terminal facilities and 3 at other locations, for training, testing of interfaces, and software support and maintenance. The 34 systems that FAA plans to deploy at terminal facilities will enable air traffic controllers to better identify terminal area weather hazards at 45 major airports, thereby improving safety and capacity in bad weather.[30]

ITWS' Cost and Schedule

The total estimated F&E cost of ITWS has not changed since the contract was awarded in January 1997. Cost estimates were rebaselined during the contract's award because of a decrease associated with a higher-than-anticipated level of software productivity and reuse and a reduction in newly developed software lines of code. As of September 1998, FAA had obligated all of the $87.8 million appropriated since 1992 for the ITWS project. Funding was used to develop and test terminal weather algorithms, conduct demonstration/validation of the system using three functional prototypes, continue the operation of these prototypes, and test initial software.

ITWS has been on or ahead of schedule since the contract was awarded. For example, the Preliminary Design Review was conducted 2 months ahead of schedule in March 1998, and the Critical Design Review scheduled for January 1999 was completed 4 months ahead of schedule in September 1998. FAA plans to have the first of the 34 systems operational by April 2002 and have all 34 systems operational by July 2003. FAA has been successfully operating ITWS prototypes at the Memphis International Airport and Orlando International Airport since 1994 and at Dallas/Ft. Worth International Airport since 1995. As a result of their success, a fourth prototype was installed and became operational at LaGuardia Airport in August 1998. This prototype provides displays at LaGuardia, Kennedy, Newark and the Teterboro, New Jersey, airports; New York TRACON; New York, Boston, and Washington, D.C., en route centers, and at the Air Traffic Control System Command Center in Herndon, Virginia. The prototype is being funded by the New York/New Jersey Port Authority in conjunction with the Massachusetts Institute of Technology/Lincoln Laboratory. These prototypes allow for testing the system at different-sized airports and provide experience with different types of weather. The four prototypes will be among the first eight sites commissioned. Table I.12 summarizes ITWS' cost and schedule since 1997.

[30]TRACONs can control airspace surrounding multiple airports; therefore, one ITWS can serve more than one airport.

Table I.12: ITWS' Cost and Schedule

Dollars in millions

Vendors: Raytheon Systems Company, Marlborough, Mass.; Massachusetts Institute of Technology/Lincoln Laboratory, Boston, Mass.

Financial information	1997	1998	Change in dollars
Total F&E cost	$276.1	$276.1	None
Cumulative F&E appropriations through fiscal year 1998		$87.8	
Schedule	**1997**	**1998**	**Change**
Estimated first-site implementation	Apr. 2002	Apr. 2002	None
Estimated last-site implementation	July 2003	July 2003	None

ITWS' Challenges and Risks

Although ITWS is currently on schedule, software development efforts present a potential risk. To mitigate the risk of the project's schedule slipping, the ITWS project plans to continue Massachusetts Institute of Technology's/Lincoln Laboratory's support during the software development effort to provide for the transfer of technology from the actual research scientists to the software developers. Also, the actual implementation effort introduces potential risk to the project. For example, ITWS will require at least one telecommunications line from each of the sensors during the implementation. Although, FAA officials have stated that this is not technically difficult, the sheer volume and coordination effort required to install all of these communication lines adds risk.

Oceanic Automation Program

Background

With radar coverage largely unavailable and aircraft navigation limited to onboard systems, the current oceanic air traffic control system is significantly different from the domestic air traffic control system. The current oceanic air traffic control system is largely manual, dependent on air/ground communications through a third party, subject to atmospheric anomalies and human error, and troublesome when obtaining accurate aircraft position reports. This lack of reliable and timely position information, in turn, requires greater separation standards for aircraft, which severely limit the system's capacity. As a result, oceanic users are rarely able to obtain maximum fuel efficiency, minimum travel time, and access to preferred takeoff times and flight paths.

The Oceanic Automation Program is designed to provide a platform for improved air traffic control over the oceans. It evolved from the Oceanic Display and Planning System into the Oceanic Automation System, and, now, into the Advanced Oceanic Automation System. In the late 1980s, the Oceanic Display and Planning System improved oceanic traffic control by providing flight data processing and a situational display of estimated aircraft positions. This system also provided a conflict probe capability that alerted controllers when any flight plan or pilot-requested aircraft route change violated appropriate separation standards. In the early 1990s, FAA improved on the Oceanic Display and Planning System with the Oceanic Automation System, which improved data display and communications. This system is now being upgraded to the Advanced Oceanic Automation System, which is designed to provide such features as a new flight data processor, Automatic Dependent Surveillance position reporting, an advanced conflict probe, and data link. FAA awarded a contract to the Raytheon Systems Company in September 1995 for the Advanced Oceanic Automation System. The contract is composed of flexible segments, which will allow for incremental functional development and delivery of benefits. Oceanic air traffic control systems are installed at the en route centers at Oakland and New York and in Anchorage, Alaska.

Changes to the Oceanic Automation Program's Cost and Schedule

Over the past 3 years, FAA has reduced the cost and schedule baselines for the Oceanic Automation Program. Since FAA awarded the Advanced Oceanic Automation System's contract in September 1995, the scope of the project has been gradually revised from an original plan of five segments (incremental deliveries of capabilities) to only a portion of the first segment. In July 1996, 10 months after the contract's award, FAA canceled segments three, four, and five of the project because the agency recognized that the cost of executing these segments was beyond the funding that had been allocated for this project. As a result, FAA abandoned many controller productivity tools needed to increase the system's capacity. Then, in December 1996, funding concerns forced FAA to revise the second segment of the project, which replaces existing infrastructure hardware and software that supports controller equipment. Eventually, in September 1997, FAA canceled the entire second segment of the project because of the agency's need to use the project's funds to correct Year 2000 problems in existing oceanic automation software and because of the need to transfer funds to the Host replacement program.[31]

Meanwhile, FAA's contractor was reporting performance problems with the first segment of the project, which adds data link and automatic dependent surveillance in the oceanic environment. To avoid a potential $45 million contractor cost overrun associated with this segment, FAA then reduced the scope of segment one of the project in September 1998 by eliminating the capability for automatic dependent surveillance. According to project officials, the remaining elements of segment one (air-to-ground data link, ground-to-ground data link, and controller tools) have successfully completed the operational test and evaluation and are expected to be delivered on schedule. Table I.13 summarizes the changes to the Oceanic Automation Program's cost and schedule since 1996.

Table I.13: Changes to Oceanic Automation Program's Cost and Schedule

Dollars in millions

Vendor: Raytheon Systems Company, Reston, Va.

Financial information	1996	1998	Change in dollars
Total F&E cost	$236.5	$189.0	–$47.5
Cumulative F&E appropriations through fiscal year 1998		$189.0	
Schedule	**1996**	**1998**	**Change in months**
Estimated first-site implementation	Feb. 2000	Sept. 1999	–5 months
Estimated last-site implementation	June 2000	Oct. 1999	–8 months

Oceanic Automation Program's Challenges and Risks

Project officials state that the Advanced Oceanic Automation System's original requirements to improve oceanic air traffic control automation remain valid today and that they will require FAA's attention in the very near future, particularly those that increase controller's efficiency. According to project officials, FAA is presently examining alternatives for satisfying these needs.

[31]The Host replacement project replaces en route center and oceanic automation hardware that has reached the end of its commercial support life and may have problems with Year 2000 date requirements.

Operational and Supportability Implementation System

Background

The Operational and Supportability Implementation System (OASIS) project (1) replaces all existing Flight Service Automation System hardware and software with a leased commercial, off-the-shelf-based service; (2) provides a graphic weather display capability that is currently being obtained through the Interim Graphic Weather Display system; and (3) incorporates direct user-access functionality that is currently being obtained through two Direct User Access Terminal contracts. The integration of these three capabilities and functions into a single system will enable flight service specialists to more efficiently produce weather and flight-planning information for pilots. In August 1997, FAA awarded Harris Corporation a contract for OASIS services. The contract requires Harris to provide up to 61 operational systems and 3 support systems.

Changes to OASIS' Cost and Schedule

FAA's May 1998 decision to replace existing workstation consoles and install new ones in response to human-factor concerns raised by the unions that represent the controllers and the technicians caused the project's cost to increase by $15.8 million. Table I.14 summarizes the changes to OASIS' cost and schedule since 1997.

Table I.14: Changes to OASIS' Cost and Schedule

Dollars in millions

Vendor: Harris Corporation, Melbourne, Fla.

Financial information	1997	1998	Change in dollars
Total F&E cost	$174.7	$190.5	+$15.8
Cumulative F&E appropriations through fiscal year 1998		$25.9	
Schedule	**1997**	**1998**	**Change in months**
Estimated first-site implementation	July 1998	Jan. 1999	+6 months
Estimated last-site implementation	Aug. 2001	Aug. 2001	None

OASIS' Challenges and Risks

Since FAA awarded the contract for OASIS services in August 1997, the agency has seen the project's schedule slip because of a larger-than-planned developmental effort. FAA's January 1998 review of the Harris system's architecture for OASIS revealed that the contractor's commercial-off-the-shelf solution was not as mature as FAA had envisioned when the contract was awarded and revealed that many of the contractor's commercial products did not fully satisfy its requirements. FAA delayed first-site implementation from July 1998 to January 1999—a 6-month slip. Last-site implementation is not affected by the protracted development effort and remains scheduled for August 2001.

Adding more risk to the project's schedule are a number of human-factor issues that have been raised by the National Association of Air Traffic Specialist union and the Professional Airways Systems Specialists. While the unions have yet to formally develop a comprehensive list of concerns, project officials said that the unions are troubled about such issues as lighting glare, shelf height, and immoveable keyboards. The unions want these issues resolved before OASIS is deployed. FAA officials responsible for requirements are working collaboratively with the program office to address these concerns.

Finally, according to project officials, the project's schedule has the potential to slip further because the amount of fiscal year 1999 funding was less than requested.

Standard Terminal Automation Replacement System

Background

The Standard Terminal Automation Replacement System (STARS) is designed to replace FAA's automated radar terminal system, which comprises 15- to 25-year-old controller workstations, and supporting computer systems that allow controllers at TRACONs to separate and sequence aircraft. According to FAA, this system is prone to failures and is maintenance intensive. The system also has capacity constraints that restrict the agency from making required safety and efficiency enhancements. STARS equipment is also expected to provide the platform needed to make enhancements to the system that would increase the level of air traffic control automation and improve surveillance, communications, and weather display. (See fig. I.7.)

In September 1996, FAA signed a contract with Raytheon Systems Company to acquire STARS. In producing the system, Raytheon originally intended to rely exclusively on commercially available hardware and, to a large extent, on commercially available software. The strategy for replacing and enhancing the system is divided into two stages—the initial system capability stage and the final system capability stage. Stage 1 is expected to provide the same functions as the current automated radar terminal systems. Under Stage 2, FAA expects to implement new functions to help controllers move aircraft more safely and efficiently. In 1997, FAA created another stage, known as early display configuration, because of concerns about operational problems at Ronald Reagan National Airport. This new stage will be implemented prior to Stages 1 and 2. The new stage replaces the current controller displays and monitoring equipment but will require the use of the existing computer system and software. It also provides an emergency back-up system.

STARS replaced the Terminal Advanced Automation System segment of the Advanced Automation System project, which was terminated because of serious cost and schedule problems. The terminal segment was estimated to cost about $810 million, and at the time of termination, FAA had sunk about $317 million into it. The terminal segment's first-site implementation date was August 1997. FAA did not establish a last-site implementation date.

STARS' Cost and Schedule

Table I.15 summarizes STARS' cost and schedule since 1996.

Table I.15: STARS' Cost and Schedule

Dollars in millions

Vendors: Raytheon Systems Company, Marlborough, Mass.

Financial information	1996	1998	Change in dollars
Total F&E cost	$940.2	$940.2	None
Cumulative F&E appropriations through fiscal year 1998		$211.6	
Schedule	**1996**	**1998**	**Change**
Estimated first-site implementation—initial stage	Dec. 1998	Dec. 1998	None
Estimated last-site implementation—final stage	Feb. 2005	Feb. 2005	None

STARS' Challenges and Risks

Although FAA has not officially changed the STARS' baseline that was approved in 1996, the baseline is in jeopardy of being breached because of unions' concerns surrounding human-factor and design issues, the refinement of requirements, and the interjection of a new project phase. FAA estimates that these issues have the potential to increase the project's costs from $294 million to $410 million over the approved baseline. FAA also estimates that the project's initial completion could be delayed by almost 2-1/2 years. For future projects, cost overruns and schedule slippages in excess of 10 percent of the cost and schedule baselines will require the Administrator of FAA to consider terminating the project under recently passed legislation.[32]

In addition to the issues cited above, the project has experienced other challenges related mainly to software testing. While project officials stated that they have been able to absorb the cost increases within the existing baseline, additional risks could cause further cost increases and schedule delays.

Unions' Concerns

NATCA and the Professional Airways Systems Specialists are working to resolve 98 and 59 human-factor problems with STARS, respectively. In September 1998, FAA estimated that the total cost for incorporating all human-factors issues into the final design of STARS would be $192 million. According to FAA, if the full scope of these issues is incorporated into the system's design, doing so would require the development of an additional

[32]Air Traffic Management System Performance Improvement Act of 1996 (P.L. 104-264, Oct. 9, 1996).

220,000 lines of software code and delay the deployment of the final design of the system to June 2001—an almost 2-1/2-year delay from the initial systems capability.

For example, one of NATCA's human-factor concerns centered around a lack of sufficient details about an aircraft's position and movement, which could hamper controllers' ability to monitor traffic movement. The Professional Airways Systems Specialists' concerns centered mainly on a lack of standardization between the primary and backup STARS systems. For example, technicians must use two different screens to monitor the integrity of both systems, and the visual warning alarms and color coding to denote problems in the systems were not standard.

FAA could incur an additional cost of $116 million, if the agency addresses NATCA's concerns that the system's design include synchronization between the primary and backup systems. If the primary system fails, synchronization would provide the backup with a smoother transition by enabling controllers to forego having to recalibrate information needed for controlling and separating aircraft. Without synchronization, such system inefficiencies as slowing down traffic or increasing the separation between aircraft could occur.

Requirements Refinement

In order to promote competition among vendors who may have had commercial and nondevelopmental applications that could address FAA's needs, the STARS system specification was written at a high-level. Consequently, when FAA awarded the contract, it left the system's functional specifications open to interpretation. As a result, according to FAA officials, considerable engineering was expended in an effort to clarify the system's requirements. For example, the additional engineering effort caused software development to grow from an estimated 124,000 lines of software code to about 162,000 lines of code because of more-detailed specifications on how STARS was expected to function. The engineering effort also identified, among other things, the need to strengthen security and seismic requirements and add additional equipment. FAA officials estimate the added cost for these requirements refinements to be about $56 million.

New Early Display Configuration Stage

Because of the concerns about human-factors problems and delays in developing the initial system, FAA now anticipates that it may have to deploy the system's early display configuration to as many as 33 additional TRACONS and to install automated radar terminal systems in new TRACONS that were scheduled to begin operation prior to June 2001. FAA believes that this early deployment of the system's displays solves one of its most immediate problems—the failure of displays in the existing system. FAA estimates that the additional costs associated with these changes account for about $46 million of the cost growth.

Other Challenges

Other challenges that could have an impact on the STARS project include FAA's software development problems related to the system's early display configuration and its initial system capability. For example, software problems have pushed back the initial deployment of the early display configuration at Ronald Reagan National Airport from September 1998 to March 1999. An additional deployment of software to make the system operationally ready is scheduled for July 1999. According to FAA, because of concerns about completing the development of software and resolving testing issues, a high probability exists that meeting both the March and July 1999 dates will not be achieved. Technical problems with software are also affecting the development of the system's initial system capability software. For example, Raytheon and FAA report software problems through their program trouble reports. Two of the most worrisome program trouble reports are types 1 and 2. Type 1 program trouble reports, if not corrected, could prevent the accomplishment of mission-essential capabilities. Type 2 program trouble reports must be corrected before key site testing of software can proceed. As of September 1998, the total number of open program trouble reports totaled nearly 570, and type 1 and 2 program trouble reports totaled 8 and 231, respectively.

FAA and Raytheon have mitigation efforts under way, including monthly reviews that involve software demonstrations and the weekly monitoring of the progress of software testing. Also, according to project officials, they have been able to contain cost increases within the existing baseline by using planned baseline reserves and by eliminating, combining, and compressing certain tests. These actions may cause further cost and schedule delays in the future. For example, we have reported that systems development without careful and thorough testing has proven to be imprudent and unproductive in many software development efforts. The results from such shortcuts are systems that typically cost more, are of low quality, and are generally late.[33]

Finally, FAA has assured the Congress that it will not place a new system into service without first verifying that the system will not experience Year

[33]In Air Traffic Control: Immature Software Acquisition Processes Increase FAA System Acquisition Risks (GAO/AIMD-97-47, Mar. 21, 1997), we pointed out that the lack of a disciplined software development process has contributed to FAA's past problems to deliver systems capabilities on time and within budget.

2000 problems. FAA is now in the process of assessing whether STARS will have a Year 2000 problem, and it plans to invest over $4 million to carry out Year 2000 assessment and testing activities. While FAA's initial assessment results show the Year 2000 processing risks to be low to medium, officials are awaiting the results of final assessments, and tests needed to determine whether additional software changes may be needed.

Figure I.7: STARS

Source: FAA.

Terminal Doppler Weather Radar

Background

The Terminal Doppler Weather Radar (TDWR) system will alert aircraft in the terminal area of hazardous weather conditions, such as microbursts, gust fronts, and precipitation. The radar also will alert controllers of changing wind conditions, thereby permitting them to make timely runway changes. (See fig. I.8.) In November 1988, FAA contracted with Raytheon to develop, produce, and install 47 TDWR systems.

Changes to TDWR's Cost and Schedule

According to FAA officials, three factors have caused the cost of the project to increase by $71.3 million since November 1988. First, FAA's failure to properly estimate the cost for installing TDWR systems caused the project's cost to increase by $30 million. Second, environmental reviews conducted by FAA at proposed sites identified environmental issues that caused the project's costs to increase by $26 million. Finally, land acquisition problems necessitated that FAA and its contractor keep key project personnel longer than planned to field the systems. This caused the project's cost to increase by $15.3 million. The project's schedule delays are primarily due to land acquisition and environmental problems. Table I.16 summarizes the changes to TDWR's cost and schedule since 1988.

Table I.16: Changes to TDWR's Cost and Schedule

Dollars in millions

Vendor: Raytheon Systems Company, Marlborough, Mass.

Financial information	1988	1998	Change in dollars
Total F&E cost	$322.2	$393.5	+$71.3
Cumulative F&E appropriations through fiscal year 1998		$382.8	
Schedule	**1988**	**1998**	**Change in years/months**
First-site implementation	Aug. 1993	July 1994	+11 months
Estimated last-site implementation	Aug. 1996	July 2001	+4 years, 11 months

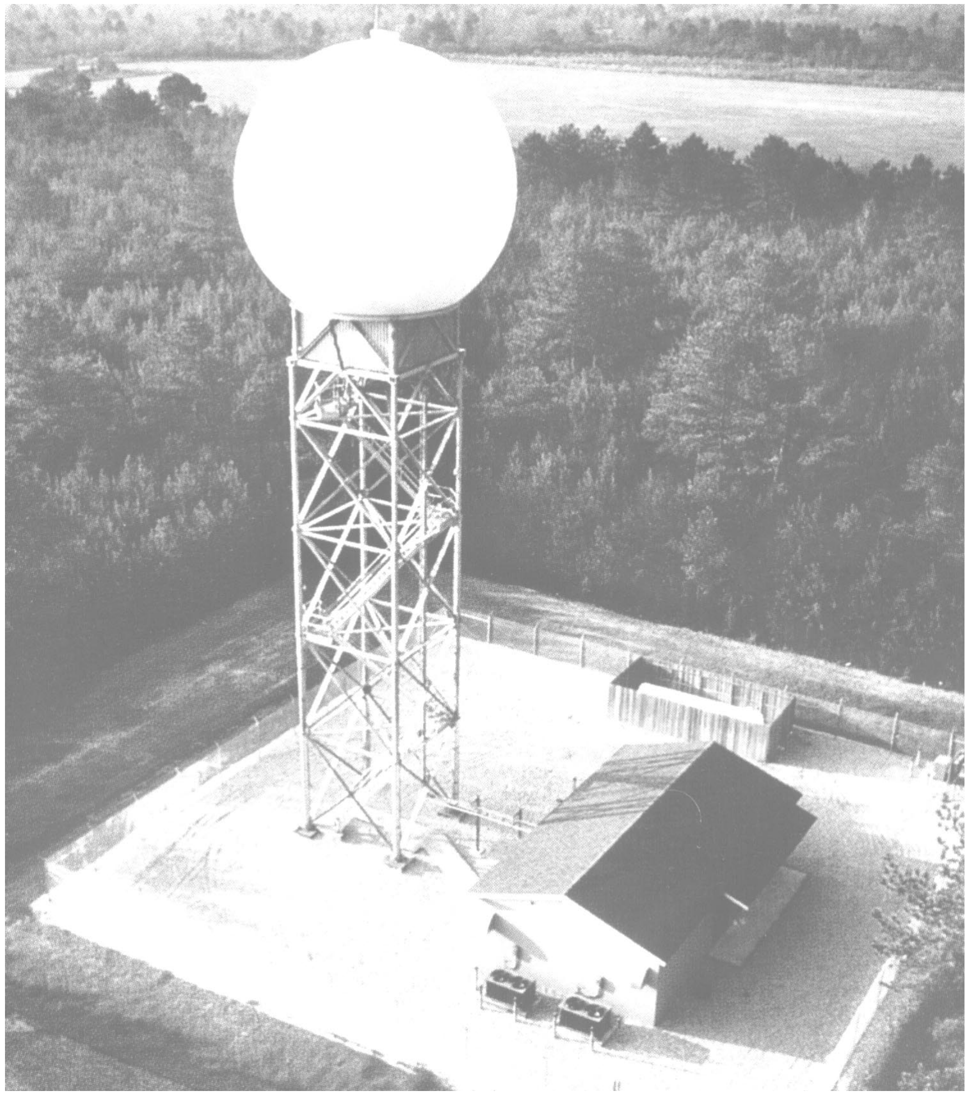
TDWR's Challenges and Risks

For the past 10 years, land acquisition and environmental problems have plagued the project. These problems continue, causing increased delays to installation schedules and increased installation costs. As a result, FAA does not have much confidence in its last-site implementation date for completion of the project. The project office is working toward implementing 45 of the 47 planned systems by December 1998. The final two systems, scheduled for Chicago's Midway Airport and New York, remain in storage at FAA's Aeronautical Center in Oklahoma City.

According to project officials, FAA's progress with Chicago-Midway had been stymied for 2 years by problems associated with buying land. As a last resort, FAA used condemnation procedures to reach closure on this matter. In June 1998, FAA acquired the land for the Chicago-Midway TDWR installation. Project officials anticipate that an operational system will be available at Chicago-Midway in the summer of 2000.

Project officials stated that New York has experienced great difficulty in finding a suitable location for the TDWR. Over a 4-year period, proposed locations were rejected by both residents and local politicians on the grounds that the radar's electromagnetic radiation posed potential health problems. Residents also rejected the radar itself as being inappropriate and unsightly for a residential community. FAA's current preferred site is located on public land. According to project officials, an extensive environmental impact study is being made of the site, which has prolonged the system's installation. Project officials expect to receive the necessary environmental approvals by November 1998. Project officials also expect residents who oppose FAA's planned use of the site to initiate a court action. Because of the expected court action, the last-site implementation date remains tentative and could be pushed back even further.

Figure I.8: TDWR



Source: FAA.

Terminal Radar Digitization, Replacement, and Establishment Program: Airport Surveillance Radar-11 Project

Background

The Terminal Radar Digitization, Replacement, and Establishment (TRDRE) program includes projects to replace and upgrade current surveillance radars. The Air Route Surveillance Radar-11 (ASR-11) project is a primary and secondary surveillance radar system that will enable air traffic controllers to monitor aircraft approaching, departing, and passing through airport terminal areas. (See fig. I.9.) ASR-11 will provide a more reliable replacement for aging analog ASR-7s and ASR-8s, and will also provide digitized radar data necessary for interfacing with new automation systems, such as STARS, planned to be used by terminal controllers. FAA also plans to upgrade several ASR-8s with interim digitizers under a separate contract to ensure that the radars are available to meet STARS' implementation schedule.

Through a contract managed by the Department of Defense, FAA is providing the Air Force with funding for the procurement of 112 ASR-11 radars that are designated for use at midsize airports. Ninety-five systems will replace aging ASR-7/8s; 13 systems will be used for new establishments or the Department of Defense takeover sites; 2 will be mobile units; and 2 will be support systems. Unlike the existing ASR-7/8s, ASR-11s are intended to be more reliable and easier to maintain. They are also designed to provide more accurate weather and target information, less clutter, and fewer false targets on the controllers' displays. The ASR-11 is a nondevelopmental item with modifications to approximately 15 percent of the system. The most significant modifications are to the interface equipment.

Changes to ASR-11's Cost and Schedule

At the time the contract was awarded in August 1996, FAA had yet to determine the total number of ASR-11 systems that it would require or the total cost estimates of the project. The agency had preliminary project cost estimates of $561.3 million for the purchase of 48 ASR-11s and the upgrade of the ASR-8s with digitizers. However, during 1997, FAA conducted an analysis that demonstrated that it would be more cost beneficial to replace all the ASR-8s with ASR-11s rather than upgrade them with digitizers. As a result, in November 1997, FAA approved an estimated $743.3 million for 112 ASR-11s. Also, included in this amount was more than $9 million to upgrade 10 ASR-8s with interim digitizers. As of September 1998, FAA had provided $70.4 million for the procurement of two preproduction units for the initial development of the automation interface, in-plant testing, five production units, and three ASR-8 interim digitizers.

Factory testing of the ASR-11 began in October 1997, and, in September 1998, the installation of the ASR-11 at the Department of Defense's test site at Eglin Air Force Base, Florida, was completed. Site preparation at FAA's test site at Stockton, California (the first of two FAA preproduction sites) has begun and is scheduled to be completed in December 1998. First-site implementation at Stockton is scheduled for January 2000. As of October 1998, the current last-site implementation date is scheduled for September 2005 at a presently undetermined location. Table I.17 summarizes the changes to ASR-11's cost and schedule since 1996.

Table I.17: Changes to ASR-11's Cost and Schedule

Dollars in millions

Vendor: Raytheon Systems Company, Marlborough, Mass.

Financial information	1996	1998	Change in dollars
Total F&E cost	$561.3	$743.3	+$182.0
Cumulative F&E appropriations through fiscal year 1998		$70.4	
Schedule	**1996**	**1998**	**Change**
Estimated first-site implementation	Jan. 2000	Jan. 2000	None
Estimated last-site implementation	Not determined	Sept. 2005	N/A

Legend

N/A = not applicable

ASR-11's Challenges and Risks

ASR-11 faces risk if (1) unexpected environmental problems and bad weather occur, (2) the schedule for STARS continues to slip, and (3) the contractor's test and system modification development strategy for the project is not successful.

First, seasonal constraints for site surveys and preparations and additional processing time related to environmental impact surveys could cause ASR-11's schedule to slip. A risk mitigation strategy was employed to accomplish site surveys up to 2 years in advance of delivering systems and site designs up to 1 year in advance of delivering systems.

Second, the ASR-11 deployment schedule is currently based on the need to have a digital signal available for STARS. STARS requires a digital radar, but ASR-11 can be delivered and commissioned without STARS. Although STARS' schedule is slipping, an operational need for ASR-11 still remains because the current ASR-7 and ASR-8 equipment is aging and needs to be replaced. According to project officials, if STARS' schedule slips more than 1 year, FAA will likely reevaluate the ASR-11 deployment schedule on the basis of the condition of the current ASR-7 and ASR-8 equipment rather than on the basis of the STARS' schedule.

Finally, the ASR-11 contractor's current strategy for testing requirements and developing system modifications could lead to delays in the project's baseline schedule. The original strategy called for a test program that utilized previous test data and quick approval of test documentation from the Contract Data Requirements List. Currently, however, little previous test data have been used to verify specification requirements, and the test Contract Data Requirements Lists originally submitted by the contractor did not meet minimal requirements. As a result, testing has been delayed. In April 1998, FAA implemented a streamlined test documentation development and approval process to facilitate better management of the testing process.

In addition, contractor's delays have occurred in the completion of the development and integration of system modifications. As a result, resources for the radar system have been dedicated to development activity rather than test activity. This has caused additional delays in the test program. The contractor has proposed double shifts for testing and parallel testing as a means of offsetting these delays.

Figure I.9: ASR-11 at Eglin Air Force Base, Florida

Source: FAA.

Voice Switching and Control System

Background

The Voice Switching and Control System (VSCS) replaces existing communication systems at en route centers with an expandable, highly reliable system for both ground-to-ground and air-to-ground communication. VSCS will also provide a communication capability for new en route center controller workstations. (See fig. I-10.) FAA is also installing the VSCS Training and Backup Switch (VTABS)—an emergency back-up communications system, should VSCS experience an equipment outage—at all en route centers.

VSCS was designed to provide the communication capabilities for the new Initial Sector Suite System workstations under the Advanced Automation System program. By the time that the VSCS contract was awarded in December 1991 to the Harris Corporation, FAA had spent 5 years in developing prototypes and had incurred cost growth of around $1 billion.[34] The contract required Harris to deliver 23 VSCS systems—21 for en route centers and 2 support systems. FAA's plans called for VSCS to be installed with the current equipment and with the new controller workstations. During the initial development, the cost of the VSCS project increased by $53.1 million to approximately $1.45 billion—costs associated primarily with FAA's decision in 1994 to cancel the Initial Sector Suite System component of the Advanced Automation System and replace it with the DSR project. The restructuring resulted in the need for additional equipment and testing and the extension of contractor and project personnel longer than planned to field VSCS equipment with DSR equipment. FAA has also added new functionality requirements to the project. Harris developed and installed the system in the existing en route controller work stations in February 1997—5 months ahead of schedule established at the time of contract award.

Harris is reinstalling the controller interface equipment into the en route DSR controller workstations. First- and last-site implementation dates for this phase are the same as those for DSR—October 1998 and May 2000, respectively.

[34]According to project officials, the primary reason for this growth was the inability of commercially available products to effectively and accurately manage air traffic control communications functions.

Changes to VSCS' Cost and Schedule

Since the schedule for transferring VSCS to the DSR console is the same as that for the DSR project, the agency is projecting a 1-1/2-month slip in first-site implementation from October to December 1998. Table I.18 summarizes the changes to VSCS' cost and schedule since 1994.

Table I.18: Changes to VSCS' Cost and Schedule

Dollars in millions

Vendor: Harris Corporation, Melbourne, Fla.

Financial information	1994	1998	Change in dollars
Total F&E cost	$1,452.9	$1,452.9	None
Cumulative F&E appropriations through fiscal year 1998		$1,388.9	
Schedule	**1994[a]**	**1998**	**Change in months**
Estimated first-site Implementation	Oct. 1998	Dec. 1998	+1.5 months
Estimated last-site implementation	May 2000	May 2000	None

[a]Schedule is for activities that coincide with the schedule for the DSR project.

VSCS' Challenges and Risks

Harris has completed software development for the primary system to be fielded with the new DSR controller workstations. According to the project manager, the project has not encountered any technical problems and is not expected to incur any major schedule slips.

Meanwhile, FAA is in the process of installing VTABS at all en route centers. By the end of 1998, FAA expects to have VTABS equipment installed at 10 en route centers, the FAA Technical Center, and the FAA Academy. FAA plans to have VTABS installed at the remaining en route centers and in Alaska by November 1999.

In fiscal year 1998, FAA reprogrammed $22 million of the $45.4 million appropriated for VSCS to support the Host replacement project. This reprogramming action forced the project office to defer, until at least 2001, the replacement of Tandem computers used by VSCS in its operating system. The project office views this computer replacement as critical because Tandem will not certify the existing computers as Year 2000 compliant. Currently, FAA and its contractor are conducting tests to determine if there is a Year 2000 problem. Tests to date have uncovered only minor problems for which FAA has identified solutions.

According to the VSCS project manager, although no significant Year 2000 problems have been identified with the Tandem computer, the computer and its operating system are several generations old. FAA's current software licensing and hardware maintenance agreements have expired for FAA's Technical Center and FAA's Academy systems, greatly increasing the monthly licensing and maintenance fees. Software licensing agreements for the operational systems will begin to expire in 2003 and will have similar program effects. On the basis of the fees that Tandem charges FAA for the obsolete operating systems at FAA's Technical Center, it is conceivable that the fees that Tandem will charge for the obsolete operating systems for the operational sites for one year could exceed the cost to replace the Tandem computers. FAA currently has efforts under way to restore funding for the Tandem computer replacement project in fiscal year 1999 to ensure that the computers are replaced before the license agreement expires for the operational system.

Figure I.10: VSCS Display Module

Source: FAA.

Weather and Radar Processor

Background

The Weather and Radar Processor (WARP) is an automated processing and display system that will acquire, process, and disseminate Next Generation Weather Radar data to air traffic personnel at 21 en route centers and one each at the Air Traffic Control System Command Center and the FAA Technical Center. Meteorologists will receive the data at their workstation; area supervisors, via WARP briefing terminals; and en route controllers, via the situation displays provided by DSR. WARP is being acquired in three stages and will replace the current Meteorological Weather Processor system. Stage 0 is an early deployment of a commercial off-the-shelf system that will replace and improve the functionality of the current system that experienced many problems in the past. Stage 1/2 is the core of the project, where interfaces with DSR, several Next Generation Weather Radar products—such as precipitation detection at multiple levels—and other current systems will be developed. The latter part of this stage is intended to improve the interface with Next Generation Weather Radar products and allow for other improvements, such as providing the controller with the ability to request and reply to data. FAA plans to implement Stage 3 in the future to provide WARP with critical operational changes. This stage will also allow WARP to interface with other systems now being developed, such as ATM/Free Flight Phase 1, ITWS, OASIS, and Oceanic Automation Program.

Changes to WARP's Cost and Schedule

Stage 0 has been completed. The project met all its milestones on or ahead of schedule for this stage since the contract was signed in July 1996. For example, the first operational readiness demonstration for Stage 0 was met 2 months ahead of schedule in July 1997, and the last demonstration was met 5 months ahead of schedule.

Also, in 1997, both preliminary and critical design reviews for Stage 1/2 were achieved months ahead of schedule. According to an FAA Office of Aviation Research official, a working group was also initiated during preliminary design review to address any human-factor questions that might be raised in the project's early stages. However, first- and last-site implementation for Stage 1/2 have slipped 5 months each because of Year 2000 testing requirements; a slip in the Next Generation Weather Radar certification testing schedule; an anticipated delay in operational test and evaluation because of the unavailability of the DSR interface; and an additional requirement to develop initial weather telecommunications capabilities. Currently, Stage 1/2 is in full-scale development, and three limited production systems for Stage 1/2 have been procured. Cost estimates for the project have remained constant since the contract's award. Stage 3 was originally scheduled to get started in 1999. Stage 3 is not considered part of the project schedule's official baseline. Table I.19 summarizes the changes to WARP's cost and schedule since 1996.

Table I.19: Changes to WARP's Cost and Schedule

Dollars in millions

Vendor: Harris Corporation, Melbourne, Fla.

Financial information	1996	1998	Change in dollars
Total F&E cost	$125.6	$125.6	None
Cumulative F&E appropriations through fiscal year 1998		$57.7	
Schedule	**1996**	**1998**	**Change in months**
Estimated first-site implementation	Sept. 1999[a]	Feb. 2000[a]	+ 5 months
Estimated last-site implementation	Feb. 2000[a]	July 2000[a]	+ 5 months

[a]Represents Stage 1/2.

WARP's Challenges and Risks

According to an FAA project official, three of the four issues that caused the 5-month slip in the project's first- and last-site implementation have been mitigated. The required development of initial weather telecommunications capabilities—the fourth issue—is an ongoing effort but should not cause further slips in the project's first- and last-site implementation.

Modernization Projects Completed Through August 1998

Dollars in millions

Project (project number)	Completion date	Total reported facilities and equipment cost
Automated Radar Terminal System (ARTS) IIIA Assembler (22-02)	1983	0[a]
ARTS II Displays (22-07)	1984	$ 3.6
Radar Remote Weather Display System (23-10)	1984	0[a]
Interim Voice Response System (23-06)	1985	0[a]
Geostationary Operational Environmental Satellite Recorders (23-11)	1985	1.9
En Route Automation (21-01)	1986	2.3
ARTS IIIA Memory (22-04)	1986	8.6
Additional ARTS IIIA at FAA Technical Center (22-05)	1986	4.7
ARTS II Interfacility Interface (22-08)	1986	0[a]
Consolidated Notice to Airmen System (23-03)	1986	0[a]
Radar Microwave Link Trunking (25-01)	1986	8.2
Teletypewriter Replacement (25-09)	1986	5.1
Nonradar Approach (21-14)	1987	1.6
Air Traffic Control Tower Closures (22-14)	1987	1.5
Air/Ground Communications Equipment Modernization (24-01)	1987	60.6
Airport Telecommunications (25-05)	1987	4.2
Data System Specialist Support (51-20)	1987	32.0
Host Computer (21-07)[b]	1988	290.7
Altitude Reporting Mode of Secondary Radar (Mode-C) (21-10)	1988	0[a]
Enhanced Target Generator Displays (ARTS III) (22-03)	1988	0[a]
Nondirectional Beacon (24-04)	1988	23.8
National Airspace Data Interchange Network IA (25-06)	1988	17.0
Aircraft Fleet Conversion (26-11)	1988	68.6
Enhanced Terminal Conflict Alert (22-01)	1989	0.4
Automatic Terminal Information Service Recorders (22-10)	1989	11.2
High-Altitude En Route Flight Advisory Service (23-07)	1989	6.3
Hazardous In Flight Weather Advisory Service (23-08)	1989	7.3
Instrument Landing System (24-06)	1989	69.6

(continued)

Dollars in millions

Project (project number)	Completion date	Total reported facilities and equipment cost
Power Conditioning Systems for ARTS III (26-06)	1989	21.5
TPX-42 Replacement (22-17)	1990	40.0
Flight Data Entry and Print-Out Devices (21-02)	1991	18.8
En Route Automated Radar Tracking System Enhancements (21-04)	1991	2.8
Offshore Flight Data Processing System (21-16)	1991	1.0
Sustain New York Terminal Radar Approach Control (TRACON) (22-18)	1991	95.4
Computer-Based Instruction (26-02)	1991	10.4
National Radio Communication System (26-14)	1991	82.7
Direct Access Radar Channel System (21-03)	1992	45.0
Air Traffic Control Tower/TRACON Modernization (22-13)[c]	1992	391.4
Communications Facilities Consolidation/Network (24-02)	1992	16.8
National Airspace Data Interchange Network II (25-07)	1992	42.4
Power System (26-07)	1992	71.5
Modernization of Unmanned FAA Buildings and Equipment (26-08)	1992	85.7
Aircraft and Related Equipment (26-12)	1992	68.9
National Airspace System Spectrum Engineering (26-15)	1992	9.4
System Support Lab (26-17)	1992	31.5
General Support Lab (26-18)	1992	25.6
ARTS IIA Enhancements (22-06)	1993	12.9
Area Control Facilities (21-15)	1993	9.6
Data Multiplexing Network (25-02)	1993	34.0
Radar Microwave Link Replacement and Expansion (25-03)[d]	1993	268.4
Large Airport Cable Loop Systems (26-05)	1993	20.3
Interfacility Data Transfer System for Edwards Air Force Base Radar Approach Control (35-20)	1994	1.8
Visual Navaids (24-09)	1994	137.7
Acquisition of Flight Service Facilities (26-10)	1994	79.7
Interim Support Plan[e] (46-30)	1994	362.9
Tower Integration Program (42-20)	1994	11.2

(continued)

Dollars in millions

Project (project number)	Completion date	Total reported facilities and equipment cost
Radar Pedestal Vibration Analysis (44-43)	1994	5.0
Low-Level Wind Shear Alert System (23-12)	1994	47.2
Human Resource Management (56-22)	1994	7.3
Brite Radar Indicator Tower Equipment (22-16)	1994	64.5
Approach Lighting System Improvement Program (24-10)	1994	121.9
Central Weather Processor (23-02)	1994	81.1
General Support (26-16)[f]	1994	824.0
National Implementation of the “Imaging” Aid for Dependent Converging Runway Approaches (62-24)	1994	4.6
Integrated Communications Switching System (23-13)	1995	98.3
System Engineering and Integration Contract (26-13)	1995	759.3
National Airspace Data Interchange Network II Continuation (35-07)	1995	23.7
ARTS IIIA Peripheral Adapter Module Modernization (52-21)	1995	5.9
Instrument Landing System and Visual Navaids Engineering and Sparing (44-24)	1995	13.1
Air Traffic Control Tower/TRACON Establishment (32-13)	1995	13.1
Flight Service Automation System (23-01)	1995	313.7
Multichannel Voice Recorders (22-11)	1996	40.2
Weather Message Switching Center Replacement (23-04)	1996	32.5
Computer Aided Engineering Graphics Enhancements (56-25)	1996	3.7
Oceanic Display and Planning System (21-05)	1996	36.8
Integrated Communications Switching System Logistics Support (43-14)	1996	10.6
Maintenance Control Center (26-04)	1996	47.9
Long-Range Navigation-C (LORAN-C) Systems (24-17)	1996	51.9
ARTS IIA Interface with Mode-S/Airport Surveillance Radar-9 (22-09)	1996	0[a]
Replacement of Controllers Chairs (42-24)	1996	5.1
ARTS IIIA-Expand Capacity and Provide Mode-C Intruder Capability (32-20)	1997	109.8
Display Channel Complex Rehost (A-01)	1997	61.3

(continued)

Dollars in millions

Project (project number)	Completion date	Total reported facilities and equipment cost
Digital Bright Radar Indicator Tower Equipment (32-16)	1998	24.2
Civil Aviation Registry Modernization (56-24)	1998	34.4
FAA Telecommunications (45-21)	1998	16.1
Precision Automated Tracking System (56-16)	1998	3.3
National Airspace Integrated Logistic Support (56-58)	1998	27.6
Long Range Radar Radome Replacement (44-42)	1998	39.5
Computer Resources Nucleus (56-28)	1998	158.1
Total		**$5,714.2**

[a]The cost of this project was covered under another facilities and equipment project.

[b]Installed at en route centers to allow processing of existing air traffic control software on new equipment.

[c]Project comprised a variety of tower and terminal replacement and modernization projects. Project was continued in the Capital Investment Plan under projects 42-13 and 42-14.

[d]Also known as the Radio Communications Link project, it was designed to convert aging “special purpose” Radar Microwave Link System into a “general purpose” system for data, voice, and radar communications among en route centers and other major FAA facilities.

[e]Project was activated to sustain and upgrade air traffic control operations and acquire eight terminal radars awaiting the full implementation of the Advanced Automation System.

[f]Project comprised a variety of diverse support projects and has been continued in the Capital Investment Plan under Continued General Support (46-16).

Source: FAA. We did not independently verify the schedule and cost information.

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