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Report to Congressional Requesters

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AIR TRAFFIC CONTROL

Continuing Delays Anticipated for the Advanced Automation System

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Information Management and
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The Honorable Frank R. Lautenberg
Chairman, Subcommittee on Transportation
and Related Agencies
Committee on Appropriations
United States Senate

The Honorable William Lehman
Chairman, Subcommittee on Transportation
and Related Agencies
Committee on Appropriations
House of Representatives

In response to your request, we reviewed the Federal Aviation Administration's (FAA) efforts to develop the Advanced Automation System (AAS). AAS, estimated to cost approximately $5 billion, is intended to replace aging air traffic control computer systems with new hardware, software, and controller workstations.

In 1988, FAA awarded a $3.6-billion contract to International Business Machines (IBM), Inc. to complete the design and production of AAS. The first key phase of AAS, the initial sector suite system (ISSS), is to replace controller workstations at facilities that control air traffic between airports. As agreed with your offices, our objective was to evaluate whether FAA was effectively managing ISSS in order to minimize program delays. An explanation of our scope and methodology is contained in appendix I.

Results in Brief

Less than a year after IBM began work on the contract, ISSS implementation had already encountered a 13-month delay because not all requirements issues had been resolved, and FAA and IBM had underestimated the time it would take to develop and test software. However, the revised 13-month schedule does not include sufficient time to resolve requirements issues and allocates little time to resolve problems that may arise during system testing. Consequently, it is likely that ISSS will be delayed even longer. In commenting on a draft of this report, FAA officials stated that they now anticipate that the ISSS will be delayed by a total of 19 months.

Under FAA's current plan, the second step of the AAS is to provide additional hardware and software to support terminal automation capabilities. This component, which is to be installed in existing en route facilities, is to allow FAA to consolidate some smaller terminal facilities into en route centers. The third step of AAS is to provide additional automation support in airport towers and is to allow for the consolidation of the remaining large terminal control facilities at en route facilities.

FAA has about 60 headquarters employees, including 43 technical staff, dedicated to the AAS project. FAA also has six support contractors with over 340 personnel who provide technical and managerial guidance to FAA and monitor the efforts of IBM. IBM has over 1500 people working on the project.

ISSS Implementation Has Been Delayed

In July 1989, only 8 months after beginning work, an FAA and IBM task force reported a minimum of a 10-month delay in the ISSS software schedule. By October 1989, IBM had amended this projection to a 13-month delay. Table I shows the original schedule and the schedule with the 13-month delay.

Table 1: ISSS Acquisition Schedule

Milestones	Original date	Revised schedule date
Factory acceptance testing completed	January 2, 1991	February 2, 1992
FAA Technical Center acceptance testing completed	November 1, 1991	December 1, 1992
FAA Technical Center operational testing and evaluation completed	August 3, 1992	September 3, 1993
First Site operational readiness demonstration[a]	January 4, 1994	February 4, 1995
Last Site operational readiness demonstration	October 4, 1995	November 4, 1996

[a]A system is deemed operationally ready when it can perform required functions

In April 1990, FAA directed IBM to baseline its schedule to incorporate the 13-month delay. However, the contract has not yet been modified to reflect this delay. FAA anticipates that the contract will be modified to include all schedule delays and requirements changes in December 1990.

Further Schedule Delays Likely

The announced 13-month delay probably underestimates how long ISSS will be delayed. Additional delays are likely because requirements issues from the design competition phase have still not been resolved and new requirements have been identified. In addition, little time has been allocated for taking corrective action resulting from testing.

Many Requirements Issues Are Still Not Resolved

FAA and IBM have made some progress in addressing the unresolved requirements issues from the design competition phase. In November 1989, FAA and IBM had approximately 135 unresolved ISSS requirements issues. By April 1990, they had reduced this number to about 45. Among the requirements issues still open were determining how to properly display tabular data and aeronautical charts on controller screens.

In addition, FAA has begun to identify several new requirements that threaten to further delay the schedule. For example, FAA has identified a requirement for sector-by-sector transition. This requirement would allow ISSS to be deployed at a center one sector at a time rather than a total one-time change from the old control room to the new control room. Sector-by-sector transition is expected to reduce operational risk to the ISSS by enabling some sectors to be supported by the new system while other sectors are supported by existing equipment. Currently, FAA and IBM are discussing the need for additional time to satisfy new requirements. FAA anticipates that in December 1990 the contract will be modified to include additional time to satisfy these new requirements, as well as to reflect schedule changes.

Schedule Allocates Little Time for Corrective Action

To better define the design and the requirements and thus reduce risk, FAA and IBM planned to perform early demonstrations of software capabilities. However, to date, the benefits of these early demonstrations have not been fully realized because the demonstrations have been narrowly focused or deferred due to software delays. By failing to run early demonstrations as planned, IBM may not identify problems and resolve them until the formal testing phase, when they are more difficult and time consuming to fix.

Given that only 10 months is allocated for formal software qualification testing and corrective action, IBM may not have allocated enough time to fix problems revealed through testing. In addition, IBM's planned software qualification test schedule includes many overlapping activities and interdependencies, and a slip in one activity could delay the entire ISSS schedule.

However, regarding the need to explore alternatives, the Department of Transportation believed that FAA had already developed an appropriate interim solution in 1987 to meet TRACON requirements for the next 10 years. This interim solution calls for increasing the capacity of the present systems in large TRACONs by pursuing sole-source contracts to expand current system configurations to their maximum design limits. This expansion will require FAA to buy 1960s-vintage computers similar to existing processors. These antiquated processors have less processing capability than a desktop computer purchased in a local store.

To meet its immediate needs for additional computer capacity, FAA may have little choice other than to upgrade the existing systems. However, because larger TRACONs may not be modernized until 2000 or beyond, the limited capabilities of this interim solution may not be able to handle long-term automation requirements and the continued growth in air traffic.

Conclusions

The development of the ISSS, the first step in FAA's plan to modernize air traffic control computer systems, is behind schedule by at least 13 months and will likely be delayed much longer. The delay resulted because FAA and IBM failed to resolve requirements issues and underestimated the program's complexity. The 13-month extension that FAA and IBM have added to the baseline schedule does not adequately consider the time required to resolve remaining requirements. Further, little time has been allotted for resolving problems that may arise from system testing.

Under FAA's current plan, the ISSS delay will delay the remaining phases of AAS that are scheduled to replace current automated systems at TRACONs. This could have significant repercussions on the safety of the air traffic control system, since some large TRACON automated systems are already overloaded. The longer these aging systems are maintained, the greater the danger that additional shortfalls will occur. Given the delay in AAS and the clear inadequacies of the existing computer systems in large TRACONs, FAA may not have the needed automation capabilities in time to handle the increasing air traffic of the 1990s.

Recommendations

We recommend that the Secretary of Transportation direct the FAA Administrator to establish, with IBM, a new and realistic schedule for AAS development and delivery. An analysis should be conducted immediately that assesses remaining tasks and determines realistic timeframes

Secretary of Transportation, the FAA Administrator, and other interested parties, and will make copies available to others upon request. This report was prepared under the direction of JayEtta Hecker, Director, Resources, Community, and Economic Development Information Systems, who can be reached at (202) 275-9675. Other major contributors are listed in appendix II.

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Scope and Methodology

To accomplish our objective, we examined contract documents from the program's design competition phase to the acquisition phase and analyzed completed and remaining tasks. We examined FAA's AAS program management structure and the roles and responsibilities of the development and support contractors. We reviewed the acquisition phase contract, critical design memoranda, and system specifications. We also reviewed support contractor monthly status reports and correspondence to obtain information on AAS contractor performance. Further, we analyzed information on the estimated development schedules versus actual completion time of systems of comparable difficulty. Finally, we interviewed officials from FAA's AAS program office, IBM, and Martin Marietta to obtain their views on program development and the causes of schedule delays.

Our work was performed from August 1989 to April 1990 at FAA headquarters, Washington, D.C., IBM, Rockville, Maryland, and Martin Marietta, Inc., Washington, D.C. The views of agency and contractor officials were obtained during the course of our work and have been incorporated where appropriate. In addition, at the completion of our review, we discussed the report's key facts, conclusions, and recommendations with FAA officials. Finally, we obtained formal oral comments from Department of Transportation and FAA officials on a draft of this report. These comments and our analysis are also included in this report. We conducted our review in accordance with generally accepted auditing standards.

for IBM to complete the development and delivery of ISSS as well as the remainder of AAS. The analysis should include an appropriate safety factor, such as the time needed to conduct retesting and tuning of the system to meet performance requirements. The analysis should also explore the feasibility of revising the order of AAS implementation to expedite modernization of larger TRACONS.

Agency Comments and Our Evaluation

We obtained official oral comments from the Department of Transportation and FAA officials on a draft of this report. The officials agreed that one reason the ISSS acquisition schedule slipped so soon after contract award was unresolved requirements issues. However, they stated that IBM's performance on the contract was the key factor in the delay. Officials added that, because of their concerns about contractor performance, they requested IBM to reevaluate the ISSS schedule shortly after work commenced. Officials also commented that the contract schedule was mutually agreed upon by FAA and the contractor, and that IBM officials did not express concerns at the time about the schedule being unrealistic. Officials stated that, in order to resolve open issues and to incorporate new requirements, they now intend to delay the ISSS schedule by a total of 19 months. They believe this schedule is realistic and provides sufficient time to continually test the ISSS throughout development.

As presented in the report, we believe that unresolved requirements issues and an unrealistic schedule were key factors causing the delay. While recognizing FAA's revised estimate of a 19-month ISSS delay, FAA still needs to assess remaining open tasks in order to develop a basis for a realistic schedule that provides sufficient time to allow for problems that may result from software qualification testing.

As arranged with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution of this report until 30 days after the date of this letter. We will then send copies to the

One example of where additional time may be needed is in modifying the system to meet the stringent processing load and system response time requirements of ISSS. Real-time systems such as the ISSS are much more difficult to build successfully within budget and schedule than systems without severe performance requirements. At present, according to the contractor, IBM performance models indicate that the selected software design will meet system requirements. However, model results can be inaccurate; models may indicate that a design will meet requirements, but once the system is built, it may not. For example, on a complex, real-time Navy program,[3] the initial version of the local communications network performed only one-sixth as fast as the model predicted resulting in adverse cost, schedule, and performance impacts on the Navy's plans to improve its submarine command and control systems.

ISSS Delays Will Delay Other AAS Phases

According to FAA officials, FAA is anticipating that the entire AAS schedule will be delayed an amount of time comparable to the ISSS delay. ISSS deployment is critical to the development of other AAS phases because later phases require the new controller workstations and software. Delays in AAS may impair FAA's large TRACON facilities, since the longer that AAS is delayed, the longer FAA will have to operate and maintain current systems.

As we reported last year, many of the automated systems at these facilities were experiencing capacity shortfalls.[4] Indeed, almost 70 percent of the large busy TRACONs surveyed reported that they had experienced aircraft information disappearing from controllers' screens, flickering displays, or delayed computer responses to controllers' attempts to update or request data. These overload problems threaten the ability of controllers to track and safely handle aircraft.

To address this dilemma, last year we recommended that FAA immediately fix those facilities experiencing the worst shortfalls, institute a capacity management and performance program to monitor work loads and system utilization in all facilities, and investigate different alternatives for meeting the larger TRACONs' air traffic control requirements until AAS becomes available. Since then, FAA has initiated some steps to remedy capacity deficiencies.

[3]SUBACS Problems May Adversely Affect Navy Attack Submarine Programs (GAO/NSIAD-86-12, Nov. 4, 1985).

[4]Air Traffic Control: Computer Capacity Shortfalls May Impair Flight Safety (GAO/IMTEC-89-63, July 6, 1989).

Delay Caused by Unresolved Requirements Issues and Inadequate Schedule Estimates

Two major reasons for the 13-month delay were (1) requirements issues scheduled to be resolved during the design competition phase were deferred to the acquisition phase without allocating any time to resolve the issues, and (2) FAA underestimated the time it would take to develop and test the software. During the design competition phase, IBM and Hughes were supposed to conduct a thorough analysis of requirements, including producing detailed design documentation, and conducting design reviews. However, FAA allowed the contractors to proceed with major design reviews without completing requirements analyses and with incomplete documentation. Thus, the design reviews were incomplete. For example, IBM's analysis did not address all specification requirements, such as those associated with the ability to electronically process and display flight plan data and aeronautical charts. Some of these specification requirements have, to date, still not been finalized.

Despite these open requirements issues, FAA determined that the work completed was sufficient and awarded the acquisition contract to IBM. As a result, IBM proceeded with software development based on requirements that were not thoroughly analyzed and finalized and based on incomplete designs and specifications. FAA did not add more time to the acquisition contract schedule to reflect the work needed to be done to analyze all requirements and to complete the design.

ISSS is a complex effort that, according to FAA, requires the development of approximately one million lines of software using Ada, a relatively new programming language. Originally, IBM planned the ISSS effort to be completed in six software builds[2]. However, IBM subsequently determined that this projection was inadequate. Now, IBM has projected that an additional build and 7 additional months will be needed to complete the software.

According to IBM officials, FAA set the overall schedule and did not allow contract bidders to offer their own schedule. IBM officials admitted that they considered the acquisition schedule to be unrealistic. However, they simply accepted the challenge of trying to meet an overly ambitious schedule. In response, FAA officials stated that IBM agreed to the schedule and did not express reservations at the time about the difficulty of meeting the schedule.

[2]A build is an incremental portion of software intended to perform a specific subset of functions of the total system.

ISSS delays will push back later AAS phases scheduled to replace aging automated systems at terminal radar approach control (TRACON) facilities. This could affect air traffic safety, since large TRACON automated systems have already experienced computer capacity shortfalls resulting in data flickering and disappearing from controllers' screens. Because of the delays in AAS and the limitations of the existing TRACON computer systems, FAA may not have the needed automation capabilities in time to handle the increasing air traffic of the 1990s.

Background

FAA intends to automate and modernize the nation's air traffic control system through its National Airspace System Plan. AAS is the centerpiece of this plan and is being acquired to increase controller productivity, reduce operating costs, save fuel and passenger time, and allow controllers to handle anticipated traffic increases more safely and efficiently. Improvements are expected to result primarily from (1) the use of modern equipment and (2) the development of new software functions intended to automate some controller functions and allow more aircraft to fly user-preferred, fuel-efficient routes.

To design AAS, FAA awarded competitive contracts to IBM and Hughes Aircraft Corporation in 1984. On July 25, 1988, after spending about $500 million on the design competition, FAA awarded a $3.6-billion contract to IBM to complete the design and produce the AAS. However, on August 10, 1988, a stop work order was issued to IBM as a result of a protest filed by Hughes Aircraft Corporation. On October 28, 1988, the General Services Administration's Board of Contract Appeals issued a decision upholding FAA's contract award. IBM resumed work on AAS in November 1988.

AAS Implementation Approach

The AAS contract calls for implementing the system in three steps. Deployment of the first step is to begin in 1993, the second in 1995, and the third in 1996. According to FAA officials, the system is to be completed by 2003 with contract options extending until 2010.

ISSS is the primary component of the first step and constitutes the largest portion of the AAS program. It is to supply new controller workstations at en route centers[1] to replace existing controller displays, and automate some related processes that are currently done manually.

[1] FAA currently maintains 20 Air Route Traffic Control Centers in the continental United States that control air traffic between airports.