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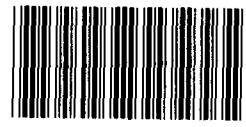
Report to the Chair, Government Activities and Transportation Subcommittee, Committee on Government Operations, House of Representatives

September 1992

# AIR TRAFFIC CONTROL

# Advanced Automation System Still Vulnerable to Cost and Schedule Problems

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**United States**
**General Accounting Office**
**Washington, D.C. 20548**

**Resources, Community, and**
**Economic Development Division**

B-249517

September 18, 1992

The Honorable Barbara Boxer
Chair, Government Activities and
Transportation Subcommittee
Committee on Government Operations
House of Representatives

Dear Madam Chair:

The Federal Aviation Administration's (FAA) Advanced Automation System (AAS) is a $5-billion project intended to replace and enhance the work stations and computer systems used by air traffic controllers to provide a safe and orderly flow of aircraft throughout the nation's air traffic control (ATC) system.

In your letter of August 13, 1992, you expressed serious concern about AAS costs and schedules and the effects of delays in AAS on the ATC system, and you asked us to report on these issues. As agreed with your office, this report discusses (1) cost and schedule changes in AAS since the project's inception, (2) effects of delays in AAS, and (3) issues that could further increase AAS costs and delay implementation. To meet your needs, this report presents information that we have recently gathered, as well as updates to our previous work on AAS. A list of related GAO products appears at the end of this report.

## Results in Brief

Substantial cost growth and schedule delays have beset AAS over the last decade. FAA originally proposed AAS in 1983 as a project that would cost $2.5 billion and be complete in 1996. Since that time, the costs for AAS have doubled to an estimated $5.1 billion, and the schedule has slipped by 6 years. These cost and schedule problems have generally arisen because FAA underestimated the effort required to develop and implement AAS.

Delays in implementing AAS have forced air traffic controllers to rely on 20-year-old equipment. Although it is difficult to assess the exact condition of the current ATC system, there is increasing risk that the aging of the existing hardware and software is reducing the margin of safety in the ATC system. In reviews conducted during the past 3 years, we identified problems with existing hardware and software scheduled to be replaced by AAS. We found, in addition, that delays in implementing AAS have

prompted FAA to start interim projects to sustain computer systems that AAS will replace. These projects will cost at least $500 million.

Delays in implementing AAS have also deferred benefits projected for users of the ATC system, such as savings in fuel costs for airlines. These benefits are largely expected to come from advanced software functions that are intended to allow pilots to fly preferred routings and to help controllers resolve potential conflicts between aircraft. Although FAA originally expected that some of these functions would now be operational, the software is still in the earliest stages of development.

To its credit, FAA has taken positive steps to improve AAS, such as developing a demonstration facility to gain an early assessment of controllers' and technicians' concerns and conducting additional testing to confirm the performance of work stations before making production decisions. Despite these positive steps, several major issues make the project vulnerable to further cost increases and schedule delays. First, the plan for AAS was predicated on the consolidation of 202 facilities into 23. But a more recent plan would increase the number of facilities to 53 or 54. The potential doubling in the number of facilities and the uncertainty created by FAA's delay in reaching a decision on consolidation increase the risk of cost and schedule problems for AAS. Additional issues that are likely to result in cost increases and schedule delays include unresolved requirements for users and a shortage of space for AAS equipment.

## Background

FAA's ATC mission is to promote the safe, orderly, and expeditious flow of aircraft. Air traffic controllers maintain separation between aircraft by utilizing information processed by computers and displayed on video screens at controller work stations. FAA uses three types of facilities to control aircraft. Airport towers control aircraft on the ground and in the vicinity of an airport. Terminal facilities sequence and separate aircraft from the point at which the tower control area ends to about 20 to 30 miles from the airport. At that point, en-route centers assume control of the aircraft and maintain control until the aircraft enters terminal airspace at its destination.

AAS is the largest project in FAA's program to modernize the nation's ATC system and is considered the centerpiece of this effort. AAS will replace computer hardware and software and controller work stations at tower, terminal, and en-route facilities. In addition, AAS is being developed to

allow the ATC system to accommodate forecasted large increases in traffic through the use of modern equipment and advanced software functions.

FAA awarded a contract to International Business Machines (IBM) in 1988 to complete the design and production of AAS. FAA and IBM will implement the system in five phases:

- The Peripheral Adapter Module Replacement Item (PAMRI) will provide new communications computers to connect en-route centers with external systems, such as radars.
- The Initial Sector Suite System (ISSS) will replace controller work stations, including radar displays, at en-route centers. The ISSS work stations will provide higher-resolution screens and color capabilities.
- The Terminal Advanced Automation System (TAAS) will provide terminal controllers with new work stations identical to those used in ISSS, as well as new hardware and software to perform terminal control functions.
- The Tower Control Computer Complex (TCCC) will revamp hardware and software at selected airport towers.
- The Area Control Computer Complex (ACCC) will provide new software and combine ISSS and TAAS functions in a single facility. ACCC also allows FAA to add advanced software functions, known as Automated En Route Air Traffic Control (AERA), which are expected to provide most of the quantifiable benefits of AAS.

Thus far, FAA and IBM have worked primarily on the key ISSS phase. ISSS is important because subsequent phases are greatly dependent on its successful development. The current schedule calls for IBM to deliver ISSS to FAA's testing center in December of this year, and FAA now expects the first ISSS to be operational at the Seattle en-route center in December 1995.

AAS is funded from the Airport and Airway Trust Fund, which is supported by taxes and other fees assessed on users of the ATC system. Therefore, the system's users essentially pay for the development and production of AAS.

## The Cost of AAS Has Grown Significantly

Since AAS was introduced in 1983, its estimated cost has doubled. Because FAA underestimated the effort required to develop and implement AAS, the agency's 1983 estimate of $2.5 billion grew to $4.8 billion by the time the contract with IBM was signed in 1988. Since 1988, costs for AAS have risen by an additional 6 percent to FAA's current estimate of $5.1 billion. Cost increases since the contract was signed have occurred primarily because FAA has changed system requirements. For example, FAA needs to change

AAS tower equipment because the original design would have limited the ability of a tower controller to maintain awareness of the airport environment and inhibited the controller's mobility in the tower cab. FAA estimated that this change would cost about $150 million.

## AAS Has Fallen Well Behind Schedule

Not only have costs for the AAS project increased, but also schedules have been significantly delayed. Since 1983 projections, implementation of ISSS at the first en-route center has slipped from 1990 to 1995. Completion of all AAS phases has been delayed by 6 years, from 1996 to 2002.

Schedules are, of course, difficult to predict when projects are in the early stages of development. However, when FAA signed the AAS contract with IBM in 1988, specific dates were set for delivering AAS hardware and software. Less than a year after IBM began work on the contract, though, FAA and IBM realized that the schedule could not be met. In December 1990, FAA finalized a contract modification that delayed the ISSS schedule by 19 months. Five months of that delay were due to changes in AAS required by FAA, and the remaining 14 months were attributed to problems in developing software. FAA has recently announced an additional 4-month delay in ISSS, which FAA has ascribed to continuing problems in developing software. As table 1 shows, the first ISSS is now expected to become operational in December 1995—about 2 years later than the date set at contract award. Table 1 also shows that similar delays have occurred in subsequent phases of AAS.

**Table 1: Implementation Milestones for AAS Phases**

| AAS phase | Field site | 1983 schedule | 1988 contract schedule | Current schedule | Delay in months 1988 to current |
|---|---|---|---|---|---|
| PAMRI | First | [a] | Oct. 1991 | Oct. 1991 | 0 |
| | Last | [a] | July 1993 | July 1993 | 0 |
| ISSS | First | Late 1990 | Jan. 1994 | Dec. 1995 | 23 |
| | Last | Late 1991 | Oct. 1995 | Sept. 1997 | 23 |
| TAAS | First | [a] | June 1995 | Jan. 1997 | 19 |
| | Last | [a] | Mar. 1997 | Oct. 1998 | 19 |
| TCCC | First | [a] | June 1995 | Jan. 1997 | 19 |
| | Last | [a] | July 1999 | Dec. 2002 | 29 |
| ACCC | First | Late 1992 | July 1996 | Feb. 1998 | 19 |
| | Last | 1996 | June 1998 | Dec. 2002 | 54 |

[a]In 1983, the AAS project consisted of just two phases: sector suites and the full AAS. Later, the transition to AAS was divided into four phases: ISSS, TAAS, TCCC, and ACCC. PAMRI was added as an initial first step. In table 1, we have used 1983 sector suite milestones for en-route centers to compare with later ISSS schedules and 1983 full-AAS milestones to compare with later ACCC schedules.

## Delays in Implementing AAS Have Had Serious Effects

We found that delays in implementing AAS have forced FAA to continue to work with aging hardware and software. Although it is difficult to assess the exact condition of the current ATC system, there is increasing risk that aging systems will malfunction, reducing the margin of safety in the ATC system. Because of delays in implementing AAS, FAA has started some costly interim projects to sustain current hardware and software.

FAA cites high levels of reliability for the current system as evidence that current ATC systems are operating effectively. In previous reports, however, we have noted that FAA's calculation of system reliability does not give a complete picture of equipment problems and that some hardware and software problems have created very real difficulties for air traffic controllers. In our August 1991 report on en-route center equipment,[1] we stated that although FAA reports overall system availability of 99 percent at en-route centers, many equipment failures are not included in this figure, which reflects only overall system availability and not the availability of the particular pieces of equipment that make up the system. Our analysis showed that during a 1-year period at a single en-route center there were 1,935 failures or malfunctions of computer

[1]Air Traffic Control: FAA Can Better Forecast and Prevent Equipment Failures (GAO/RCED-91-179, Aug. 2, 1991).

equipment due to be replaced by AAS, such as controller radar displays and control panels.

Deterioration of equipment can have serious effects. For example, our August 1991 report described an incident in which a controller's display failed and another controller temporarily had to assume responsibility for the airspace served by the failed radar display. The sudden increase in the volume and complexity of air traffic contributed to the controller's not maintaining the required minimum separation between two aircraft.

In December 1991, we reported on disruptions in the ATC system caused by software problems at en-route centers.[2] For example, in September 1989, a software problem at the Oakland center affected several air traffic sectors and resulted in "considerable controller confusion and hardship" in identifying aircraft. A 77-minute software outage at the Los Angeles center in July 1990 resulted in 57 aircraft delays averaging 22 minutes each.

Delays in implementing AAS have forced FAA to develop expensive interim projects to sustain the existing ATC system. FAA initiated the $435-million Interim Support Program in 1987 to bridge the gap between current and future ATC systems by sustaining terminals' existing automation systems and increasing these systems' computer capacity. FAA has also begun to update terminals' existing automated radar tracking systems (ARTS). For example, FAA has proposed an $80-million project in its fiscal year 1993 budget to purchase new versions of ARTS, such as the one currently in place at the New York terminal, to provide additional computer capacity until AAS is operational.

## Much Remains to Be Done Before Benefits Will Be Realized

Delays in implementing AAS also defer benefits projected for users of the ATC system. These benefits, such as reductions in fuel costs for airlines, are largely expected to come from advanced AERA software functions that are intended to allow pilots to fly preferred routings and to help controllers resolve potential conflicts between aircraft.

FAA projects the total benefits of AAS to be about $87 billion (in 1991 dollars) through the year 2016. Benefits are expected to accrue largely in the form of savings in time for passengers and reductions in fuel costs. Officials from two major airlines have emphasized the potential importance of AAS in their discussions with us. They have indicated that

[2]Air Traffic Control: Software Problems at Control Centers Need Immediate Attention (GAO/IMTEC-92-1, Dec. 11, 1991).

the projected capabilities of future AAS software, especially AERA, would substantially increase efficiency.

In 1983, FAA planned that initial AERA functions would be operational this year. However, the development of AERA software is still in its earliest stages. Design review is now scheduled for September 1993, and initial operational use of AERA is not expected until February 1999. Therefore, users will not realize the promised benefits of AERA until early in the next decade even if current schedules are maintained.

## FAA Has Taken Positive Steps, but Cost and Schedule Concerns Still Exist

The replacement of a large, real-time computer system in which safety is a paramount concern is a major challenge. While recognizing the complexity of this effort, we have reported many times over the years that FAA's schedules for AAS were unrealistic because they did not allow enough time for designing the system, developing software, and testing the system. We stated that, as a result, FAA's acquisition strategy was risky in terms of cost growth, schedule delays, and performance problems. An April 1992 report on AAS, which was done by the Volpe National Transportation Systems Center for FAA at the request of the House Committee on Appropriations, indicates that unrealistic scheduling continues to be a problem. It states that "aggressive schedules are established, only to be overtaken by internal program factors, such as open requirements, design rework, and software rework." Unrealistic schedules put pressure on FAA to compress testing activities and to defer the development of critical software until after production decisions have been made.

To its credit, FAA has taken some positive steps to improve AAS. In line with our recommendation that FAA test critical components before making any production decisions,[3] it plans to test ISSS work stations to confirm that their performance meets agency requirements before it decides whether to move to full production in January 1994. Also, as a step to gain an early assessment of controllers' and maintenance technicians' concerns, FAA has developed an AAS demonstration facility in Gaithersburg, Maryland. At this facility, teams of users have been able to evaluate actual ISSS work stations and software.

Despite the steps that it has taken to improve the AAS project, FAA still faces a number of major issues that could have a significant impact on costs and schedules. First, FAA still has not decided how many facilities

[3]Air Traffic Control: FAA's Advanced Automation System Acquisition Strategy Is Risky (GAO/IMTEC-86-24, July 8, 1986).

will receive AAS and has not yet delivered a facility consolidation plan to the Congress. FAA's plan for AAS was originally predicated on the consolidation of all 202 terminals and en-route centers into 23 facilities. But a more recent plan under consideration by FAA would have 53 or 54 facilities instead of 23 and would therefore require additional AAS equipment. FAA currently has contract options valued at about $64 million to purchase AAS equipment in addition to that required for the 23 facilities. However, some of these options are due to expire in fiscal year 1994, the year for which FAA is currently formulating its budget. Additionally, IBM has emphasized its need to know the number of AAS facilities before this fall, when the initial review of the ACCC design will be conducted. Design for that phase depends on the number of facilities and their size. FAA has still not delivered a facility consolidation plan to the Congress, despite direction from the House Committee on Appropriations that it do so by February 1, 1992.

Second, issues concerning users' requirements still have to be resolved for AAS. The Volpe Center report stated that issues concerning the system's interface with users are still unresolved and negatively affect the project's progress. For example, there is concern that the time needed to enter data into ISSS may be excessive, requiring controllers to divert their gaze from the radar display for an unacceptably long time. Another major unresolved requirement is the need—in case the main computer fails—for additional ISSS work station capabilities, such as the automatic reconstitution of the controllers' data base. Finally, ISSS requires the conversion of paper flight strips to electronic versions that will appear on the work stations.[4] The Volpe report identified this issue as a possible source of high schedule and technical risk.

Third, a shortage of space for AAS equipment at both en-route centers and towers is still a concern. In April 1992, we reported that FAA was considering building a mezzanine level at en-route centers to house support functions in order to make room for ISSS equipment. FAA had planned to decide on solutions to this problem by this past spring but has not yet done so. FAA has also just begun to analyze its needs for space at towers, and agency officials believe that many towers will need to be expanded or refurbished to accommodate AAS. FAA's current estimate of $5.1 billion for AAS does not include estimates for all changes needed to address these space concerns.

[4]Flight strips provide controllers with basic status information, such as aircraft routes, altitudes, and air traffic clearances. Controllers presently mark up the paper versions to record changes in status and to coordinate information with each other.

Fourth, the current packaging of AAS as just one project limits oversight by FAA officials, Department of Transportation officials, and the Congress. AAS comprises a series of distinct segments, each at a different stage of development. FAA, however, has not separately reported either the costs or the potential benefits of each segment in the documents that it has used to justify the project. The House Committee on Appropriations, in its recent report on the Department's fiscal year 1993 appropriations, directed that each segment of the AAS project be considered a separate major acquisition.

## Conclusions

Since 1983, the estimated cost of AAS has increased from $2.5 billion to $5.1 billion, and the schedule has slipped by 6 years. Further significant cost and schedule problems are likely to occur because of problems with software development, a potential doubling of the number of facilities in which AAS will be installed, and a shortage of space for AAS equipment at some existing facilities.

Delays in AAS have created a need for costly interim projects and have deferred benefits, such as savings in time for passengers and reductions in fuel consumption for airlines. AERA's development is still in its infancy, and therefore the benefits of AAS projected for ATC system users, such as major airlines, will not be available until the next decade. The delays have also forced controllers to work with aging systems and have thus increased the risk that system outages will reduce the margin of safety in the ATC system.

We have stated in the past, and continue to believe, that FAA's schedules for AAS were unrealistic because they did not allow enough time for designing, developing, and testing the system. Unrealistic schedules put pressure on FAA to compress testing and defer the development of critical software until after production decisions have been made. Premature production decisions increase the risk of future cost and schedule problems. Unrealistic schedules can also mislead decisionmakers in the executive branch and the Congress when they evaluate FAA's progress in implementing AAS.

FAA has taken some positive steps to improve the AAS project, such as developing a demonstration facility. However, it still has not (1) determined how many ATC facilities it needs, (2) resolved many key user requirements issues, (3) created sufficient space for AAS equipment at all en-route centers and towers, or (4) provided discrete information on each particular segment of AAS. As we have pointed out in testimonies and prior

reports, quick and efficient resolution of these issues is vital to minimize further cost increases and schedule delays and to allow appropriate oversight and evaluation of the project.

We have recently begun a detailed review of AAS for the Subcommittee on Transportation of the House Committee on Appropriations. We plan to monitor FAA's actions to respond to these major concerns.

## Agency Comments

We discussed the information contained in this report with officials in FAA's Advanced Automation Program Office, Air Traffic Plans and Requirements Service, and Office of Public Affairs; other FAA officials; and officials from the Office of the Secretary of Transportation (OST). The FAA and OST officials agreed with the information in our report. However, they disagreed with the idea that the five phases of AAS were divisible and should be evaluated as separate major acquisitions. They said that dividing the project would require more managerial resources, including project managers for each segment. We responded that neither our draft nor the report of the House Committee on Appropriations called for a separate project manager for each segment, only for each segment to be reported and evaluated on its own costs and benefits. We continue to believe that evaluating each segment of AAS on its own merits is feasible and important for determining the most cost-efficient approach for replacing the hardware and software used by controllers.

FAA officials also recommended some wording changes. We incorporated their changes, where appropriate, to increase the precision and accuracy of our report. As requested, we did not obtain written agency comments on the information presented in this report.

## Scope and Methodology

To address our objectives, we updated information contained in previous GAO reports; interviewed officials in the FAA's Advanced Automation Program Office; and toured the FAA's AAS demonstration facility in Gaithersburg, Maryland. We also reviewed the report on AAS produced by the Volpe Center and documents provided by the program office. We conducted our review from July 1992 to August 1992 in accordance with generally accepted government auditing standards.

In your letter, you also expressed concern about two other important issues regarding AAS: allowable contract costs and the level of technical expertise in the AAS project. As noted in discussions with your office, the

Defense Contract Audit Agency (DCAA) conducts reviews of the AAS contract for FAA and is in the best position to address issues involving specific AAS contract charges. The issue of technical expertise was addressed in the April 1992 report on AAS by the Volpe Center. As agreed with your staff, we are not addressing contract charges or technical expertise in this report because we did not have adequate information to analyze these issues within requested time frames. We will continue to monitor AAS over the coming year and will coordinate our work with DCAA and the Volpe Center.

Unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days after the date of this letter. At that time we will send copies to interested congressional committees; the Secretary of Transportation; and the Administrator, FAA. We will make copies available to others on request.

If you have any questions about this report, please contact me at (202) 275-1000. Major contributors to this report are listed in appendix I.

Sincerely yours,

Kenneth M. Mead
Director, Transportation Issues

# Major Contributors to This Report

## Resources, Community, and Economic Development Division, Washington, D.C.

Robert E. Levin, Assistant Director
Robert D. Wurster, Assignment Manager
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# Related GAO Products

FAA Budget: Key Issues Need to Be Addressed (GAO/T-RCED-92-51, Apr. 6, 1992).

Air Traffic Control: Status of FAA's Modernization Program (GAO/RCED-92-136BR, Apr. 3, 1992).

Air Traffic Control: Software Problems at Control Centers Need Immediate Attention (GAO/IMTEC-92-1, Dec. 11, 1991).

Air Traffic Control: FAA Can Better Forecast and Prevent Equipment Failures (GAO/RCED-91-179, Aug. 2, 1991).

Aviation Acquisition: Further Changes Needed in FAA's Management and Budgeting Practices (GAO/RCED-91-159, July 29, 1991).

Air Traffic Control: Status of FAA's Modernization Effort (GAO/RCED-91-132FS, Apr. 15, 1991).

Air Traffic Control: FAA's Advanced Automation System Contract (GAO/IMTEC-91-25, Mar. 5, 1991).

Air Traffic Control: Continuing Delays Anticipated for the Advanced Automation System (GAO/IMTEC-90-63, July 18, 1990).

Air Traffic Control: FAA Should Define the Optimal Advanced Automation System Alternative (GAO/IMTEC-89-5, Nov. 30, 1988).

Air Traffic Control: Continued Improvements Needed in FAA's Management of the NAS Plan (GAO/RCED-89-7, Nov. 10, 1988).

Federal Aviation Administration's Advanced Automation System Investment (GAO/T-IMTEC-88-3, Apr. 12, 1988).

Air Traffic Control: FAA's Advanced Automation System Acquisition Strategy Is Risky (GAO/IMTEC-86-24, July 8, 1986).

GAO Questions Key Aspects of FAA's Plans to Acquire the Multi-Billion Dollar Advanced Automation System and Related Programs (GAO/IMTEC-85-11, June 17, 1985).

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