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Report to Congressional Requesters

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AIR TRAFFIC CONTROL

Voice Communications System Continues to Encounter Difficulties

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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

At the request of your offices, we evaluated the Federal Aviation Administration's (FAA) efforts to implement the Voice Switching and Control System (VSCS). This is a major system development intended to improve communications at air traffic control facilities. Currently, two contractors—Harris Corporation and American Telephone and Telegraph (AT&T) Technologies, Incorporated—are designing and developing prototype systems. In November 1989, the agency plans to award a production contract to one of these contractors to complete development, and to test, produce, and install the system.

The objectives of our review were to determine (1) if previously reported VSCS cost, schedule, and technical difficulties were continuing; and (2) if these difficulties would adversely affect deployment of new air traffic controller workstations. Appendix I describes our objectives in more detail, and our scope and methodology.

VSCS has encountered continued cost, schedule, and technical difficulties primarily because both FAA and the prototype development contractors underestimated the amount of work needed to meet system requirements. Total project cost estimates through system implementation have more than tripled, from $258 million in 1982 to over $786 million. The program has also encountered schedule slippages of up to 6 years since the 1982 schedule estimate. In addition, both prototype contractors have had continuing difficulties designing hardware and software capable of meeting system performance requirements.

VSCS is critical to FAA's plans to modernize the air traffic control system because it will provide communications for new controller workstations, currently being developed under the Advanced Automation System. This system is intended to help the air traffic control system safely and efficiently accommodate expected large increases in traffic. The Advanced Automation System is supposed to meet these goals by replacing workstations as well as other computer hardware and software. However, because the new workstations are designed to work with VSCS, they cannot be fully tested or used until VSCS is operational.

If VSCS is not available when the controller workstations are ready, deployment of the workstations will be delayed. In an effort to speed VSCS delivery, FAA has reduced testing of the prototype systems before it awards a production contract. If sufficient prototype testing is not completed, FAA will select a production contractor before the agency has complete test results showing that the chosen prototype system will work. Reduced testing may allow FAA to award a production contract earlier. However, it increases the risk that VSCS costs will increase and implementation could be delayed even more if problems are encountered later when they are more expensive and difficult to correct. Further, concerns have been raised that the contractors may be striving to meet schedules at the expense of work quality. Because VSCS components are government-furnished equipment under the Advanced Automation System contract, the government will not have met its obligation under the Advanced Automation System contract and could incur higher costs and longer delays if FAA does not deliver VSCS on time.

To ensure that it chooses a prototype system with a high probability of success, FAA should not award the VSCS production contract until sufficient prototype testing is completed and evaluated and the agency has assurance that the prototype will meet requirements. Furthermore, FAA should explore possible changes to the Advanced Automation System contract in order to limit the government's potential liability if VSCS is delayed.

Background

FAA's air traffic control mission is to promote the safe, orderly, and expeditious flow of civilian and military aircraft. Using information processed by computers and displayed on video screens at their workstations, air traffic controllers maintain the required separation between aircraft, provide safety advisories to pilots, and ensure efficient use of airspace.

Performing these duties requires a system for both ground-to-ground and air-to-ground voice communications. The ground-to-ground system provides communications among air traffic controllers, supervisors, and support personnel at control facilities, as well as communications between facilities located in adjacent geographical areas of operation. The air-to-ground system provides voice communications between controllers and pilots.

VSCS is intended to provide a computer-controlled voice system for both ground-to-ground and air-to-ground communications that is flexible, expandable, and highly reliable. It will be deployed at 23 air traffic control centers, which handle aircraft in the en route phase of flight, and is expected to serve up to 430 positions at each center. FAA expects VSCS to significantly improve communications capabilities because it will be more reliable, and easier and less costly to maintain.

The improved capabilities expected from the Advanced Automation System,[1] a critical element in the National Airspace System Plan,[2] cannot be achieved without VSCS. FAA awarded the Advanced Automation System contract to International Business Machines Corporation for $3.6 billion on July 25, 1988. The first phase includes developing and installing new controller workstations. Because it will provide the voice communications for the workstation, an operational VSCS is required to support workstation testing. The first workstation is scheduled to be delivered in August 1992.

FAA believes that, when implemented, the Advanced Automation System will allow the amount of airspace a controller handles to be reapportioned several times a day to reflect changes in staffing, amount of air traffic, and availability of equipment. Therefore, the new workstations need to be able to reconfigure their maps and displays to match these changes in airspace. To match these workstation changes, VSCS must be able to automatically reassign radio frequencies and reroute incoming calls. The current communications system cannot meet this requirement because these changes can only be made manually by changing the existing wiring, a time-consuming and costly process.

[1]Air Traffic Control: FAA's Advanced Automation System Acquisition Strategy Is Risky (GAO/IMTEC-86-24, July 8, 1986), and Air Traffic Control: FAA Should Define the Optimal Advanced Automation System Alternative (GAO/IMTEC-89-5, Nov. 30, 1988).

[2]The National Airspace System (NAS) Plan is a $15.8-billion long-term effort under which FAA will replace and modernize existing air traffic control equipment. The plan includes more than 80 projects, 12 of which have been designated major systems because of their size or importance. Both the Advanced Automation System and VSCS are major systems.

VSCS Cost, Schedule, and Technical Difficulties Continue

The VSCS program has a history of cost increases, schedule delays, and technical difficulties dating back several years.[3] Despite FAA's efforts to keep development on schedule and within estimated costs, difficulties have continued. Furthermore, the agency's decision to try to avoid further VSCS schedule delays by reducing testing during prototype development increases the risk that difficulties will continue into production.

Costs Have Continued to Rise

In October 1986 FAA awarded two VSCS prototype development contracts—one to Harris Corporation and one to AT&T Technologies, Incorporated—to design, develop, and install a prototype system. FAA intends to award a production contract in November 1989 to one of these contractors. The original cost of both prototype contracts was estimated to be $67 million. After the prototype contract awards, the agency and the contractors realized $67 million would not cover costs and in March 1988, FAA estimated that the prototype development contracts would cost $137 million. According to FAA, the contractors will now exceed this new amount by $10 to $11 million.

Total project costs are also rising. The estimated cost to design, develop, produce, and install the system has risen from $258 million in 1982 to the current estimate of over $786 million. According to agency officials, costs have increased because both FAA and the contractors underestimated the complexity of building VSCS, and original estimates did not include costs for training, site preparation, and support contractors. In April 1989, FAA officials stated that cost increases had ended. However, at that time, these officials provided a figure for VSCS acquisition costs that showed an increase of $56 million since June 1988.

Schedules Have Been Delayed

Schedules for the system's development have been delayed continually since the program began. For example, the original 1982-estimated date for VSCS to be operational at the first site has been delayed 6 years—from 1986 to 1992. As indicated in table 1, schedule delays have continued. Table 1 shows October 1986-estimated milestones, when the prototype development contracts were awarded. Later, FAA realized the contractors could not meet these milestones, and in March 1988 revised the program and schedules to reflect dates that it believed were attainable by the contractors. In November 1988, FAA estimated new milestones

[3]Aviation Acquisition: Improved Process Needs to Be Followed (GAO/RCED-87-8, Mar. 26, 1987), and Air Traffic Control: Continued Improvements Needed in FAA's Management of the NAS Plan (GAO/RCED-89-7, Nov. 10, 1988).

in its request for proposals for the VSCS production phase that reflected continued delays in the program's schedule. Table 1 also shows the System Engineering and Integration Contractor's (SEIC)[4] latest estimated dates for each milestone.

Table 1: Comparison of Estimated VSCS Dates

	FAA expected dates			SEIC latest estimated dates
Milestone	**October 1986**	**March 1988**	**November 1988**	**December 1988**
Factory acceptance tests completed	January 1989	July 1989	[a]	September 1989
Prototype delivered to FAA Technical Center for integration testing	January 1989	December 1989	June 1990	August 1990
Delivered to first site	June 1990	January 1991	August 1991	August 1991
Operational at first site	November 1990	October 1991	May 1992	September 1992

[a]The November 1988 request for proposals does not contain a comparable date for factory acceptance tests completed.

As table 1 indicates, FAA's most recent schedule for major system development milestones is more optimistic than the SEIC's estimate. For example, the SEIC believes that the agency's estimate for the system to be operational at the first site could be delayed up to 4 months. Further, the contractors may be striving to meet FAA's schedule at the expense of work quality, according to the SEIC. For instance, FAA claims that the contractors will meet the revised July 1989 milestone for completing factory acceptance tests.[5] According to the SEIC, however, if the contractors complete factory acceptance testing before September 1989, factory testing would be done at best on incomplete systems and would not provide the information needed to award the production contract.

FAA officials agree that their estimated schedule dates require extra effort from the contractors. Agency officials stated that they would rather use these dates than use "safe" dates that do not require as much effort to meet. However, according to the SEIC, FAA's schedule does not allow the contractors any extra time to absorb unanticipated difficulties.

[4]As SEIC for the NAS Plan, Martin Marietta provides technical and programmatic support to FAA in managing and technically directing nearly all facets of the plan's implementation. The SEIC provides a VSCS program manager, oversees all contractor development work, writes periodic contractor status reports, and develops cost and schedule estimates on the basis of contractor-supplied information.

[5]Factory acceptance tests are done by the contractor at its facility and are intended to demonstrate that system hardware and software perform as required.

Technical Difficulties Encountered

The prototype contractors have encountered unanticipated technical difficulties in meeting VSCS requirements. The original contractor proposals anticipated using off-the-shelf hardware and software to support these requirements. However, after contract award, it became apparent to both contractors that significant changes were needed to the off-the-shelf hardware and software.

One key requirement that has been more complicated to meet than originally believed is system availability. FAA requires the system to be available for use by controllers 99.99999 percent of the time, which is less than 4 seconds downtime per year. According to AT&T officials, no currently available commercial switching system in the world can meet this requirement. At best, switching systems currently in use can meet a 3-minute per year downtime requirement. Because the principal way to achieve this availability is through built-in redundancy, to fulfill this requirement the contractors had to develop much more software and hardware than they had anticipated.

According to FAA officials, the contractors have overcome most of their development problems. Reports issued earlier this year by the SEIC, however, show that both prototype development contractors are still discovering that equipment and software they believed would meet VSCS requirements needs to be modified.

FAA Has Reduced Required System Testing

FAA originally stated in its justification for the prototype development contracts that both factory acceptance testing and operational testing and evaluation would be completed and evaluated before the VSCS production contract was awarded. Factory acceptance testing would be performed by the prototype contractors, at their facilities, to demonstrate that the prototype meets all VSCS hardware, software, and performance requirements. Operational testing and evaluation would be performed by FAA, in an operational environment, to demonstrate the operational effectiveness and suitability of the prototypes.

Office of Management and Budget Circular A-109, which provides guidance to federal agencies on acquiring major systems, reinforces the importance of testing. It states that a production commitment should not be made until a system's performance is independently tested in a realistic operational environment. In addition, testing before production generally reduces overall system cost because the earlier in development changes are made, the less expensive they are to make. The problems

associated with going into production without adequately testing a system are well documented. For example, we previously reported that FAA's lack of testing before committing to production contracts contributed to delays ranging from 1 to 8 years for many of the agency's major systems.[6]

To avoid further VSCS schedule delays and thereby avoid delaying new controller workstations, FAA has reduced required testing before awarding a production contract. In March 1988, the agency moved operational testing and evaluation from the prototype development phase to the production phase. When FAA deferred operational testing, it stated that factory acceptance testing, including limited operational tests by air traffic controllers, would provide the basis for determining contractors' compliance with system specifications and the prototypes' operational suitability.

In addition, "to further reduce risk and strengthen the quantity and comprehensiveness of the factory data which will be used to assess performance for the [production] award," FAA said it would go to each contractor's factory and test the prototype using a traffic simulation unit. The agency stated that the traffic simulation unit would be used "to conduct independent FAA tests in order to assess the contractor's . . . performance." FAA officials further stated the traffic simulation unit would independently test areas contractors are not testing themselves. For instance, the unit would simulate heavy traffic on the prototypes up to double the maximum traffic load specified for VSCS.

According to FAA officials, the agency's current plans are to complete the following testing before awarding a production contract: (1) factory acceptance testing of critical functions only, (2) limited operational tests that include evaluations of the contractors' prototypes by air traffic controllers, and (3) tests using the traffic simulation unit. Officials stated, however, that while they plan to complete these tests, they could not guarantee that the tests would be completed before awarding the contract. Agency officials also stated that, if time permits, factory acceptance testing of noncritical functions may also be conducted prior to award.

[6]Microwave Landing Systems: Additional Systems Should Not Be Procured Unless Benefits Proven (GAO/RCED-88-118, May 16, 1988).

Even though FAA officials said they do not plan to award the VSCS production contract without factory acceptance test results on critical functions, these officials stated that because of the tight development schedule, they expect factory acceptance testing to uncover more problems than usually appear during this phase. Therefore, agency officials will accept unsuccessful factory acceptance test results as long as solutions to problems are also identified and risks are acceptable. According to FAA, these unsuccessful results will be evaluated and this assessment used in the award process. FAA points out that unsuccessful tests will be repeated until successful during the production phase. However, this will take place after the contract is awarded.

If FAA does not conduct complete factory acceptance tests, it could commit to producing a system without sufficient assurance that it will work as intended. In addition, if FAA does not conduct tests using the traffic simulation unit and the planned limited operational testing, it will not know (1) if important contractor factory acceptance tests are valid; (2) if the prototypes work as required under the stress of heavy traffic; or (3) if the prototype designs are acceptable to air traffic controllers.

VSCS Schedule Delays May Affect the Advanced Automation System

Because VSCS continues to experience development problems, Advanced Automation System workstation implementation may be delayed. The first operational site where VSCS and the controller workstation will be tested together is Seattle. However, VSCS may not be ready in time for this testing, which could delay the workstations and raise the costs of the Advanced Automation System contract. The workstation is scheduled to be delivered to the first site in August 1992 and the Advanced Automation System contract states the government will provide VSCS components, certified operational, 90 days before the workstation delivery, or currently May 1992. But, according to SEIC estimates, VSCS may not be operational at Seattle until September 1992. Because workstations are scheduled to be delivered every 2 months at the next two sites, and then every month at the remaining sites, any problems with the operational testing in Seattle could also delay the rest of the schedule.

Since components of VSCS are government-furnished equipment to the Advanced Automation System, the government will not have met its obligation under the Advanced Automation System contract and could incur additional costs and delays if FAA does not deliver VSCS on time. The Advanced Automation System contract contains no provision to reduce the government's potential liability if VSCS is delayed.

Conclusions

VSCS has experienced cost, schedule, and technical difficulties dating back several years. To date, total project cost estimates have more than tripled, from $258 million to over $786 million. Scheduled milestones have been delayed up to 6 years. Both prototype contractors have experienced difficulties designing and implementing a system capable of meeting performance requirements.

FAA has attempted to save time and thus avoid delaying the Advanced Automation System by reducing testing during the VSCS prototype development. Operational testing and evaluation has been moved from prototype development to the production phase and complete factory acceptance testing will be performed only if time allows. As we have reported previously, shortcuts to testing can result in lengthy delays and higher costs. Agency officials maintain that they still plan to have the contractors complete factory acceptance tests on critical functions, as well as conduct limited operational tests and tests using the traffic simulation unit. However, officials could not assure us that this would definitely occur prior to award.

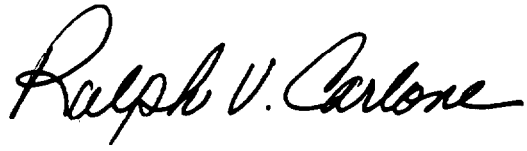
While we recognize that it is important to deploy VSCS as soon as practical, we believe FAA must have assurance that the system it selects will meet functional and performance requirements in an operationally realistic environment. Under its current approach, FAA will not have this assurance because it is not requiring complete factory acceptance testing to determine if the prototype meets all system requirements. Further, if FAA does not test the prototypes using a traffic simulation unit, the agency will not have an independent assessment of the prototypes and their performance under the stress of heavy work loads. Additionally, if planned limited operational tests are not performed, FAA will not have any operational assessment of the prototypes. Consequently, a production contract award without these tests could result in cost increases, schedule delays, and performance deficiencies.

VSCS delays now threaten to postpone deployment of the new controller workstations. Furthermore, because VSCS components are government-furnished equipment under the Advanced Automation System contract, the government may be responsible for delays in the Advanced Automation System caused by late delivery of VSCS and could therefore incur additional costs.

Recommendations

It is important that FAA select a prototype system that meets requirements and functions effectively in an operational environment. Therefore, we recommend that the Secretary of Transportation direct the Administrator, FAA, not to award the VSCS production contract until, at a minimum, the agency has (1) the results of complete factory acceptance testing to ensure that prototypes meet system requirements; (2) an independent verification of the results of the contractors' testing, including an assessment of the system's performance under maximum work loads; and (3) an assessment of the operational suitability of the system. To reduce the government's potential liability, we also recommend that the Secretary direct the Administrator to explore possible changes in the Advanced Automation System contract in order to lessen the possible adverse impact of VSCS delays.

We are sending copies of this report to interested congressional committees, the Secretary of Transportation, and the Administrator, FAA. We will also make copies available to other interested parties upon request. This report was prepared under the direction of Samuel W. Bowlin, Director. Major contributors are listed in appendix II.



Ralph V. Carlone
Assistant Comptroller General

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Abbreviations

AT&T	American Telephone and Telegraph
FAA	Federal Aviation Administration
GAO	General Accounting Office
IMTEC	Information Management and Technology Division
NAS	National Airspace System
SEIC	System Engineering and Integration Contractor
VSCS	Voice Switching and Control System

Objectives, Scope, and Methodology

At the request of the House and Senate Appropriations Committees, Subcommittees on Transportation and Related Agencies, we reviewed FAA's efforts to implement VSCS. Our objectives were to determine (1) if previously reported cost, schedule, and technical difficulties were continuing; and (2) if these difficulties would delay deployment of new air traffic controller workstations.

To evaluate VSCS cost and schedule difficulties, we examined program documents dating back to the system's inception, and compared them with actual and projected expenditures and schedules. To evaluate technical difficulties, we reviewed the prototype contracts, system requirements statements, and system specifications. We also reviewed contractor monthly status reports prepared by FAA's SEIC to obtain information on VSCS contractor performance. In addition, we interviewed Department of Transportation VSCS program office and contract office officials; AT&T Technologies, Incorporated, and Harris Corporation officials and technical staff; and SEIC officials and staff to obtain their views on the causes of the cost, schedule, and technical difficulties.

To evaluate the likelihood of VSCS delaying workstation deployment, we examined appropriate contracts and schedules. In addition, we interviewed agency and SEIC officials to obtain their views on the probability of VSCS delaying workstation deployment. Further, we examined an SEIC risk analysis of the VSCS schedule.

Our review was conducted from May 1988 to April 1989 at FAA headquarters and Martin Marietta in Washington, D.C.; at Harris Corporation in Palm Bay, Florida; and at AT&T Technologies, Incorporated, Bell Laboratories, in Naperville, Illinois. The views of agency and contractor officials were sought during the course of our work and their comments have been incorporated where appropriate. In addition, we obtained formal oral comments on a draft of this report from Department of Transportation officials. We conducted our review in accordance with generally accepted government auditing standards.

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