

June 1990

AIR TRAFFIC CONTROL

Smaller Terminal Systems' Capacity Requirements Need to Be Defined



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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 December 15, 1989, request, we reviewed the Federal Aviation Administration's (FAA) efforts to provide automated safety enhancements for air traffic controllers at smaller Terminal Radar Approach Control (TRACON) facilities. These TRACONS control aircraft arriving at or departing from airports such as Pensacola, Florida, and Binghamton, New York. To implement the enhancements and upgrade existing automation systems at these TRACONS, FAA is deploying the Automated Radar Terminal System (ARTS) IIA. As agreed with your offices, our objectives were to (1) determine the extent of and reasons for delays in developing, testing, and deploying the ARTS IIA hardware and software, and (2) determine if FAA has adequately identified current and future computer capacity requirements for smaller TRACONS. A detailed explanation of our objectives, scope, and methodology is contained in appendix I.

Results in Brief

Installation of safety enhancements at smaller TRACONS has been delayed about 3 years because FAA did not properly manage the program. FAA awarded a production contract before the system was developed and continued to change system requirements after the contract was awarded. Also, FAA did not require the contractor to perform integrated tests to determine if various portions of the system worked together correctly. As a result, the system design had to be modified during production, which led to delays in deployment.

FAA also does not have a computer capacity and performance management program for its smaller TRACONS. Such a program measures current computer utilization and is used to predict future capacity requirements. As we reported last year, the lack of a capacity management program at

tracking, the safety features of conflict alert and minimum safe altitude warning, and add a controller training function. Aircraft tracking would perform position predictions and display aircraft ground speed to controllers. Conflict alert would provide visual and sound alerts to the controller when two controlled² aircraft are in or are projected to come into close proximity to each other within the next 40 seconds. Minimum safe altitude warning would provide visual and sound alerts to controllers when an aircraft is flying or is projected to fly too low. The controller training function was to simulate live traffic situations without affecting air traffic control operations at other workstations. FAA implemented these enhancements at its larger TRACONS in several phases between 1977 and 1989.

In July 1985 FAA awarded the ARTS IIA production contract to Burroughs Corporation, now UNISYS, at an estimated cost of \$35.7 million. This contract, now valued at \$45.4 million, is to provide the above enhancements to all 119 ARTS IIA TRACONS through new hardware and software by August 1991.

In addition to these enhancements, FAA plans to award a contract late in fiscal year 1990 to improve ARTS IIA reliability and increase system capacity. This planned contract is designed to provide additional controller workstations, replace obsolete tape drives with disk drives, and provide uninterruptable power systems for several ARTS IIA locations. In addition, the planned contract contains an option to increase ARTS IIA capacity and provide another safety enhancement—the Mode C Intruder.³ This option is designed to provide 145 new computers to significantly increase processing and memory capacity. This contract is part of FAA's Interim Support Plan designed to sustain the air traffic control system until it is replaced by the Advanced Automation System in the mid-to-late 1990s.

²Controlled aircraft are followed from takeoff to landing by controllers, must carry electronic equipment including radios to communicate with controllers and a transponder to provide altitude and identity information, and must file flight plans that detail their proposed journey. Uncontrolled aircraft, although sometimes monitored by the system, do not need to carry electronic equipment unless they enter controlled airspace, and are not required to file flight plans; however, they must follow well-established FAA rules regarding where they can fly.

³The Mode C Intruder is a warning to controllers that indicates that the distance between a controlled and uncontrolled aircraft will become hazardous within the next 40 seconds. This warning differs from conflict alert in that it will monitor one controlled and one uncontrolled Mode C-equipped aircraft, rather than two controlled aircraft

requirements specifying that the ARTS IIA process 102 tracks, support up to 11 displays, and use the current operational software version, as well as provide tracking, the safety enhancements, and the training capability.

FAA awarded the production contract without requiring the contractor to demonstrate that it could meet the new system requirements. In fact, the contractor's proposal questioned whether the system could provide sufficient processing capacity to support an 11-display system. According to the program manager, FAA recognized at the time the production contract was awarded that additional modifications might be necessary to meet all ARTS IIA operational requirements.

The Office of Management and Budget's procurement policy, contained in its Circular A-109, requires production decisions to be based on evidence that the system meets requirements before committing to production. In this instance, FAA's decision to award the production contract before development was complete contributed to ARTS IIA implementation delays.

Software Baseline Not Stabilized for Production Contract

While new software was being developed under the ARTS IIA development and production contracts, FAA continued to modify the existing ARTS II software operating at smaller TRACONS. FAA did this to correct inefficiencies and provide additional features, some of which were already operational at a few sites. As these improvements were completed, FAA released the new software to sites. Although it is important to adequately specify the functions software should perform before committing to a production decision, FAA continued to modify the software requirements throughout the life of the production contract. This contributed to implementation delays. For example, FAA released new software to ARTS II sites 4 months after the ARTS IIA contract award and then changed the contract to reflect these changes. Then, in 1986, FAA required that seven additional software features be included in the ARTS IIA contract.

By late 1987, these seven additional features had been incorporated and UNISYS shipped the ARTS IIA to the FAA Technical Center for testing. The results of this test identified over 200 problems, 65 of which FAA classified as critical. The most significant problem was the system's inability to meet the 102-track requirement. Contractor personnel told us that the system failed to meet this requirement because the features added to the system baseline used significant amounts of computer capacity. As a

planning, acquiring, and using computer resources. Last year we reported that FAA lacked a computer capacity and performance management program for its large TRACONS.⁵ Consequently, FAA did not recognize capacity shortfalls until controllers' ability to maintain safe separation of aircraft was impaired.

Further, adequately defining capacity requirements and establishing a computer capacity and performance management program are necessary to ensure maximum use of existing resources and adequate capacity for growth. Capacity expansion should be based on an analysis of current system performance, new requirements, and projections for future growth.

ARTS IIA May Not Meet Small TRACON Requirements

Although we reported in 1983⁶ that FAA should implement a computer performance management function to measure terminal systems' efficiency and effectiveness, FAA lacks such a program for ARTS IIA systems. FAA officials stated that a program has not been established because ARTS II systems did not encounter capacity shortfalls. The lack of such a program constitutes a material weakness under the Federal Managers' Financial Integrity Act (31 U.S.C. 3512 (b) and (c)). This weakness is regarded as material given the fact that a capacity management program is an integral part of effective computer operations, which is central to FAA's fulfilling its air traffic control mission.

Although FAA increased the track requirement for the ARTS IIA system to 102 tracks prior to awarding the production contract, it did not analyze current and future work loads to determine if this requirement would meet actual needs. In fact, FAA did not perform any meaningful analysis to derive this stated track requirement. As a result, FAA has no assurance that the work loads at ARTS IIA facilities will not exceed 102 tracks.

Additionally, ARTS IIA tests conducted in 1989 indicate that the system uses 76 to 93 percent of total processing capacity when operating under maximum specified work loads. This indicates that ARTS IIA systems may approach computer capacity limitations under heavier work loads. However, because FAA does not collect data on current or projected instantaneous traffic levels, it does not know whether ARTS IIA sites are

⁵Air Traffic Control: Computer Capacity Shortfalls May Impair Flight Safety (GAO/IMTEC-89-63, July 6, 1989).

⁶FAA's Plans to Improve The Air Traffic Control System: A Step In The Right Direction But Improvements And Better Coordination Are Needed (GAO/AFMD-83-34, Feb. 16, 1983).

computer capacity on the basis of inadequate analysis of current usage, future traffic levels, and future work loads, including Mode C Intruder requirements. Basing an acquisition on inadequately defined requirements and incomplete performance data increases the risk that the expanded systems will be inadequate to meet operational requirements.

Recommendations

Experience gained in implementing the ARTS IIA project can be used to prevent similar problems from occurring on future projects. We recommend that the Secretary of Transportation direct the Administrator, FAA, to improve management of future TRACON automation projects by awarding production contracts only after development is complete, controlling changes to operational software during system development and production, and requiring contractors to perform integrated testing.

In addition, we recommend that the Secretary of Transportation direct the Administrator to implement a computer capacity and performance management program for ARTS IIA systems. This program should include an analysis of current system performance and future work loads, including predicted traffic levels and additional software functions to determine system requirements, as well as the potential performance of the enhanced system.

We also recommend that the Secretary direct the Administrator to report the lack of a computer capacity and performance management program as a material control weakness under the Federal Managers' Financial Integrity Act until a program has been implemented.

Finally, we recommend that the Secretary direct the Administrator to delay exercising the expansion contract option to procure additional computers until a computer capacity and performance management program is implemented and future capacity requirements are adequately defined.

Agency Comments and Our Evaluation

We obtained official oral comments from the Department of Transportation and FAA officials on a draft of this report. They stated that FAA awarded the production contract in July 1985 after considering the technical, schedule, and cost risks and found these risks to be acceptable based on the information available at that time. Department and FAA officials agreed that software requirements were modified after contract award and that this delayed the implementation of the safety enhancements. However, they commented that they took steps to control the

Appendix I
Objectives, Scope, and Methodology

Our review was conducted from May 1989 to April 1990. The views of agency officials were sought during the course of our work and their comments 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 government auditing standards.

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Major Contributors to This Report

Information
Management and
Technology Division,
Washington, D.C.

Joel C. Willemsen, Assistant Director
Andrea M. Leopold, Assignment Manager
Michael S. Dombrowski, Evaluator-in-Charge
Kelly Wolslayer, Computer Scientist

New York Regional
Office

Karlton P. Davis, Senior Evaluator

Philadelphia Regional
Office

Peter Maristch, Senior Evaluator

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 upgrade automation systems at smaller TRACONS. Our objectives were to (1) determine the extent of and reasons for delays in developing, testing, and deploying the ARTS IIA hardware and software, and (2) determine if FAA has adequately identified current and future computer capacity requirements for ARTS IIA.

To evaluate why problems occurred during the development and testing of ARTS IIA, we reviewed system specification and requirements statements, the development and production contracts, and test plans and schedules. We also reviewed FAA and contractor correspondence, technical integration meeting minutes, and software integration group meeting minutes. We examined the results of hardware and software tests conducted at the contractor's facility; at the FAA Technical Center in Pomona, New Jersey; and the Atlantic City, New Jersey, TRACON. We also reviewed monthly contractor progress reports prepared by UNISYS and those prepared by support contractors. In addition, we interviewed agency officials, both at FAA headquarters in Washington, D.C., and at the FAA Technical Center, and UNISYS program and contract officials, to obtain their views on why the ARTS IIA software had been delayed.

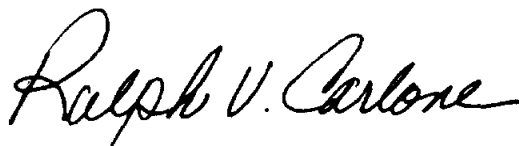
To evaluate whether FAA has adequately identified current and future capacity requirements for ARTS IIA, we examined appropriate contracts and specifications. In addition, we reviewed the request for proposals and other documentation for the planned ARTS IIA expansion project. We interviewed agency and contractor officials to obtain their views on operational capacity requirements for ARTS IIA and its expanded system. We also discussed acquisition plans with Department of Transportation officials. We met with FAA and contractor officials to discuss a computer capacity and performance management program for ARTS IIAs and capacity requirements for implementing the Mode C Intruder safety enhancement.

We performed our work at FAA's Washington, D.C., headquarters, its Pomona, New Jersey, Technical Center, and its regional office in Jamaica, New York. We also performed work at TRACON facilities in Pensacola, Florida; Binghamton, New York; Allentown, Erie, and Harrisburg, Pennsylvania; Richmond, Virginia; the Department of Transportation in Washington, D.C.; Martin Marietta Corporation in Washington, D.C.; and UNISYS Corporation in Paoli, Pennsylvania.

changes. Officials agreed that integration testing is important and recognized that there is room for improvement. Finally, Department and FAA officials agreed that they do not have a computer capacity and performance management program in place, but they plan to begin measuring computer performance.

Although we acknowledge that risks exist in making production decisions, we believe that such a decision should be based on a demonstration that the system meets requirements, including computer capacity requirements, which are critical to successful deployment. We are encouraged by agency commitments to improve integration testing and to measure computer capacity and performance.

As arranged with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution of it until 30 days after the date of this letter. We will then send copies to the Secretary of Transportation; the Administrator, FAA; and to other interested parties. We will also make copies available to others upon request. This report was prepared under the direction of JayEtta Z. 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.



Ralph V. Carlone
Assistant Comptroller General

experiencing increasing traffic levels, which could increase work loads and lead to computer capacity shortfalls.

Inadequate Analysis to Support Expansion Contract

FAA plans to award a \$63-million ARTS IIA expansion contract in late fiscal year 1990 that includes an option to increase computer processing capacity at all ARTS IIA facilities. The option calls for obtaining 145 new computers with sufficient processing and memory capacity to perform the majority of ARTS IIA functions. This option would provide additional processing capacity in order to provide the Mode C Intruder safety enhancement and to increase track requirements from 102 to 256.

However, FAA once again did not perform any meaningful analysis to determine this track requirement. According to the program manager, this requirement represents the maximum number of targets that the ARTS IIA could track when an additional computer is implemented at each site. Because there is no computer capacity and performance management program, FAA cannot adequately determine requirements for the expansion contract. Although the Federal Information Resources Management Regulation Part 201-30 states that requirements analyses should include a performance evaluation of the currently installed system, FAA evaluated neither the ARTS II nor ARTS IIA systems. Instead, FAA estimated track requirements without analyzing system performance or future work loads. As a result, it is uncertain how well the ARTS IIA expansion will meet FAA needs.

Conclusions

Safety enhancements identified over 8 years ago are just now becoming operational because of inadequate FAA program management. FAA did not ensure that development of the system was complete prior to award of the production contract, that software requirements were not modified after award of the production contract, and that integrated tests were performed by the contractor. As a result, controllers are just now getting key automation aids to assist in separating aircraft.

In addition, FAA does not have a computer capacity and performance management program at its small TRACONS. The lack of such a program constitutes a material weakness under the Federal Managers' Financial Integrity Act because such a program is an integral part of computer operations, which are essential to FAA's critical air traffic control mission. Without a capacity management program, FAA did not adequately determine capacity requirements and does not have assurance that the ARTS IIA system will meet small TRACON needs. Further, FAA plans to add

result, the contractor had to modify the system design, which further delayed system deployment.

Contractor Was Not Required to Perform Integrated Tests

The contractor's test plan did not require integration testing prior to system acceptance at the FAA Technical Center. Integration testing determines if multiple pieces of a system work together correctly. In general, detecting and solving software problems earlier is less time-consuming than solving them later in the development and production process. Contractor testing was limited to a series of stand-alone tests that verified how well individual requirements were met, but did not demonstrate full system performance. As a result, the system failed FAA integration tests several times; attempts to correct deficiencies caused additional problems. For example, a demonstration of 12 software solutions to previously noted problems showed that while the solutions worked, 11 new problems were discovered. As a result, schedule delays occurred while the contractor spent additional time developing solutions to the new problems.

FAA Lacks a Computer Capacity and Performance Management Program

According to federal regulations, agencies are required to perform computer capacity and performance management activities in planning, acquiring, and using computer resources. However, FAA has not established a capacity management program because small TRACONS have not encountered capacity shortfalls. Therefore, current processor utilization has not been measured, current and future capacity requirements have not been adequately defined, and it is uncertain whether ARTS IIA will meet FAA's needs. Additionally, FAA cannot be certain that additional capacity provided through the proposed expansion project will meet TRACON needs.

Capacity Planning and Performance Management Are Important

An effective capacity management and performance monitoring program addresses both performance management and capacity planning. Performance management involves analyzing the current work load and the performance of computer systems to determine how resources are currently used and how utilization can be improved. Capacity planning assists in forecasting future work loads and other computer resource requirements to ensure that enough capacity will be available when needed.

Moreover, Federal Information Resources Management Regulation Part 201-30 requires agencies to perform capacity management activities in

Inadequate Program Management Has Delayed Implementation of ARTS IIA

Implementation of ARTS IIA has been delayed 3 years because of inadequate program management. When FAA awarded the production contract in 1985, it planned to begin deployment of the ARTS IIA enhancements in the spring of 1987. However, FAA awarded a production contract prior to completion of system development and required changes to the production software several times after the contract was awarded. Additionally, FAA did not require the contractor to perform integration testing prior to FAA's own testing. As a result, the system failed to meet requirements when FAA tested it, contributing to delays in deploying ARTS IIA until March 1990.

ARTS IIA Has Been Delayed 3 Years

The original production contract schedule required UNISYS to deliver both the ARTS IIA hardware and software to the FAA Technical Center in Pomona, New Jersey, for testing in November 1986. UNISYS delivered the system in December 1986, but testing revealed numerous software problems. Additionally, this version of software did not include modifications already made to the software operating at smaller TRACONS. Therefore, UNISYS was tasked to include these modifications in ARTS IIA software.

UNISYS returned the system to the technical center for testing in December 1987. Three months later, test results indicated that the ARTS IIA did not have sufficient processing capacity to meet required work loads while maintaining all air traffic safety functions. UNISYS then modified the system design to provide additional capacity and returned it to the technical center for testing in June 1989. In the fall of 1989 FAA decided the system met requirements and sent the system to the Atlantic City, New Jersey, TRACON for testing in an operational environment. In March 1990, testing was deemed successful and the Atlantic City ARTS IIA became fully operational. Over the next year and a half, FAA plans to deploy the ARTS IIA to all remaining smaller TRACONS.

Development Not Complete Prior to Production Contract Award

The 1982 development contract demonstrated, on the basis of testing at the technical center, that the ARTS IIA system could provide tracking, the safety enhancements, and the controller training function. The system also met FAA's original requirements to process 48 tracks,⁴ support six controller displays, and use a 1982 software version. However, prior to awarding the production contract, FAA decided to change the

⁴A track occupies a portion of memory in the ARTS IIA computer and contains the pertinent data on a controlled aircraft.

large TRACONS led to computer shortfalls and resulting system degradation. FAA has not established a capacity management program because smaller TRACONS have not encountered capacity shortfalls. As a result, FAA does not have a good understanding of current computer utilization or future computer capacity requirements at smaller TRACONS. Therefore, it is uncertain whether ARTS IIA will meet FAA's needs at smaller TRACONS.

FAA needs to improve management of future TRACON automation acquisitions and upgrades by making production decisions only after development is complete, controlling system requirements changes after contract award, and requiring contractors to perform integrated testing. Further, FAA needs to implement a computer capacity and performance management program for smaller TRACON automation systems, and define future capacity requirements prior to expanding ARTS IIA.

Background

FAA's air traffic control mission is to promote the safe, orderly, and expeditious flow of aircraft. Maintaining the required horizontal and vertical separation between aircraft is critical to safety. Air traffic controllers maintain the required separation by using information that is assembled and processed by FAA's air traffic control computer systems and displayed on video screens at controllers' workstations. The position information displayed on controllers' screens is accompanied by aircraft identity, altitude, and direction data. Additional information such as a flight's route, destination, and expected arrival time is provided to controllers on paper.

Automation Systems at Smaller TRACONS

Air traffic controllers at FAA's TRACON facilities sequence and separate aircraft arriving at or departing from airports under their control. Controllers at each of the 119 smaller TRACONS are supported by a computer system known as an ARTS II.¹ This computer system receives input from radar, identifies aircraft, associates the aircraft with flight plans, and displays aircraft identification and position location to controllers.

In March 1982 FAA awarded a \$4.1-million development contract to Burroughs Corporation to determine if ARTS IIs could be enhanced to an upgraded system—ARTS IIA. The enhancements were to provide aircraft

¹FAA also maintains 22 air route traffic control centers, which control air traffic that is en route between airports, and 63 larger TRACONS, which control traffic at busier airports. Each of these facilities is supported by an automated system to help controllers maintain aircraft separation.

