

GAO

Report to the Chairman, Subcommittee
on Transportation and Related
Agencies, Committee on
Appropriations, U. S. Senate

September 1989

AIR TRAFFIC CONTROL

FAA Needs to Implement an Effective Testing Program





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

Information Management and
Technology Division

B-230526

September 22, 1989

Senator Frank R. Lautenberg
Chairman, Subcommittee on Transportation
and Related Agencies
Committee on Appropriations
United States Senate

Dear Mr. Chairman:

At your request, we reviewed the Federal Aviation Administration's (FAA) program for testing the systems and equipment it procures for controlling air traffic. FAA began a major effort in 1981, known as the National Airspace System (NAS) plan, to replace and modernize its radar, communication, and data processing equipment. The agency expects to spend about \$16 billion for systems and equipment to implement this modernization effort. In your request, you noted your concern that the agency's test policy not be compromised to expedite implementation of new systems. Therefore, as agreed with your office, our review focused on determining whether FAA's test policy provided the foundation necessary for a sound test and evaluation program. Appendix I describes our objective in more detail, and our scope and methodology.

The success of FAA's test and evaluation program has been limited because (1) the 1986 order containing the agency's test policy did not establish how users were to be involved in testing systems and equipment, and (2) FAA did not implement effective controls to assure compliance with this order. The effectiveness of the test program has also been impaired because the group responsible for oversight of the testing program is not independent of developers and users. Such independence is recommended by federal policy. Further, this group does not review systems that cost less than \$150 million. As a result, many systems critical to the success of the NAS plan are not reviewed.

The absence of an effective agency testing program has allowed projects to proceed into production without sufficient testing and contributed to schedule delays of 1 to 8 years. Further, the lack of testing has led to the deployment of systems, such as the \$1.6-billion acquisition of microwave landing systems, without addressing key safety and reliability issues.

FAA issued a new test order in February 1989 that, if properly implemented, can address some of the shortcomings associated with the test

Recognizing that its test program was not adequate for the size and complexity of procurements under the NAS plan, FAA contracted, in 1984, with MITRE Corporation to identify ways that testing could be improved. MITRE reviewed four agency acquisition programs and identified 35 problem areas where the testing process could be improved. Specifically, MITRE reported that FAA lacked an agencywide test and evaluation policy, did not conduct operational testing independent of agency development and user groups, and had deployed systems that were inadequately tested. The report emphasized that because of the magnitude and intensity of the effort to modernize the air traffic control system, it was critical that the agency establish an effective test and evaluation program.

After MITRE's 1984 report, FAA's Associate Administrator for Development and Logistics directed that a standard policy be developed for testing systems before acceptance and deployment. He then issued a test and evaluation order incorporating this policy in December 1986.

The order required a test and evaluation process for all NAS systems to assure that requirements, including operational effectiveness and suitability, were verified before deployment. Projects already under contract were to conform with the order to the extent practicable. Master test plans were to be developed for each project, and were to address required testing for systems from design through deployment.

The order also directed that as much testing as possible be done before systems were installed at field locations. This testing was to occur primarily at FAA's national test center located in Pomona, New Jersey. This center's primary mission is to provide needed laboratories, skills, and services to develop, test, and evaluate new FAA equipment and systems. As we have previously reported, the center reports to FAA's development organization.²

FAA Test Order Was Inadequate

While FAA's December 1986 test and evaluation order was an important first step in establishing a testing program, shortcomings existed in the agency's development and implementation of the order. The order did not address the roles of system users and the agency did not implement effective controls to assure compliance with the order.

²Air Traffic Control: Continued Improvements Needed in FAA's Management of the NAS Plan (GAO/RCED-89-7, Nov. 10, 1988).

In an effort to remedy the situation, in November 1987 FAA sent a letter to project managers reiterating the test management branch's responsibility for monitoring compliance with the test order. The letter requested that project managers add branch personnel to their distribution lists, and that they be invited to participate in design reviews and meetings. According to test management personnel, the letter did not produce significant improvements in the branch gaining the information it needed to monitor compliance.

The low level of support given the test management function was indicated in a July 1988 reorganization of Development and Logistics in which the test management function was ignored and not assigned to any organizational element. As described by one test management official, "it fell through the cracks" and no longer exists. Recognizing that FAA needs this type of oversight, agency officials recently said that they plan to establish test directors at FAA's national test center to assure that systems are adequately tested.

FAA's Operational Test Group Has Had Limited Effectiveness

Federal policy recommends that testing of major system acquisitions be conducted independently of the development and user organizations. As previously noted, FAA's national test center is not independent of system developers. Therefore, in an effort to comply with federal policy, FAA established an operational test and evaluation group independent of system developers and users to monitor testing. This group, while providing oversight similar to that offered by the old test management branch, differs in that the test and evaluation group was to be the agency's independent overseer. However, this group has not been fully effective because it only reviews systems costing at least \$150 million and it is no longer independent.

Office of Management and Budget Circular A-109 recommends that operational tests and evaluations within an agency be conducted independently from those who develop and those who use systems. Independence has long been a recognized principle of effective test programs. Independence is important because contractors, developers, and users have goals, such as meeting cost and schedule commitments, which can conflict with thorough testing. To avoid a real or apparent conflict, a test organization needs to oversee operational tests and report test results independently.

When the test and evaluation group was organized in 1983, this group was to monitor, rather than conduct, operational testing because FAA

development. According to FAA officials, this reorganization occurred primarily because the Administrator wanted to consolidate the number of organizational groups reporting directly to him. These officials contend that this reorganization has not hindered the effectiveness of the testing group even though it reports to the Executive Director for Systems Development. However, Circular A-109 clearly recommends that the testing group should be independent of the developing organization.

Systems Were Deployed Without Needed Testing

The lack of an effective test program has permitted NAS systems to proceed into production and deployment without the testing necessary to assure that systems work as intended and are operationally suitable. Further, in some instances, FAA decided to deploy systems even though initial tests identified problems that needed resolution. We have previously reported that inadequate testing of systems prior to committing to production contracts has contributed to schedule delays ranging from 1 to 8 years for many of FAA's systems.³

These test and evaluation shortcomings are also evidenced by our review of the results of FAA's deployment readiness reviews. Deployment readiness reviews are intended to ensure that NAS projects are ready for delivery to the first operational site and that the site is ready to receive and use the systems. These reviews consist of an assessment of such items as site preparedness, implementation plans, regional funding, testing, and training. Readiness reviews occur 6 months before projects are scheduled for deployment.

Our review of available documentation for the 15 projects that had reached the initial stage of the deployment readiness review process showed that

- 11 of the 15 projects did not comply with FAA's December 1986 test order, and
- 7 of the 15 projects did not have approved master test plans.

The ineffectiveness of FAA's test program is demonstrated by the fact that most projects entering the readiness review process did not comply with the December 1986 test order. In some cases, systems proceeded to production and deployment without needed testing. For example, we previously reported that FAA's testing of precision microwave landing

³Microwave Landing Systems: Additional Systems Should Not Be Procured Unless Benefits Proven (GAO/RCED-88-118, May 16, 1988).

test plans were either not done or not completed in a timely manner. In one project a production contract was awarded in 1984, but a master test plan was not produced for the project until 1988. Because the system developer and the user did not coordinate test requirements for this project, decisions were based on incomplete test results. If a timely master test plan had been developed, software problems that were later identified by systems users might have been remedied earlier.

New Policy Issued But Management Support Uncertain

In February 1989, FAA issued a new test and evaluation order to replace the order issued in 1986. According to agency officials, the new order was needed to overcome many of the past testing deficiencies in areas such as user involvement and master test plans. Specifically, officials point out that the new order now requires that (1) Air Traffic be involved in the test and evaluation process, and (2) master test plans be prepared and issued within 3 months of project inception. The new order also sets out responsibilities for all agency components involved in testing, including the establishment of test directors who will be responsible for verifying compliance with the new order.

While it appears to address some shortcomings, the new test policy does not recognize the need for independent oversight of FAA's test program for all critical systems. Specifically, under the new policy, the independent operational test and evaluation group continues to review only those systems exceeding \$150 million and the group remains within the agency's development organization. In response to these concerns, FAA officials contend that the new order will reduce the need for an independent operational test and evaluation group because FAA plans to have test directors verify test order compliance. However, these test directors, who work for the developing organization, would not be independent.

Implementing an effective test program requires management support. The history of FAA's testing and evaluation program demonstrates that top management has not provided this support, even though many agency program and technical managers believe that FAA has adequate funding and personnel to properly test systems and equipment. Also, we reported during a prior review that agency test officials believed that the laboratories and facilities at FAA's national test center have the hardware, software, and simulation capability to test about 90 percent of

critical NAS systems. To discharge its responsibilities, the component should

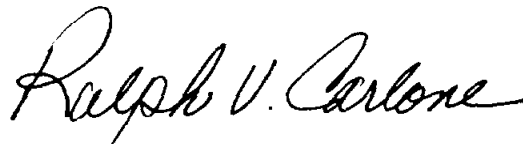
- be responsible for reviewing all NAS systems it considers critical to safety, regardless of their cost;
- be given test plans, procedures, and other documentation that it determines is necessary to assess tests and evaluations; and
- review test results and report findings to an appropriate level.

We also recommend that the Secretary of Transportation direct the FAA Administrator to focus management attention on implementing fully the test and evaluation policy and to periodically review the program to ensure its success.

The views of agency officials were sought during the course of our work and their informal comments were obtained on this report. We have incorporated these comments where appropriate. We also obtained formal oral comments from Department of Transportation officials. The Department noted that the report identifies significant testing issues and agreed with our recommendations.

We are sending copies of this report to interested congressional committees, the Secretary of Transportation, and the Administrator of 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, Defense and Security Information Systems, who can be contacted at (202) 275-4649. Other major contributors are listed in appendix II.

Sincerely yours,



Ralph V. Carlone
Assistant Comptroller General

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Objective, Scope, and Methodology

The Chairman, Senate Appropriations Committee, Subcommittee on Transportation and Related Agencies, asked that we review the adequacy of FAA's test policy. The Chairman pointed out that FAA was receiving considerable pressure from various sources to hasten the implementation of the NAS plan in order to expedite expansion of the airspace system's capacity. As a result, he was concerned that the agency's test policy not be compromised to quicken implementation. Therefore, as agreed with his office, our objective was to determine whether FAA's test policy provided the foundation necessary for a sound test and evaluation program.

To address this objective, we analyzed a 1984 MITRE report on FAA's testing program, the 1986 test order, and FAA's February 1989 order. We also reviewed the organizational structures involved in the acquisition and utilization of systems, the assignment of test and evaluation roles and responsibilities, and the control mechanisms used to ensure compliance with the test and evaluation order and to ensure that adequate testing was conducted for individual projects before deployment. We interviewed agency officials responsible for systems development and acquisition about policy implementation, and we interviewed Air Traffic officials responsible for system maintenance and use concerning the adequacy and applicability of the policy. We also discussed the testing process with officials responsible for monitoring system testing. In addition, we reviewed the results of the agency's deployment readiness review process to determine whether tests were being required for newly developed NAS Plan systems.

Our review was performed from January 1988 to May 1989 at FAA headquarters, Washington, D.C., and at the FAA Technical Center, Pomona, New Jersey. The views of agency 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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Abbreviations

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| FAA | Federal Aviation Administration |
| GAO | General Accounting Office |
| IMTEC | Information Management and Technology Division |
| NAS | National Airspace System |

current NAS system requirements.⁵ Therefore, it appears that FAA may have the resources to do adequate testing, but it has lacked the commitment to use these resources as it should.

Conclusions

FAA's commitment to a successful testing and evaluation program has not been demonstrated. This has contributed to the test program's limited effectiveness. As we have previously reported, inadequate testing has contributed to schedule delays ranging from 1 to 8 years for many of FAA's systems. It also has increased the risk of further system cost increases due to problems encountered later when they are more expensive and difficult to correct.

Even though FAA recognized many years ago that it needed to improve its test program and MITRE's 1984 report confirmed this need, FAA has not yet corrected all test weaknesses. The 1986 test order did not define a role for the air traffic controller group, a main user of systems, and effective controls were not implemented to assure compliance with this order. FAA has also not provided effective independent operational testing and evaluation of systems. The role of the group established to monitor operational testing has been limited because it only monitors high-cost systems and due to an agency reorganization, it is no longer independent of system developers.

FAA recently issued a new order that can solve some of the current test program's problems, but it does not address the need for independent oversight of testing. In addition, greater FAA management support and emphasis is required to implement the new policy and ensure the program's success.

Recommendations

It is important that FAA have an effective test and evaluation program for systems critical to safe air travel. Therefore, we recommend that the Secretary of Transportation direct the FAA Administrator to revise the recently issued test policy by providing for a test and evaluation component organizationally independent of the development and user communities, in accordance with federal guidance. This independent component should be responsible for ensuring that adequate test plans and procedures are developed and that testing is successfully completed for all

⁵FAA Technical Center: *Mission and Role in National Airspace System Plan Implementation* (GAO/IMTEC-88-6BR, Jan. 6, 1988).

systems costing up to \$1.6 billion was not completed as planned.⁴ A key factor in integrating these systems into the air traffic control environment was to ensure that all issues related to safety were recognized and satisfactorily addressed, including landings and the aborting of landings. However, tests designed to address user concerns regarding the demonstration of the system in wide-body aircraft were curtailed. In addition, FAA only tested prototype systems in good weather and using straight-in rather than curved and segmented approaches. As a result, the landing systems entered production even though their potential benefits as well as their safety and reliability were in question.

In other instances, FAA has deployed systems even though initial tests identified problems needing resolution before deployment. For example, FAA decided to install a system for controlling aircraft flying over oceans before completing necessary testing, even though initial tests at the contractor's facility identified 80 unresolved problems. At the completion of our review, the project's users were considering a number of change proposals to make the system operationally suitable. If these proposals are accepted, the cost to change the system will likely be much greater than if the modifications had been done earlier.

In another case, FAA accepted contractor-supplied hardware for a critical upgrade before testing to determine if the system would work. This upgrade was to enhance controllers' ability to separate and control aircraft in terminal airspace. FAA testing of system software at its national test center identified 47 critical problems that had to be resolved before the system could be used. However, FAA had already accepted hardware before this testing. After placing the accepted hardware in storage for over a year, the agency decided in 1988 to begin deploying the hardware to 128 field locations without the software. This only replaced existing hardware; it did not achieve the planned enhancement because the software was not ready.

Projects Did Not Have Approved Test Plans

In addition to incomplete testing, 7 of the 15 projects in the initial stage of the deployment readiness review did not have approved test plans. Master test plans are important to outlining the testing responsibilities of all participating organizations. They should establish arrangements for sharing test resources and test data as well as establishing responsibility for test management decisions. However, in many cases master

⁴Microwave Landing Systems: Additional Systems Should Not Be Procured Unless Benefits Proven (GAO/RCED-88-118, May 16, 1988).

believed that establishing an independent group to perform testing was too costly to implement. The group was responsible for providing an overview of the test program by monitoring tests; reviewing system requirements and technical specifications; reviewing test plans, procedures, and results; witnessing tests; and contracting for technical assistance or independent technical analysis of test data. Because the group reported to the Deputy Administrator, it was independent of system developers.

In accordance with the directive establishing it, the independent operational testing and evaluation group limited its monitoring to major acquisition programs expected to cost more than \$150 million. However, there are a number of systems in the NAS plan that are important to the day-to-day operations of air traffic control, but which are not designated as major systems because their acquisition cost is not expected to exceed \$150 million. As such, these systems are not subject to review even though they may be critical to air safety. During our review, the group was monitoring 11 major systems, although the NAS plan contains over 90 projects. For example, a planned computer upgrade to enhance controllers' ability to direct airplanes in terminal airspace is not scheduled for review because it is not expected to cost more than \$150 million.

Testing Group Not Independent

In addition to only reviewing systems costing more than \$150 million, the operational testing and evaluation group is no longer independent. Its independence has been lost through a series of agency reorganizations. In 1986, an agency reorganization had the group report to the Office of Science and Advanced Technology, which is one level below the Deputy Administrator, but still independent of system developers and users. FAA then underwent two more significant reorganizations in July and October 1988. The July reorganization moved the group under a newly created Associate Administrator for Advanced Design and Management Control, four levels below the Deputy Administrator. Then, in October, FAA established an Executive Director for Systems Development position and gave the position responsibility for organizations under the Associate Administrator for Advanced Design and Management Control, such as the test and evaluation group, as well as those under the Associate Administrator for NAS Development.

As a consequence of this last reorganization, the testing group's independence from the developing organization was eliminated because the group now works under the Executive Director responsible for system

Order Did Not Include Users

As MITRE pointed out, FAA lacked an agencywide policy to help ensure that new systems were adequately and consistently tested and evaluated. Despite the need for this, the December 1986 test order did not address system users' duties and responsibilities regarding testing.

FAA's Air Traffic organization is responsible for operational control and technical direction of the air traffic control system. This agency component, which includes air traffic controllers, represents the users of many critical NAS systems. New acquisitions that affect controllers' ability to handle aircraft need to be tested to determine whether the acquisition meets controllers' needs. To do this requires considerable testing and involvement of the users.

When the Associate Administrator for Development and Logistics issued the test order in December 1986, FAA recognized that an agencywide policy was needed to include users. Therefore, a test policy oversight team was formed and a policy was drafted and circulated among FAA components. However, this attempt to expand on the December 1986 order and create an agencywide policy to include users did not receive the needed management support. According to FAA officials, turnover at top management positions contributed to this effort not receiving needed support. Therefore, no agencywide policy was issued.

Controls Did Not Assure Compliance With Test Order

After issuing the test order, the Associate Administrator for Development and Logistics established a test management branch as an internal control to assure that all NAS programs complied with the order. However, this branch, within the development organization, did not provide this assurance because project managers, who had overall responsibility for individual systems, were reluctant to cooperate with the branch and because FAA management did not provide necessary support.

Because project managers wanted to deploy systems as soon as practical to meet their schedules, they generally viewed the branch as a hindrance to meeting deadlines. Therefore, many project managers chose not to provide master test plans and other test documentation to the branch for review, and to exclude branch personnel from attending system design reviews and other critical meetings. As a result, test management branch officials claimed that they frequently had to "beg, borrow, and steal" the documentation needed for their compliance reviews.

program. However, the new test order does not address the requirement for an independent test and evaluation group. To implement an effective testing program, FAA needs to (1) establish and support an independent component that can provide needed assurance that systems are adequately tested, and (2) provide the necessary management attention to assure compliance with test policy.

Background

In 1981, FAA embarked on a long-term program, the NAS Plan, to replace and modernize the radar, communication, and data processing equipment used to control air traffic. The program was initiated to achieve safer airspace and a more efficient air traffic control system at a reasonable cost. These goals are important, especially in view of predictions that air traffic in this country will double by the year 2000. To implement the plan, FAA expects to spend almost \$16 billion on new systems and equipment. The NAS plan is technically and managerially a complex undertaking, and is one of the largest civil procurements in the federal government.

The NAS plan is now entering its eighth year and program implementation is well underway. About 90 percent of all projects are under a development or production contract and over 65 percent have had equipment delivered. Despite this progress, projects have encountered delays and cost increases. For example, we recently reported that the Voice Switching and Control System, a major FAA system development project to improve voice communications at air traffic control facilities, has experienced significant schedule and cost overruns.¹ FAA's latest estimate is that the first Voice Switching system will be operational in 1992, 6 years later than estimated in 1982. Furthermore, project cost estimates have more than tripled, from \$258 million in 1982 to over \$786 million currently.

Such cost increases and schedule delays can occur with automated systems when agencies do not adhere to sound acquisition and testing principles. Office of Management and Budget Circular A-109 articulates these principles for acquiring major systems. The circular establishes critical decision points in the acquisition process where agency heads need to reevaluate project direction. Tests and evaluations are key ingredients in this decision-making process.

¹ Air Traffic Control: Voice Communications System Continues to Encounter Difficulties (GAO/IMTEC-89-39, June 1, 1989).

