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Report to Congressional Requesters

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AIR TRAFFIC CONTROL

Inadequate Planning Increases Risk of Computer Failures in Los Angeles

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Information Management and
Technology Division

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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 1988 the Federal Aviation Administration (FAA) started a project—the Southern California Terminal Radar Approach Control (TRACON) project—to consolidate four TRACON facilities in the Los Angeles basin area by 1995. These facilities control aircraft arriving at or departing from airports in the area. FAA believes this consolidation will help it provide better service in the basin's congested airspace. Because of the problems FAA has encountered in providing automation support for its large terminal facilities, you asked us, on December 15, 1989, to assess the agency's plans to meet the automation needs of the Los Angeles basin's terminal airspace. A detailed explanation of our objective, scope, and methodology is contained in appendix I.

Results in Brief

The airspace in the Los Angeles basin area, one of the most congested in the world, has experienced more near midair-collision reports than any other location in the United States. Moreover, the four TRACONs in the area have all previously reported computer capacity shortfalls resulting in the loss of aircraft identification information from controllers' screens. FAA has reacted to these shortfalls with stopgap measures designed to keep current, aging systems operating.

Due to its lack of a computer capacity and performance management program, FAA does not know if its current automation plan for the consolidated facility will meet future needs. Furthermore, FAA's plan for the consolidated facility does not allow for steep growth in air traffic, involves the procurement of antiquated 1960s computer processors, and assumes that an advanced system will be implemented on schedule in the mid-to-late 1990s.

To meet its immediate needs for additional computer capacity, FAA may have little choice other than to upgrade the existing systems with antiquated computers. However, to meet the requirements of the Los Angeles basin area through the 1990s and possibly beyond, alternatives exist that could better meet future requirements of the consolidated facility. At the conclusion of our review, FAA officials acknowledged this and stated they were studying the feasibility of systems such as the one currently used at the New York TRACON. However, officials stated they would not consider any other alternatives that required new hardware or software development due to the additional time they believe would be required to undertake such an effort.

Background

From an air traffic control perspective, the airspace in the Los Angeles basin, surrounded by the Pacific Ocean and several mountain ranges, is extremely busy and complicated. One of the most concentrated sectors of air traffic in the world, the Los Angeles area has more than 6.5 million flights per year. The area has 21 airports, including five major commercial airports, three military air fields, and the busiest general aviation airport in the United States—Van Nuys Airport. The airspace is also complicated by the varying rules and restrictions in effect at different altitudes and locations.

The complexity and congestion of the Los Angeles airspace is evidenced by its high number of reported near midair collisions. From 1986 to 1988, Los Angeles had the highest concentration of serious near midair-collision reports in the nation.[1] Specifically, it had 57 serious near midair-collision reports, approximately twice the number of the next highest location. In August 1986, a tragic midair collision between two airplanes over Cerritos, California, resulted in the loss of over 80 lives.

According to FAA, the continued air traffic growth within the Los Angeles area has nearly exceeded the capacity of the present airspace. To help alleviate this, the agency has initiated two projects: the Southern California Terminal Airspace Realignment and the Southern California TRACON project. The realignment is designed to allow the use of closer air traffic separation standards by expanding the altitude limits of terminal controlled airspace. FAA believes this should allow more planes in the airspace.[2]

[1] Air Traffic Control: FAA's Interim Actions to Reduce Near Mid-air Collisions (GAO/RCED-89-149, June 30, 1989).

[2] Aircraft Noise: Status and Management of FAA's West Coast Plan (GAO/RCED-89-84, May 8, 1989).

The Southern California TRACON project is designed to consolidate the four TRACON facilities in the Los Angeles basin into a single facility at Miramar, California. The TRACONs involved are now located at Los Angeles, Burbank, El Toro, and Ontario. The project, estimated to cost about $114 million, involves designing and constructing a new building and moving the computer systems into the consolidated facility. FAA is scheduled to complete the consolidation by 1995.

FAA expects this planned consolidation to result in safer, more efficient use of Southern California's airspace. It believes that airspace will be more effectively utilized and that air traffic controller work load will be reduced because coordination of the high-volume, complex pieces of airspace among a number of facilities will be reduced. FAA also believes that by maintaining one facility instead of four, procedures may be streamlined and management personnel may be reduced.

Each of the four TRACONs currently has a computer system, known as an Automated Radar Terminal System (ARTS) IIIA, that provides essential aircraft position and flight plan information to controllers. In consolidating the four facilities, FAA does not plan to consolidate the four computer systems. Instead, it intends to retain and enhance the ARTS IIIAs used in the Los Angeles and El Toro TRACONs and combine the Burbank and Ontario systems, resulting in three separate systems. FAA then expects to operate these three systems until they are replaced by an advanced system in the mid-to-late 1990s.

FAA Has Not Adequately Determined Automation Requirements for the Los Angeles Basin

FAA's lack of a computer capacity and performance management program for its large TRACONs, including those in the Los Angeles basin, has limited its ability to determine current and future automation requirements. This allowed alarming capacity shortfalls, resulting in aircraft information disappearing from controllers' screens. Although it has begun to take some actions to address these shortfalls, FAA has not yet adequately identified its needs. Until FAA does, it will continue to react to shortfalls and, in the case of the Los Angeles basin, assume a risk that its automation plans for the consolidated facility will not meet requirements. This risk is further amplified by the possibility that growth in air traffic could be more than currently estimated, and the fact that FAA-planned upgrades are based on 1960s technology with limited performance capabilities.

FAA's Lack of a Capacity Management Program Prevented Accurate Identification of Needs

An effective computer capacity management and performance monitoring program is important to ensure maximum use of existing resources and adequate capacity for growth. Further, Federal Information Resources Management Regulation Part 201-30 and standard industry practices call for agencies to perform capacity management activities in planning, acquiring, and using computer resources.

As we reported last year, FAA lacked an effective computer capacity management program at its larger TRACONs, such as the four involved in this planned consolidation.[3] Consequently, FAA did not recognize capacity shortfalls until controllers' ability to maintain safe separation of aircraft was impaired. Almost 70 percent of the large TRACONs we surveyed indicated that their systems suffered from one or more of the following problems: critical aircraft information disappearing from controllers' screens, flickering displays, and slow system responses.

All four TRACONs in the Los Angeles basin area reported that they had experienced instances of aircraft identification information disappearing from controllers' displays. Two of the TRACONs reported that data losses occurred for brief periods of time during heavy traffic while another stated that problems occurred randomly. In addition, three of the four reported instances of data flickering on controllers' displays and three of four indicated that system responses to controllers' commands were delayed.

To begin to address these problems, we emphasized in our 1989 report that FAA needed to act quickly to ensure that critical air traffic control functions were not interrupted by capacity shortfalls. Specifically, we recommended that FAA (1) gather and report important capacity-related data, identify quickly those TRACONs that had the most urgent problems, and identify potential solutions to the problems; and (2) implement a computer capacity and performance management program at its large TRACONs that would include analyses of present and future data processing work loads to determine when system capacity would be saturated.

In its response to our report, FAA pointed out several actions it was taking to ensure that air traffic control functions were not interrupted by capacity shortfalls. For example, headquarters informed its field offices that software had been developed and was being deployed to aid

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

in determining the real-time performance of the ARTS IIIA systems at specific locations. Field offices were directed to begin using this monitor to establish a baseline on processor utilization. In addition, FAA stated that it had identified locations constrained by computer capacity and had directed these capacity-sensitive facilities to develop contingency plans to use when computer system demand approached effective capacity. Further, FAA stated that additional processors were being supplied to the three sites most in need of additional capacity.

While these actions appear promising, the level of attention that the Department of Transportation and FAA have given to developing an overall computer capacity and performance management program at the large TRACONs has been disappointing. In its response to our report, submitted almost 7 months after our report was issued—and approximately 5 months later than required—the Department of Transportation dismissed our key finding on FAA's lack of a thorough analysis of short-term and long-term requirements associated with traffic growth and enhancements at its large TRACONs. Transportation stated "the Department agrees that FAA's studies of computer capacity are not as formal as GAO expects; however, we believe the FAA has thoroughly analyzed not only the short-term ARTS IIIA system needs . . . but also the long-term requirements associated with traffic growth and incorporation of the Mode C intruder function."[4] However, as we reported, FAA did not have sufficient data on current utilization to serve as a baseline for determining future requirements and had not adequately assessed the impact of future safety enhancements.

FAA's inadequate analysis of current and future requirements is evidenced by its reactive approach to dealing with the capacity shortfalls it has faced. For example, after experiencing several system failures, headquarters requested that all field automation specialists submit any and all software modifications that they believed could increase processor efficiency. In addition, FAA has in some instances been lowering demands on its systems by reducing the number of controller training displays and the length of time its systems retain flight data. In another case, after learning that the ARTS IIIA system at the Chicago TRACON did not perform properly for 19 continuous hours, FAA added an unplanned fifth processor and developed additional software modifications at the Los Angeles TRACON to reduce the potential for serious capacity shortfalls and to promote controller confidence in the system.

[4]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.

FAA's inability to foresee system shortfalls and its ad hoc responses after shortfalls occurred indicate that it did not have reliable data to determine its current or future requirements. At the conclusion of our review, FAA officials stated that they were beginning to acquire data to determine requirements at these TRACON facilities.

FAA's Los Angeles Basin Solution May Not Provide Sufficient Processing Capacity in the Future

Due to its lack of a computer capacity and performance management program, FAA does not know if its current automation solution for the Los Angeles basin will be able to meet its needs through the 1990s. Furthermore, additional risk exists that the solution may not be sufficient because (1) traffic growth in the Los Angeles basin area may continue to exceed projections, and (2) the new advanced system to replace existing TRACON systems may be significantly delayed, thereby requiring the ARTS IIIA systems to operate even longer.

Because FAA had not collected the data necessary to determine future demand for computer resources, it used another estimator—the number of instrument operations[5] —to project what the demand for computer resources would be in future years. However, instrument operations is an imprecise measure for estimating computer resource utilization. While instrument operations is indicative of the demand for computer resources, this estimator is not an adequate measure for predicting computer utilization. Without knowing other information, such as the peak periods of traffic and the expected distribution of increased instrument operations, FAA cannot adequately predict its needs for computer resources. For example, if a significant number of additional instrument operations occurred during peak periods—when computer utilization would be highest—computer capacity could be exceeded much more quickly than if these increases occurred during non-peak periods.

To predict the need for computer resources in the consolidated facility, the FAA Technical Center was tasked with determining whether the consolidated ARTS IIIA systems, with planned upgrades, could meet work load demands based on annual instrument operations growth rates ranging from 2.4 to 10.5 percent. Rather than using the maximum growth rate of 10.5 percent, the Technical Center study elected to assume maximums of 5.5, 7.2, and 7.8 percent for the three automated systems at the consolidated facility because the primary author of the

[5]An instrument operation represents a takeoff or landing under instrument flight rules. Aircraft operating under these rules must be controlled and in contact with an air traffic controller, while aircraft flying under visual flight rules are only monitored by controllers.

Technical Center study believed that 10.5-percent growth would not occur in the 1990s and therefore should not be used. This official could not provide analysis or documentation to support his assertion that the 10.5-percent maximum growth rate was too high. Under the maximum growth assumptions used, FAA concluded that the upgraded ARTS IIIA systems would provide the consolidated facility with sufficient processing capacity until the year 2000.

According to FAA, the Southern California area "has historically experienced growth well in excess of projections," which has made it difficult to predict future increases. For example, in 1979 the agency predicted instrument operations at airports nationwide would increase at an annual rate of 3.9 percent through 1991. However, growth rates of instrument operations were very sporadic. From 1980 to 1982, the area actually experienced a decline in instrument operations due to a general economic downturn and the air traffic controller strike. Then, between 1982 and 1987, the TRACONS in the Los Angeles basin experienced annual growth rates averaging 10.5 percent. Between 1987 and 1988, the most recent years for which data are available, instrument operations in the basin area grew by 4.8 percent. However, according to FAA, several upcoming developments, such as new terminals under construction at the Ontario, Burbank, and Orange County airports, "are likely to force traffic increases in the Los Angeles basin area." Given the above and the conservatism that should be built into safety-related assumptions, it may be risky to assume that a high rate of growth will not occur in the basin area.

If the study had utilized the maximum growth rate of 10.5 percent, it would have concluded that the track[6] capacity of the Los Angeles TRACON system alone would become saturated in 1993—2 years before the consolidation is due to be completed. This scenario also assumes that planned interim upgrades and additional capacity would be provided at the Los Angeles TRACON.

In addition to these risks, the schedule for the advanced systems to replace terminal automated systems later in the 1990s is slipping. Less than a year after beginning work on the contract, the contractor—International Business Machines Corporation—and FAA announced a 13-month delay in the first component of the advanced system. Moreover,

[6]A track occupies a portion of memory in the air traffic control computer. A track can hold data on controlled aircraft, uncontrolled aircraft, false target radar reports, aircraft detected by radar but not yet associated with a flight plan, and flight plans for aircraft not yet detected by radar.

as we recently testified, the eventual delay in this first phase will probably be greater than announced because some requirements issues are still unresolved, and FAA has identified other new requirements.[7] Under FAA's current plans, this will lead to delays in the delivery of later phases to replace TRACON automation systems that were originally scheduled to be implemented in the mid-to-late 1990s and require existing systems to operate longer than expected. The advanced system may not be fully implemented in the terminal environment until 2000. If this proves to be the case, the current terminal automation systems, with currently planned interim enhancements, may not be sufficient to handle future traffic growth. FAA personnel acknowledged that a significantly delayed advanced system could result in the need for a second interim solution.

FAA's System Solution Uses Outdated Technology

FAA recognizes that TRACONs need more capacity to address current shortfalls and to meet future work load requirements. Therefore, it plans to upgrade each of the ARTS IIIA systems, through contracts with UNISYS Corporation, by (1) adding solid state memory to the existing equipment to increase processing speed, (2) refurbishing the disk drives, (3) increasing the number of processors to eight, (4) purchasing and implementing new displays, and (5) upgrading the existing software. The additional processors will upgrade each of the systems to their maximum design limit; little additional significant processing capacity can be added under the ARTS IIIA system design.

This expansion will require FAA to buy 1960s-vintage processors similar to existing TRACON processors because the system software only operates on the current hardware and because FAA believes rewriting new software in order to buy processors currently marketed would involve too much development risk. To procure the old processors, FAA will have to rely on the one contractor—UNISYS—that can produce them. Dependence on a single contractor increases the government's vulnerability to escalating costs for hardware and software maintenance because no other vendor exists to provide price competition.

To supply the outdated processors, UNISYS will have to restart a production line. The capability of these 1960s-vintage processors—UNIVAC 8303s—is low. The processor can store up to 256,000 characters in

[7]FAA Encountering Problems in Acquiring Major Automated Systems (GAO/T-IMTEC-90-9, Apr. 26, 1990).

random access memory[8] and process up to approximately 500,000 instructions per second. By contrast, microcomputers available for consumers on today's market usually have more memory and processing speed. For example, a typical desktop computer can store 4 million characters and process between 2 and 3.5 million instructions per second.

The system software that runs the old processors, Ultra, is a UNISYS-proprietary, assembly-language product that is antiquated and cumbersome. Therefore, few programmers in the computer industry need to be knowledgeable about this software. Nevertheless, UNISYS officials are confident that they can maintain a sufficient quantity of qualified staff to support the ARTS IIIA systems, although they admit that other staff may have to be retrained as Ultra programmers leave the company or retire.

In addition, the old UNIVAC processors can perform only one task at a time, whereas modern processors are multitask. Further, because of the UNIVAC processor's design, an entire program resides in the main memory in order for it to be executed. Therefore, modifications to software must be developed within the constraints of available memory. This also makes programs more difficult to maintain since modifications must be made in a highly efficient manner in order to minimize the amount of memory they consume.

Alternative Solutions Could Potentially Meet FAA's Needs in the 1990s

FAA's solution to remedying capacity deficiencies and addressing the work load requirements of the Los Angeles basin involves risk. Before deciding to pursue this solution, FAA considered other alternatives, including (1) a system similar to the one currently used at the New York TRACON, (2) a system similar to those used at air route traffic control centers,[9] (3) an International Business Machines Corporation proposal, and (4) an unsolicited proposal by BDM Corporation.

FAA concluded that only two alternatives—co-locating three ARTS IIIA systems, and implementing a UNISYS-developed system similar to the one at the New York TRACON—were viable. The other alternatives were not explored in depth primarily because they would have required additional time to embark on a new system development. FAA subsequently

[8]Random access memory describes the computer's main memory, from which programs and files can be most quickly accessed.

[9]FAA maintains 22 air route traffic control centers that control air traffic en route between airports.

decided not to use the New York system because it believed that it would involve too much development risk.

In our July 1989 report, we identified the risks inherent in the approach of upgrading the ARTS IIIA system at large TRACONs and noted that a new advanced system was not scheduled to replace existing TRACON systems until the mid-to-late 1990s. We therefore recommended that FAA conduct a complete analysis of all available alternatives for meeting the larger TRACONs' air traffic requirements for at least the next 10 years. In its response, the Department of Transportation dismissed our recommendation and stated that FAA had already formulated a plan in 1987, after an analysis of alternatives, to meet TRACON automation requirements for the next 10-year period. For the Los Angeles consolidated facility, this plan calls for buying the old processors and continuing with the ARTS IIIA systems.

To meet its immediate computer capacity needs, FAA may have little choice other than to proceed with sole-source arrangements with UNISYS, procure the 1960s-vintage processors, and maintain the antiquated software. However, to meet the requirements of the Los Angeles basin area through the 1990s and possibly beyond, modern technology alternatives exist that do not have the growth constraints of the ARTS IIIA system and do not rely on antiquated, cumbersome software. Other contractors have previously made proposals to FAA for automating the consolidated facility and for air traffic control automation in general. Additionally, several FAA technical officials have recommended to agency management that modern computers be used to replace the old-technology processors. At the conclusion of our review, FAA officials stated that, in view of the anticipated delays in the advanced automation system, they have decided to reevaluate whether UNISYS systems such as the one in New York could meet the requirements of the Los Angeles basin area through the 1990s. However, in spite of the availability of other system approaches, officials stated that they would not consider other alternatives that involved system development because of the additional time they believe would be required to undertake such an effort.

Conclusions

FAA's task is to assure that the Los Angeles area has sufficient computer capability to safely control air traffic until an advanced system is installed. We have serious reservations about FAA's planned approach.

Our primary concern is that FAA does not have a computer capacity and performance management program to determine future computer requirements. As a result, FAA cannot accurately predict how long these computers can operate before they become overloaded. Because it lacked a capacity management program, FAA used instrument operations as an indicator of computer demand in determining how long the consolidated facility could meet anticipated traffic growth. This is not a precise indicator of expected computer work load, since it does not consider other information affecting computer utilization, such as the expected distribution of forecast instrument operations. Even this imprecise indicator would predict that the Los Angeles TRACON alone would run out of computer capacity in 1993, if traffic growth continues at the rate experienced through much of the 1980s.

Additionally, the advanced system may not be ready in the mid-to-late 1990s, as FAA predicted, due to delays that have already occurred in the first year of this project. The longer this advanced system is delayed, the longer that the Los Angeles TRACON will have to depend on 1960s-vintage computers.

The uncertainties in estimating future computer work loads and in determining when the advanced system will be ready reflect the high risk of FAA's plan. While enhancing existing systems with limited technology may help address immediate capacity problems, it may not meet Los Angeles' needs through the 1990s. Alternative hardware and software solutions have been proposed that could provide greater assurance that the consolidated facility will be able to meet future requirements. While FAA officials' recent recognition of the risk of continuing to pursue their current plan and their decision to reevaluate the New York TRACON alternative are encouraging, it is important that the Department of Transportation and FAA not limit their evaluation of alternatives. If the full range of alternatives is not evaluated, then agency officials will not have the most complete information available to decide how to best meet the needs of the Los Angeles area.

Recommendations

To help assure that future computer capacity needs of the Los Angeles basin are met and that continued air safety is assured, we recommend that the Secretary of Transportation direct the Administrator, FAA, to institute a computer capacity and performance management program to determine the current and future requirements for the Los Angeles area. As part of this program, FAA should analyze the current demand on systems during peak work load periods, determine the expected growth in

demand for computer capacity and processing resources for at least the next 10 years, and determine what computer resources will be required to meet the expected growth and ensure continued air safety.

Because of the many uncertainties surrounding the capability of the ARTS IIIA systems to adequately support the consolidated Los Angeles facility through the 1990s, we also recommend that the Secretary direct the Administrator to conduct a complete and documented assessment of all viable alternative hardware and software solutions for addressing future capacity and processing needs. This evaluation should not be constrained by discarding without analysis any alternative that involves software development.

In view of the critical impact that insufficient computer capacity could have on safe air travel nationwide, and because the Department of Transportation has not acted expeditiously in response to our prior report on FAA's lack of a computer capacity management program, we continue to believe that this area must be closely monitored by high-level agency officials. We therefore recommend that the Secretary direct the Administrator to assess the efficacy of FAA actions to date to address capacity shortfalls in TRACONs nationwide.

Agency Comments and Our Evaluation

We obtained official oral comments from the Department of Transportation and FAA officials on a draft of this report. Although expressing agreement with most of the facts in the report, officials believed that they were already implementing a computer capacity and performance management program. They also pointed out that they would evaluate a system such as the one at the New York TRACON as an alternative for meeting the needs of the consolidated facility.

Regarding officials' assertions that they were already implementing a capacity and performance management program, we noted in the report that FAA had begun deploying software to aid in measuring processor utilization. However, this is only a first step in implementing an effective program. FAA also, at a minimum, needs to fully analyze the work loads being placed on its systems, including analysis of peak work loads; determine the expected future growth in demand for computer resources; and then determine what computer resources will be required to meet this expected demand. Regarding evaluating other alternatives for the consolidated facility, FAA needs to expand its evaluation of alternatives to include a full range of possibilities in order to ensure that it selects the solution that can best meet the needs of the Los Angeles area.

As arranged with your offices, we are sending copies of this report 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.

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Objective, Scope, and Methodology

At the request of the House and Senate Committees on Appropriations, Subcommittees on Transportation and Related Agencies, we reviewed FAA's automation plans for the consolidation of TRACONs in the Los Angeles area. Specifically, our objective was to determine if FAA had adequately planned for its air traffic control automation needs for the Los Angeles consolidated facility.

To address this objective, we interviewed agency personnel and reviewed documents at FAA headquarters in Washington, D.C.; the FAA Technical Center in Pomona, New Jersey; and the FAA western pacific regional office in Hawthorne, California. We also interviewed automation specialists and controllers at the four TRACON facilities in Southern California that are to be consolidated. To determine what analysis had been done to meet the automation needs of the consolidated facility, we interviewed FAA headquarters and Technical Center personnel, and contractor personnel with UNISYS Corporation in St. Paul, Minnesota; and International Business Machines Corporation in Rockville, Maryland. We also reviewed FAA and contractor documents, as well as applicable federal information resources management regulations.

We discussed the complexity of the Los Angeles airspace and current FAA automation capabilities with representatives from the Air Line Pilots Association in Los Angeles and in Washington, D.C.; the Aircraft Owners and Pilots Association in Washington, D.C.; and the National Air Traffic Controllers Association in Washington, D.C.

We performed our work at FAA headquarters, the FAA Technical Center, and the FAA Western Pacific regional office; at TRACON facilities in Burbank, El Toro, Los Angeles, and Ontario, California, and New York, New York; at a radar approach control facility at Edwards Air Force Base, California; at the Air Route Traffic Control Center in Palmdale, California; and at UNISYS Corporation in St. Paul, Minnesota.

We performed our review from April 1989 through April 1990, in accordance with generally accepted government auditing standards. 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 and have incorporated these comments where appropriate.

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