

June 1992

AVIATION RESEARCH

FAA Could Enhance Its Program to Meet Current and Future Challenges



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**Resources, Community, and
Economic Development Division****B-248342**

June 3, 1992

**The Honorable George E. Brown, Jr.
Chairman
The Honorable Robert S. Walker
Ranking Minority Member
Committee on Science, Space, and Technology
House of Representatives**

**The Honorable Tom Lewis
The Honorable Tim Valentine
House of Representatives**

The Federal Aviation Administration's (FAA) Research, Engineering, and Development (RE&D) Program plays an important role in ensuring the safety, security, and efficiency of the U.S. air transport system. FAA's RE&D budget has grown over the past several years from \$153 million in fiscal year 1988 to \$218 million in fiscal year 1992. The Administration requested \$230 million for fiscal year 1993. Much of the funding increase over the past several years occurred in the areas of aircraft safety, security, and human factors, which includes the interface between controllers and air traffic control systems.

As agreed with your offices, this is the second and final report addressing FAA's research program. We previously provided you with a fact sheet that detailed the funding, staffing, and timing of FAA's research projects to assist in reviewing FAA's fiscal year 1993 budget request.¹ Specifically, this report examines

- FAA's progress in responding to the Aviation Safety Research Act of 1988;
- the long-term research that FAA undertook in fiscal year 1991; and
- factors that will affect FAA's success in meeting its RE&D goals.

Results in Brief

FAA has made progress in responding to the Aviation Safety Research Act of 1988. FAA has expanded research in aircraft structures, human factors, and simulation modeling of the air traffic control system and has developed a draft RE&D Plan. The plan enjoys industry support and provides information on FAA's research efforts in, among other things, aircraft safety, security, and weather. However, FAA has not included

¹Aviation Research: Funding, Staffing, and Timing of FAA's Research Projects (GAO/RCED-92-108FS, Feb. 28, 1992).

resource estimates for research efforts as required by the act or delineated specific long-term projects in the plan. The plan's resource requirements are increasingly important because several research areas, including security and human factors, have the potential to enhance the safety of air travel and to cost significantly more in the next several years.

For many years, the Congress has been concerned that FAA's RE&D Program is not sufficiently future-oriented. As a result, for fiscal years 1989 and 1990, the Congress mandated that FAA allocate at least 15 percent of its RE&D funds to long-term research. FAA met this requirement for fiscal years 1989 and 1990. In addition, although no current statutory allocation requirement exists, the RE&D Program Analysis Division estimated that about 41 percent of fiscal year 1991 obligations were for long-term research. FAA's total RE&D efforts are difficult to estimate because FAA does not track the amount of long-term research under way in its program, and some research is funded by other sources, including other federal agencies. However, on the basis of our review of individual projects and discussions with project managers, we estimate that 17 percent of FAA's 1991 RE&D obligations were for long-term research as defined in the Aviation Safety Research Act of 1988.

FAA's draft RE&D Plan establishes measurable goals. However, these goals are so ambitious that the RE&D Program alone cannot achieve them because they rely heavily on other FAA programs. FAA's success in meeting its RE&D goals will depend on several interrelated factors. These factors include (1) incorporating RE&D goals into other programs, such as the Capital Investment Plan to modernize the air traffic control system; (2) utilizing research conducted by other federal agencies; (3) integrating various technologies to address existing and future capacity, security, and safety concerns; and (4) incorporating human factors into all research.

Background

FAA conducts a wide range of research to ensure the safety, security, and efficiency of the U.S. aviation system. The results of FAA's research programs include prototypes of systems, new procedures, rules, regulations, and certification criteria. Most, if not all, of FAA's research focuses on refining existing technology and equipment. FAA has several joint programs with the National Aeronautics and Space Administration (NASA) in such areas as aging aircraft, windshear, and human factors.

The RE&D Program played a role in developing FAA's plan to modernize the air traffic control system. Furthermore, in response to recent safety and

security incidents, FAA is spending more of its RE&D funds on aircraft safety, security, and human factors. Nevertheless, FAA believes it faces many long-term challenges that will require sustained research over the next few years. These challenges include

- alleviating capacity and congestion problems that continue to plague the national airspace system,
- developing systems that can detect a wide range of explosives with a high degree of reliability at an affordable cost,
- developing tools to detect cracks and corrosion in the nation's aging fleet without grounding aircraft for extended periods of time, and
- ensuring that the next generation of air traffic control systems, which rely heavily on automation, are engineered so that controllers and pilots can effectively operate and work with the systems.

To assist FAA in meeting its long-term challenges, the Congress enacted the Aviation Safety Research Act of 1988. The act requires FAA to (1) submit to the Congress an annual plan with 2-year detailed cost, schedule, and staffing data as well as 5-year total cost estimates for each project; (2) undertake research on aircraft structures, fire safety, human factors, aeromedical research, and computer simulation models of the air traffic control system; and (3) establish a research advisory committee. In addition, during fiscal years 1989 and 1990, the act required FAA to allocate not less than 15 percent of its RE&D budget to long-term research.² This last requirement has been superseded.

FAA Has Made Progress in Responding to the Aviation Safety Research Act of 1988

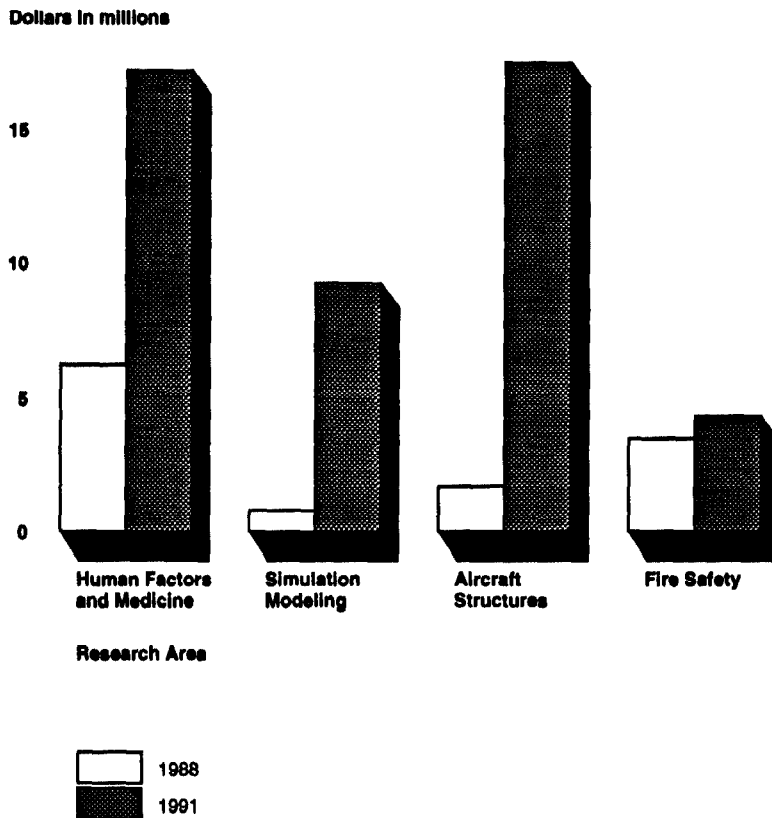
In responding to the act's requirements, FAA has expanded research in aircraft structures, human factors, and simulation modeling; established the research advisory committee; and developed a draft RE&D Plan. FAA's RE&D Plan enjoys industry support and provides information on, among other things, aircraft safety, security, and weather research. However, FAA has not included resource estimates—of either staff or dollars—for research efforts as required by the act or delineated specific long-term projects in the plan.

²The act defined a long-term research project as a discrete project in the aviation research plan that was unlikely to result in a final rulemaking within 5 years or in initial installation of operational equipment within 10 years after the project began.

FAA Has Expanded Research Mandated by the Act

FAA increased overall funding for research mandated by the act by almost 300 percent between 1988 and 1991. Simulation modeling of the air traffic control system experienced the most dramatic growth—in excess of 1,000 percent. The hallmark of this effort is the creation of FAA’s National Simulation Laboratory, which for the first time will allow FAA to simulate the interaction between new air traffic control systems and controllers. Laboratory studies also will provide better information on how major air traffic control systems work together before they are installed in an operational environment. FAA plans to continue to refine the laboratory over the next few years and complete it in 1995. Figure 1 compares FAA obligations in fiscal year 1988—before the passage of the Aviation Safety Research Act—and fiscal year 1991 for the areas mandated by the act.

Figure 1: Research Under Way Mandated by the Aviation Safety Research Act, Fiscal Years 1988 and 1991



Note: These figures do not include funding provided by other federal agencies.

Source: GAO analysis of FAA data.

Although FAA has increased funding for research areas mandated by the act, FAA officials told us that it will take time to complete much of the work. For example, FAA plans to explore the human factors issues associated with the interface between air traffic control automation and controllers. Similarly, FAA's aging aircraft research program (aircraft structures) has tested several prototype techniques for detecting cracks and corrosion in aircraft, but additional research will be needed to identify and test systems that can quickly detect all types of cracks and corrosion with a high degree of accuracy.

FAA's Draft RE&D Plan Does Not Provide Resource Requirements

Although FAA's draft RE&D Plan contains information on key dates for each project, it does not include detailed cost and staffing estimates for each project as required by the act or identify projects that are long-term. On March 4, 1992, the Secretary of Transportation submitted a 3-year reauthorization proposal to the Congress. For RE&D, the proposal requested \$230 million, \$253 million, and \$278 million for fiscal years 1993, 1994, and 1995, respectively. However, FAA previously estimated that it would need about \$350 million in fiscal year 1993 and over \$500 million by fiscal year 1997 to implement the RE&D Plan. To achieve the proposed reauthorization levels, FAA scaled back some research efforts and stretched the schedule for others. The RE&D Plan does not discuss the project changes that FAA made to meet the requested reauthorization levels.

Such information is important because several research areas, especially human factors and security, have the potential to enhance the safety of air travel and cost significantly more in the next several years. For example, FAA officials told us that the joint human factors plan with NASA will cost each agency about \$45 million annually to implement. FAA will be making key decisions regarding allocation of scarce RE&D resources to many competing areas in the next decade. Without cost and staffing information, neither the Congress nor FAA can adequately oversee decisions to ensure that resources are being used most effectively.

Most of FAA's Research Is Focused on Short-Term Projects

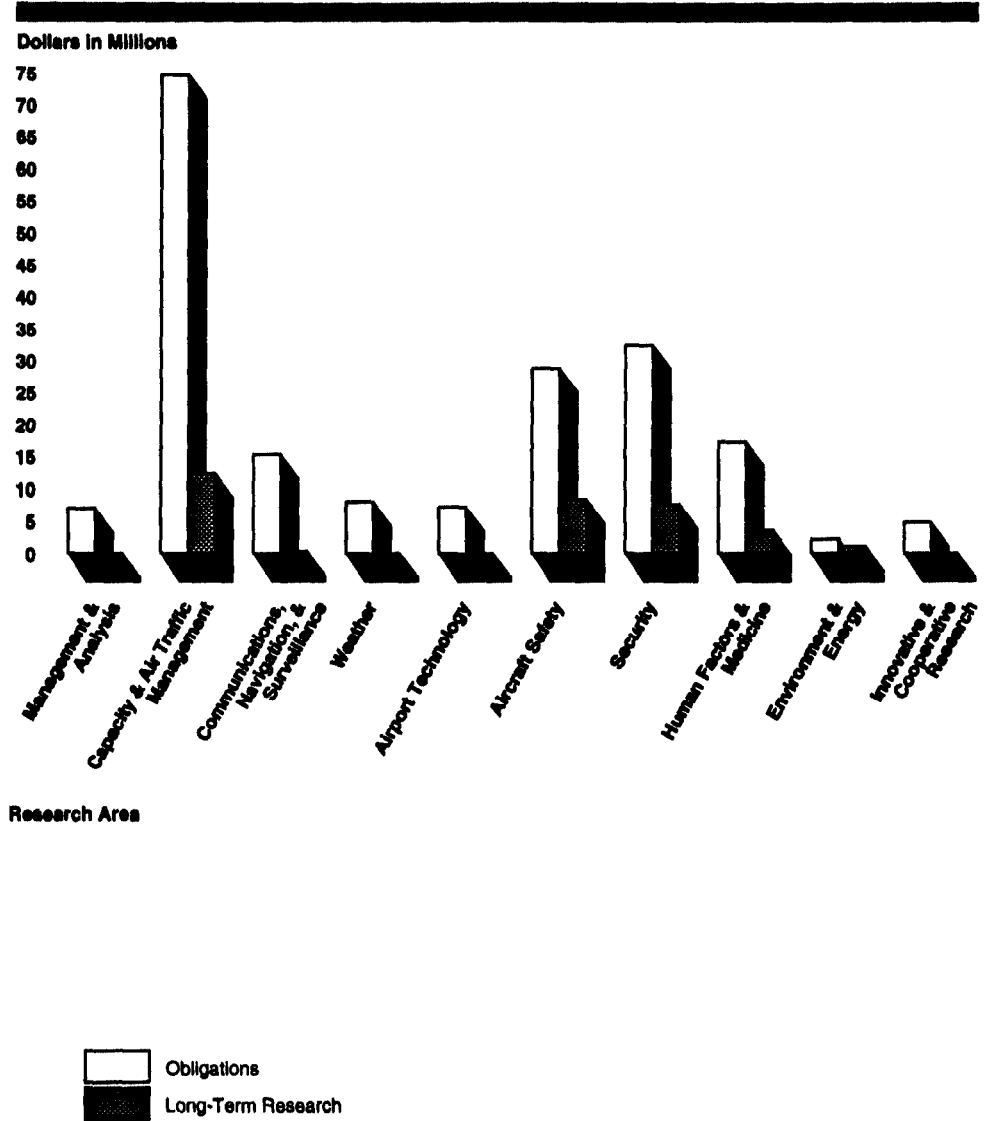
Passage of the Aviation Safety Research Act of 1988 is evidence of the Congress' concern with FAA's emphasis on short-term research at the expense of long-term research. Long-term research is important because it can identify potential safety vulnerabilities before they result in catastrophic accidents or incidents. In addition, such research will help ensure that air traffic control systems, when fielded, will reduce burdens

on controllers and increase their efficiency. FAA's RE&D Program Analysis Division estimated that about 41 percent of fiscal year 1991 obligations was for long-term research.³ Our calculations—based on an analysis of individual projects and discussions with project managers—differ significantly from FAA's estimate.

Although the allocation provision is no longer in effect, we found that about \$33 million, or 17 percent, of FAA's 1991 obligations were for long-term research as defined by the Aviation Safety Research Act. The remaining \$163 million (83 percent) focused on short-term projects. Moreover, many projects that FAA had classified as long-term were actually short-term or a combination of short-and long-term efforts. For example, FAA officials said that they obligated about \$12 million for long-term aging aircraft research. Our calculations show that only about \$2.9 million was used exclusively for such research. FAA overestimated the funds spent on long-term research because it did not determine the amount of long- and short-term research within individual projects, and project managers were not familiar with the act's definition of long-term research. Figure 2 shows the amount of long-term research undertaken in fiscal year 1991 by major research area.

³FAA's RE&D appropriation in fiscal year 1991 was \$205 million. FAA's obligations of appropriated funds almost kept pace at \$196 million.

Figure 2: Long-Term Research Undertaken in Fiscal Year 1991



Source: GAO analysis of FAA data.

In addition, FAA officials do not believe that the act's definition of long-term research, which focuses on final rulemakings and equipment installation, appropriately reflects the demands being placed on the RE&D Program. They noted that many projects, such as human factors, will not

result in a final rulemaking or the installation of equipment but rather enhanced training for safety work forces and new procedures. The officials suggested that the definition should more appropriately focus on the impact of research on the future air transport system and the next generation of equipment. FAA officials also suggested that the definition include research that is conducted to increase general knowledge and has no specific application at the time a project is initiated.

Furthermore, FAA's total RE&D efforts are difficult to estimate because some research is funded from other sources, including other federal agencies and the facilities and equipment (F&E) account for modernizing the air traffic control system. For example, NASA provided about \$21 million in fiscal year 1991 for cooperative research efforts with FAA. We previously reported that FAA needed to link its process for acquiring major projects with its budget to enhance project management and reduce the potential for cost growth and schedule delays.⁴ On the basis of our recommendations, FAA has for the first time delineated about \$393 million in F&E funds for engineering, development, test, and evaluation in its fiscal year 1993 budget. According to FAA, these funds are earmarked for research and development on specific systems rather than production.

The Congress and FAA Would Benefit by Having Information on Long-Term Projects

FAA does not track information on the amount of long-term research conducted. Consequently, budget and planning documents do not indicate the level of funds for short- or long-term efforts. Tracking long-term research would allow FAA to evaluate the overall direction of the RE&D Program, identify trends, and make the necessary adjustments. For example, FAA has no long-term research related to airport technology or weather. However, a mechanism exists that could help FAA track long-term research. The Department of Transportation has invested about \$24 million in the Departmental Accounting and Financial Information System (DAFIS) and has implemented it at FAA. This system has the capability to track long-term projects and resources. However, FAA does not use this system to track RE&D projects, and FAA officials with whom we spoke were not aware of the system's capabilities for tracking long-term projects. On the basis of our discussions, FAA has begun to explore using DAFIS and other internal systems to track long-term research.

Without a method for tracking long-term research, neither the Congress nor FAA can be assured that FAA's RE&D Program is allocating sufficient

⁴Aviation Acquisition: Further Changes Needed in FAA's Management and Budgeting Practices (GAO/RCED-91-159, July 29, 1991).

resources to future-oriented safety, security, and capacity projects. The Aviation Safety Research Act of 1988 stipulated that FAA allocate 15 percent of its RE&D funds for long-term research. Because this provision applied only to fiscal years 1989 and 1990, FAA is currently not required to allocate any specific portion of RE&D resources to long-term projects. Although FAA officials told us that they are committed to investing in long-term research projects, they also said that such efforts are frequently curtailed or postponed in favor of projects needed to address existing problems.

Several Interrelated Factors Will Affect FAA's Ability to Achieve RE&D Goals

The draft RE&D Plan includes nine ambitious but, in FAA's view, attainable goals. For example, the plan shows that FAA expects to increase airspace and airport capacity by at least 20 percent in 1999 and an additional 20 percent by 2005 and reduce runway incursions by 80 percent by the year 2000. (App. I contains FAA's RE&D goals.) Goals are important elements of a good plan because they set expectations and establish a basis to measure performance. Furthermore, goals give the RE&D Plan direction and form a basis for providing feedback on the overall program. We recently reported that two other key FAA programs—the Capital Investment Plan and National Plan of Integrated Airport Systems—did not have measurable goals and would benefit by having them.⁶

FAA's RE&D Goals Cannot Be Achieved by Research and Development Alone

FAA's RE&D goals are so ambitious that research and development alone cannot achieve them. For example, FAA's increasing capacity by 20 percent in the year 1999 can only be achieved in combination with ongoing capital investment and airport development projects. Similarly, FAA's goal of eliminating aging aircraft as a significant safety issue by 1996 will rely heavily on the coordinated efforts of FAA, the airlines, and aircraft manufacturers. However, the RE&D Plan does not discuss how such integration would occur or specify the particular contribution that the RE&D Program will make to achieving the goals. Therefore, we previously recommended that FAA develop goals to reflect the activities that the RE&D Program can accomplish independent of other FAA programs.⁶

⁶Air Traffic Control: Challenges Facing FAA's Modernization Program (GAO/T-RCED-92-34, Mar. 3, 1992) and Airport Development: Improvement Needed in Federal Planning (GAO/T-RCED-92-30, Feb. 19, 1992).

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

Several Interrelated Factors Will Affect the Success of FAA's Program

Our review of FAA's RE&D Program and discussions with NASA, Department of Defense (DOD), and industry officials identified four interrelated factors that will affect FAA's success in achieving its RE&D goals and meeting the safety, security, and capacity demands of the next decade and beyond.

First, the RE&D goals must be incorporated into other program areas because the RE&D Program must rely heavily on other programs to bring about improvements in safety and capacity. For example, FAA has not included the RE&D goals to increase capacity in its plan to purchase the next generation of air traffic control systems. Similarly, FAA will need to integrate the reduced runway incursion goal into agencywide efforts to reduce the number of accidents on crowded runways.

Second, FAA must utilize research conducted by other federal agencies and private organizations. For example, FAA is working to make better use of NASA's investment in aeronautical research, which amounted to \$900 million in fiscal year 1991.⁷ In the past several months, FAA has begun a dialogue to increase its use of DOD's laboratories. Although the extent and type of technologies that could be transferred is unknown, DOD officials believe that they can contribute to FAA's research efforts. Also, they believe that using DOD's in-house capabilities would be more cost-effective than FAA's current practice of contracting for much of its research.

In addition, the Congress authorized FAA to make grants to Centers for Excellence in Aviation Research at colleges and universities. The centers will expand FAA's access to the resources of the academic community. FAA has yet to establish a center and believes that the cost of establishing and maintaining the centers—between \$2 million and \$3 million annually per center—may limit FAA to establishing no more than one or two in the next few years. Officials at the National Science Foundation and NASA believe that FAA should encourage industry participation in these centers to offset costs and speed technology transfer.

Third, in such areas as air traffic control and security, an important relationship exists between developing specific technologies and how various technologies work together (system engineering and integration). For example, in the air traffic control area FAA must ensure the integration of ground-based systems and satellites for communications, navigation, and surveillance. Also, FAA must ensure that future security devices can successfully blend several technologies to detect a wide range of explosives. In the past, integration problems and issues have contributed

⁷NASA's efforts include a wide range of research on civil and military aircraft, including helicopters.

to cost increases. For example, costs increased for the Terminal Doppler Weather Radar System because FAA did not fully consider the need to integrate that system with the Low-Level Windshear Alert System.

Finally, for more than 30 years, human error has contributed to over 65 percent of aviation accidents. As a result, FAA has developed a multiyear plan with NASA that focuses on the many aspects of human factors in aviation. FAA has prioritized efforts in the plan to determine the correct balance of short- and long-term research on human factors. The results of this work will help identify potential safety issues and maximize efficiency in air traffic control and the operation and maintenance of aircraft. A critical area in the plan is the relationship between automation and air traffic controllers. Increased automation has profound implications for air traffic controllers and may bring a new generation of problems. For example, FAA officials told us that as automation increases, controllers will rely on advanced systems to make decisions about traffic flow. These officials emphasized the importance of research to ensure that automation does not diminish controllers' ability to effectively monitor air traffic because of boredom.

Conclusions

FAA has taken steps to improve its RE&D Program and respond to the Aviation Safety Research Act of 1988. FAA has embarked on research in human factors, simulation modeling, and aircraft structures. However, additional research in these areas remains to be done to ensure the safety of the air transport system.

In addition, FAA's including project cost and staffing information in the RE&D Plan as the Congress directed would strengthen the plan. Moreover, FAA's including the amount of funding dedicated to long-term efforts in budget documents would demonstrate to the Congress FAA's future vision for aviation research. Without this information, neither the Congress nor FAA can adequately assess the plan's requirements or its overall direction. Although a mechanism—DAFIS—exists to track long-term research, FAA does not use this system to track RE&D projects.

To ensure that FAA's RE&D Program is sufficiently future-oriented, the Congress mandated that FAA allocate 15 percent of its RE&D budget to long-term research, but this provision applied only to fiscal years 1989 and 1990. Therefore, FAA is not required to allocate a minimum level of current resources to long-term research. Since FAA does not know the amount of funds allocated to long-term research and might sacrifice long-term

research for short-term activities needed to address current problems, the Congress needs a mechanism to ensure that FAA is allocating sufficient funds to meet future safety, security, and capacity needs. Furthermore, the statutory definition of long-term research used in the 1988 law does not fully recognize the wide range of demands being placed on FAA's research programs, such as the need to refine training and procedures for key safety work forces.

FAA's RE&D Plan has established goals to direct its research efforts. However, these goals cannot be accomplished by the RE&D Program alone and seem to reflect the overall challenges facing FAA and the air transport system through the next decade. In addition, the RE&D Plan does not provide specifics on the particular contribution that the RE&D Program will make to achieving these goals. FAA's developing appropriate goals for the RE&D Program and integrating them into other agency efforts or specifying the manner in which the program can achieve its goals will enhance overall program management as well as FAA's ability to meet current and future challenges.

Recommendations

To improve FAA's management and provide the Congress with better information on the RE&D Program, we recommend that the Secretary of Transportation direct the Administrator, FAA, to (1) develop a method, utilizing DAFIS or other internal systems, for tracking the funding for long-term research; (2) include cost and staffing information in the RE&D Plan as required by the Aviation Safety Research Act of 1988; and (3) either integrate the RE&D goals into the Capital Investment Plan and other agency efforts that rely heavily on the RE&D Program or adopt goals that are directly achievable by the RE&D Program.

Matters for Congressional Consideration

The Congress may wish to consider mandating that some portion of FAA's RE&D budget be allocated to long-term research as it did for fiscal years 1989 and 1990. In doing so, the Congress may wish to consider including in its definition for long-term research the demands being placed on the RE&D Program for shaping the future air transport system and its safety, security, and efficiency. In addition, the Congress may wish to consider requiring FAA to provide long-term research resource information in its annual budget submissions. This action will help ensure that FAA's RE&D activities clearly distinguish between resources devoted to short- and long-term research.

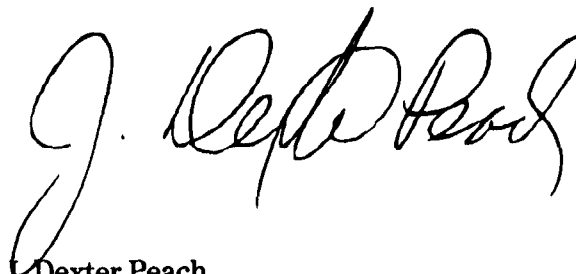
Agency Comments

We discussed the facts, conclusions, and recommendations in this report with FAA officials. FAA generally agreed with this report but offered the following comments for clarification. FAA's Deputy Director, RE&D Service, said that DAFIS may have the capability to track long-term research but other internal systems may be better suited to the task. In addition, the Deputy Director told us that FAA would prefer to integrate the current RE&D goals into other programs—including the Capital Investment Plan—rather than revise the RE&D Program goals. As requested, we did not obtain written agency comments on a draft of this report.

We conducted our review from August 1991 to April 1992 in accordance with generally accepted government auditing standards. Our objectives, scope, and methodology appears in appendix II.

Unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from the date of this letter. At that time, we will provide copies to the Secretary of Transportation; the Acting Administrator, FAA; the Director, Office of Management and Budget; and other interested parties. We will make copies available to others upon request.

This work was performed under the direction of Kenneth M. Mead, Director of Transportation Issues, who can be reached at (202) 275-1000. Other major contributors to this report are listed in appendix III.



J. Dexter Peach
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Abbreviations

DAFIS	Departmental Accounting and Financial Information System
DOD	Department of Defense
FAA	Federal Aviation Administration
F&E	facilities and equipment
GAO	General Accounting Office
NASA	National Aeronautics and Space Administration
RE&D	research, engineering, and development

FAA's RE&D Goals

The Federal Aviation Administration has established goals to guide its Research, Engineering, and Development Program over the next several years. The following are the nine RE&D goals:

- Reduce civil aviation fatality rate from all causes by at least 10 percent by 1999.
- Develop a fire-resistant aircraft cabin.
- Increase airspace and airport capacity by at least 20 percent by 1999 and an additional 20 percent by 2005, achieving commensurate reductions in delay.
- Reduce runway incursions by 80 percent by the year 2000.
- Reduce the number of accidents and incidents attributable to controller, flight crew, and maintenance crew human error by 50 percent by the year 2000.
- Reduce the number of accidents and incidents attributable to weather by 20 percent in 1997.
- Eliminate aircraft fires and aging aircraft concerns as significant safety issues by 1996.
- Provide non-precision approach capability or better at 95 percent of all U.S. public airports by 1996.
- Anticipate new threats and implement new security philosophies, technologies, and systems that operate effectively with minimal interference to passengers and carriers.

Objectives, Scope, and Methodology

The Chairman, House Committee on Science, Space, and Technology, asked us to examine (1) the Federal Aviation Administration's (FAA) progress in implementing the Aviation Safety Research Act of 1988; (2) the long-term research FAA undertook in fiscal year 1991; and (3) factors that will affect FAA's meeting its research, engineering, and development goals. To meet these objectives, we reviewed pertinent legislation, policies, and procedures. We performed work at FAA headquarters in Washington, D.C., and at the FAA Technical Center in Atlantic City, New Jersey. Also, we performed work at the U.S. Air Force's Wright Patterson Laboratory to collect information on relevant Department of Defense programs in aircraft safety and security.

In addition, we reviewed FAA's RE&D Plan, the joint FAA/National Aeronautics and Space Administration (NASA) National Human Factors Plan, project summaries, a recent joint industry-government study on FAA's RE&D Program, and attended meetings of FAA's RE&D advisory panel. We analyzed fiscal year 1988-91 funding, staffing, and timing information for 140 RE&D projects. We supplemented our work with discussions with industry, defense, National Science Foundation, and NASA officials familiar with FAA's RE&D Program concerning the factors that will affect the success of FAA's program in attaining RE&D goals. We conducted our work from August 1991 to April 1992 in accordance with generally accepted government auditing standards.

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