Office of Inspector General

Federal Aviation Administration's Research, Engineering, and Development

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Memorandum

U.S. Department of Transportation

Office of the Secretary of Transportation

Office of Inspector General

Subject: INFORMATION: Federal Aviation Administration's Research, Engineering, And Development Program
Report No. AV-1998-092

Date: March 25,1998

From: Kenneth M. Mead
Inspector General

Reply to Attn of:

To: Federal Aviation Administrator

At the request of the Chairwomen, Subcommittee on Technology, Committee on Science, we provided a statement for the record for a March 12, 1998 hearing on FAA's Research, Engineering, and Development (RE&D) budget request for Fiscal Year 1999. A copy of our statement is attached for your information.

Our statement discusses (1) the Modernization Task Force's recent actions and their implications for the RE&D Program, (2) the importance of human factors considerations in acquiring new technology, and (3) our ongoing work on coordination between FAA and the National Aeronautics and Space Administration (NASA). We are not making recommendations at this time.

We are encouraged by the steps taken thus far by the Modernization Task Force and share the view that a careful balance must be struck in replacing older equipment and implementing new capabilities to support aviation operations.

An important message of our statement is the need for FAA to take an active and early role in resolving human factors concerns in the development of new air traffic control technology. Moreover, human factors issues will become even more important as the aviation community moves to Free Flight. We emphasize the need for a process that integrates a structured, scientific human factors discipline throughout the acquisition process. Because resolving human factors issues can be difficult, we believe this process should include exit criteria to help determine which solutions will be implemented and when. These issues were also addressed in our March 5, 1998 testimony before the Subcommittee on Aviation,

Committee on Public Works and Infrastructure. (For additional details, see our testimony entitled Air Traffic Control Modernization, Report Number AV-1998-089, March 5, 1998).

Finally, because of the concerns raised by the Modernization Task Force and the need to focus limited research dollars, we are examining ways FAA and NASA could better coordinate and manage their research efforts. Specifically, we will review research goals and objectives, planning and project selection, staffing, funding, and schedules to evaluate the coordination efforts. This effort is being conducted jointly with the NASA Office of the Inspector General. We expect to complete this work later this year.

If I can answer any questions or be of any further assistance, please call me on 366-1959 or Lawrence H. Weintrob, Assistant Inspector General for Auditing, on 366-1992.

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Before the Subcommittee on Technology,
Committee on Science,
U.S. House of Representatives

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FAA's Research, Engineering, and Development Program

Statement for the Record

Statement of
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Deputy Assistant Inspector General for Aviation
U.S. Department of Transportation

Madam Chair and Members of the Subcommittee:

We appreciate the opportunity to discuss FAA's Research, Engineering, and Development (RE&D) Program. This program plays an important role in ensuring the safety, security, and efficiency of the U.S. air transportation system. Technologies developed and tested through the RE&D Program, such as the CTX-5000 explosives detection system, are now making their way into day-to-day use. FAA is requesting $290 million for RE&D for Fiscal Year 1999.

Today, a sense of urgency faces this program. The recent report of the National Civil Aviation Review Commission makes it clear that without important improvements in air traffic control, the U.S. air transportation system will suffer from system-wide delays and face gridlock in the future. A concept called Free Flight offers the possibility of reducing delays and avoiding gridlock.[1] FAA's research programs will now take a greater and more active role in assessing the risks and benefits of moving forward with Free Flight through an ambitious project called Flight 2000. In addition, FAA faces several time-critical challenges. We recently testified on our concerns about FAA's ability to meet the Year-2000 computer problem while maintaining existing equipment and installing new systems.[2]

My statement today will focus on (1) recent developments in FAA's modernization effort that have implications for the RE&D Program, (2) the need for human factors evaluations in all acquisitions, and (3) coordination between FAA and the National Aeronautics and Space Administration (NASA).

SUMMARY

Today, I would like to convey three major points to the Subcommittee.

- First, the FAA Administrator formed a Modernization Task Force that has important implications for the RE&D program. This task force has recommended, among other things, that FAA and the aviation industry pursue several "core technologies" to move toward Free Flight, address critical risk areas in the modernization effort, and proceed with making time-critical improvements to the air traffic control infrastructure. FAA is in the process of determining how to implement these recommendations as well as their

[1] Free Flight changes the philosophy of FAA and the users from that of air traffic control to air traffic management. It will permit pilots and controllers to share information and work together to manage air traffic. With Free Flight, pilots will not have to fly routes structured around ground-based navigation.

[2] See our testimony before the House Subcommittee on Aviation, Committee on Transportation and Infrastructure entitled Air Traffic Control Modernization (Report Number: AV-1998-089, March 5, 1998.)

financial implications. FAA's Flight 2000 project, a five-year $388 million RE&D effort to demonstrate Free Flight and test new technologies, is evolving and may play a larger role in mitigating risks with the modernization effort. In response to recommendations from various groups, FAA is in the process of refining the Flight 2000 project.

- Second, our recent work on a key modernization project known as the Standard Terminal Automation Replacement System (STARS) underscores the need for FAA to take an early and active role in resolving human factors concerns in the development of new air traffic control technology. History has shown that inadequate attention to human factors early in the design of new technology results in costly delays and design changes. We strongly believe that human factors will become even more important as the aviation community moves to Free Flight. FAA must implement a process that integrates a structured, scientific human factors discipline throughout the acquisition process. This process should include exit criteria that help determine which solutions will be implemented and when.

- Finally, FAA and NASA are working together to enhance the margin of safety and enhance the efficiency of the air traffic system through a series of joint research projects. Because of concerns raised by the Modernization Task Force and the need to focus limited resources, we are examining joint FAA/NASA efforts to identify ways coordination could be improved. We are examining the issue with NASA's Office of the Inspector General and will report on this issue later this year.

BACKGROUND

FAA's mission is to provide the safe, secure, and efficient movement of air traffic consistent with national security concerns. FAA's RE&D program develops and validates the technologies, systems, designs, and procedures required for the agency's full range of operational and regulatory activities. These activities include, but are not limited to, the acquisition of new technologies; air traffic services; certification of aircraft, airports, and personnel; civil aviation security; and development of environmental standards for civil aviation. FAA relies

heavily on other organizations, such as NASA and the Department of Defense to provide basic research, while it focuses on applications for civilian aviation.

Perspectives on Funding

For Fiscal Year 1999, FAA is requesting $290 million for RE&D, an increase of about 46 percent over last year's spending level of about $199 million. This represents the largest increase in the program in several years. About 30 percent of the funds are used in-house by FAA researchers while the remaining money is spent on research efforts of FAA contractors and other government agencies.

The most notable increase in the Fiscal Year 1999 budget request is an increase of about $90 million for the Capacity and Air Traffic Management Technology line of effort, which will fund the Flight 2000 project. Flight 2000, which will be discussed later, is a large scale test of new equipment--at FAA facilities and in the cockpit of aircraft--intended to modernize the national airspace system. FAA's RE&D budget request is also shaped by Congressional direction and response to specific safety concerns, such as aging aircraft.[3]

Another important highlight of this year's RE&D request is the continued FAA investment in new security technology. In response to the Gore Commission's recommendations, FAA spent $62 million in Fiscal Year 1997, expects to spend $45 million this year, and is requesting $55 million for fiscal year 1999 on aviation security RE&D.

[3] To ensure that FAA's RE&D efforts were sufficiently forward-looking, the Congress passed the Aviation Safety Research Act of 1988 which directed FAA to spend funds on, among other things, human factors and aircraft safety. In addition, the Act directed FAA to allocate at least 15 percent of its RE&D budget to long-term research.

It is important to point out that FAA's RE&D account is not the only source of funds in the agency's research and development portfolio. FAA has historically conducted considerable research and development, totaling millions of dollars annually, through its Facilities and Equipment (F&E) account for purchasing new air traffic control systems. In addition to the $290 million in RE&D requested for Fiscal Year 1999, FAA is requesting $423 million in its F&E account for Engineering, Development, Test, and Evaluation[4].

RECENT DEVELOPMENTS IN MODERNIZING THE NATIONAL AIRSPACE SYSTEM

Recent developments in FAA's plans for modernizing the National Airspace System have important implications for the RE&D Program. FAA has recognized the need to take control of its multi-billion dollar air traffic control modernization program, which has experienced significant cost overruns and schedule delays.

The FAA Administrator established a Modernization Task Force comprised of senior departmental officials as well as executives and experts from the aviation community to assess FAA's modernization needs. FAA reached out to the aviation community to solicit views and seek consensus on the priorities and objectives of the modernization program. As a result, the Congress should expect to see a more complete description of the risks associated with acquisitions, realism in project schedules, clarity in benefits to the aviation community, and greater focus on priorities.

[4] Engineering, Development, Test, and Evaluation budget activity includes programs which have migrated from the RE&D account or programs that are in the early stages of acquisition. For example, this activity funds work on mission needs analysis and alternative design analysis.

The Task Force found that FAA's modernization plans as reflected in the National Airspace System Architecture were sound but unrealistic because of, among other things, insufficient resources, risks associated with certifying new equipment, and the high cost for users to equip their aircraft.[5] Therefore, the Task Force recommended an approach that focuses more on providing near-term benefits to the user community. Under this approach, FAA would implement a set of "core technologies" to provide early user benefits, and seek ways to address critical risk areas in communication, navigation, and surveillance. (Attachment I provides details on the core technologies.) At the same time, FAA would proceed with time-critical activities related to updating existing infrastructure, such as the STARS and the Display System Replacement (DSR) system, and address its Year-2000 problem. [6]

We are encouraged by these actions and share the view that a careful balance must be struck in replacing aging infrastructure and implementing new capabilities to support aviation operations. The financial implications of these changes are unclear at this time because FAA is currently assessing the benefits and costs to both FAA and the industry. As a result, FAA is waiting until these assessments have been completed before making formal decisions about implementing the Task Force's recommendations. The Flight 2000 project can play a role in mitigating risks and facilitating the transition of new technology for communications, navigation, and surveillance by assessing the cost and performance of new aircraft avionics as well as the operational issues for pilots and controllers. This could have important implications for the RE&D Program.

[5] The NAS Architecture is prepared by FAA's Office of System Architecture and Investment Analysis and provides an overall conceptual blueprint for modernizing the air traffic control system and introducing new technologies.

[6] STARS will replace controller and maintenance workstations at terminal air traffic control facilities. DSR will replace controller work stations at enroute traffic control centers.

The Flight 2000 Project

The role and objectives of the Flight 2000 project are evolving. In response to recommendations by the Gore Commission, FAA formally announced an initiative in February 1997 called Flight 2000 to test and validate technologies required to support Free Flight. Also, the program is expected to assess avionics costs and certification issues.

In FAA's 1997 plan for the Flight 2000, the project was to be implemented in Alaska, Hawaii, and parts of oceanic airspace controlled by the Oakland Center and involve all classes of airspace users in all phases of flight.[7] At a February 27, 1998, briefing before the FAA RE&D Advisory Committee, FAA estimated that Flight 2000 will require a significant portion of its RE&D funds--about $388 million between Fiscal Years 1999 and 2003.[8] Almost 44 percent of the funds for Flight 2000 will be used to purchase new avionics for aircraft. FAA expects to equip 2,000 aircraft, ranging from general aviation aircraft to large commercial passenger aircraft, with new avionics. In our view, this raises important longer-term questions that have yet to be answered about who will purchase new avionics and FAA's role in equipping aircraft.

Flight 2000 has been controversial. According to FAA, some industry representatives have questioned the use of limited resources in light of other needs, location of test sites, and the project's linkage to the overall modernization effort. As a result of recommendations made by the Modernization Task Force, the RE&D Advisory Committee and others, FAA may make changes to the scope and

[7] According to FAA, Hawaii and Alaska were selected as evaluation sites because of their unique features. In FAA's view, they offer a controlled environment with a limited fleet allowing a full-scale evaluation without impacting safety.

[8] FAA's cost estimates also show additional funds totaling $31 million will be required from the Operations account beginning in Fiscal Year 2003.

objectives of Flight 2000. The FAA Administrator recently suggested a change to the Flight 2000 program to include a candidate site in the continental U.S. Once final decisions regarding Flight 2000 are made, FAA will make the required programmatic adjustments.

Consensus and strong commitments from FAA and the user community are essential for ensuring the success of the Flight 2000 project. In our opinion, Flight 2000 should be carefully planned, timed, and coordinated with other ongoing and planned modernization efforts to maximize the benefits of FAA's investment in this project. FAA should seek ways to keep costs within existing budgets by sharing costs with industry, particularly with acquiring new avionics; clearly defining high-risk areas and mitigation strategies; and working closely with the industry to establish realistic and measurable goals.

Another critical factor in developing and implementing new air traffic control technology is the adequate and timely attention to human factors concerns.

HUMAN FACTORS ARE CRITICAL

Our recent work on a critical modernization project called STARS has shown the need for FAA to incorporate human factors work in all acquisitions. Human factors evaluations must be performed early and throughout the entire acquisition process. The need for an effective human factors process will become more critical as FAA begins to develop and implement systems needed for Free Flight.

The $940 million STARS Program will replace displays, software, and computers in 172 terminal air traffic control facilities and is scheduled to become operational in Boston in December 1998. FAA began taking steps to resolve the STARS

human factors issues late in the acquisition process. In October 1997, however, FAA began working closely with users to identify human factors issues with the STARS controller and maintenance workstations. The controller workstation evaluation identified 98 human factors issues and the two maintenance workstation evaluations identified 106 issues.

An important lesson from the STARS Program is that FAA must develop a process to integrate a structured, scientific human factors discipline throughout the acquisition process. In future acquisitions, FAA must avoid "11th hour" human factors evaluations when development is almost complete. As STARS approached initial deployment, significant human factors concerns were raised by users.[9] As the National Research Council recently noted:

> "...good human factors is a 'pay now or pay more later' proposition. By the time the system reaches late stages of development or testing, major design commitments have been made, resources have been spent, and there is reduced motivation to discover design flaws that threaten deployment schedules."[10]

Once potential solutions acceptable to users have been identified, FAA must then analyze the solutions for the impact on a program's cost and schedule. The toughest decision, however, is determining when "enough is enough". Given the variety of human skills and abilities, users will not consistently agree on the best way to solve a human factors issue or which issues have priority. Consequently, until processes or exit criteria are established to determine which solutions to implement - (weighing safety, user acceptance, and cost) and when to implement

[9] For additional details on STARS, see our testimony before the Subcommittee on Transportation and Related Agencies, Committee on Appropriations, U.S. House of Representatives entitled Observations on the Federal Aviation Administration's Standard Terminal Replacement System (STARS) (October 30, 1997).

[10] National Research Council, The Future of Air Traffic Control: Human Operators and Automation, Washington, D.C., National Academy Press, 1998.

them - (before deployment or after deployment during product improvement), FAA will have difficulty resolving human factors issues.

FAA has initiated action to better integrate a human factors process in its acquisitions. A Human Factors Process Group was established to develop a process to manage human factors and user involvement throughout all phases of acquisition programs. In January 1998, the Process Group issued a preliminary report that identified a number of problems with FAA's management of human factors. Specifically, the January report noted that FAA's human factors management lacks a clearly articulated structure, human factors studies have not been given adequate resources, and results of evaluations have not been communicated to high-level decision makers. Our recent report on labor agreements in FAA[11] underscores the group's finding. We reported that only 12 percent of the estimated 516,000 official duty hours granted to National Air Traffic Controllers Association representatives in Fiscal Year 1996 was spent assisting FAA in developing and evaluating National Airspace System projects.

The importance of implementing better human factors processes can be illustrated in air traffic control towers. The current tower environment has large numbers of displays and keyboards, is crowded, and has limited space for controller access to critical data. For example, the Atlanta Hartsfield International Airport tower has 22 monitors and 22 data input devices for 9 systems at 6 controller positions. As new equipment has been added, air traffic control towers have not been viewed from a system perspective, but have evolved into a collection of independent subsystems. Human factors evaluations are needed in the tower environment when adding new or replacement systems, thereby avoiding the proliferation of equipment and increased risk of operator error.

[11] Air Traffic Controller Workforce Labor Agreements, Report Number AV-1998-061, January 20, 1998.

FAA also has the opportunity to use the new process for identifying human factors improvements in its Display System Replacement (DSR) Program. DSR is FAA's $1.0 billion program to replace aging and unsupportable display equipment with new displays, hardware, and software in enroute traffic control centers. The first site, Seattle, is scheduled to be operational in October 1998. Controllers and maintenance technicians participated in the design and development of DSR. Suggestions from users resulted in a number of changes to the system. Since then, users have expressed concerns, that after the system is in use, more human factors issues may be identified. In our view, prior to making future enhancements to DSR, FAA should conduct a structured human factors evaluation of DSR to identify areas where human factors can be improved.

The need for human factors evaluations will become more critical as FAA begins to add collaborative decision-making systems needed for Free Flight. Under Free Flight, the controllers' role could significantly change from a decision-making and communications role to a collaborative and monitoring role. The design of systems that the controllers will use in this new role must be carefully evaluated for human factors in order for these systems to be safe and effective.

To assist the controllers in transitioning to Free Flight, FAA should reevaluate the focus of its research and development efforts in the area of human factors. Currently, FAA is involved in 241 human factors research projects. Of these, only 21 projects, valued at approximately $2 million, relate to human factors in modernization of the National Airspace System. Further, in its January 1998 preliminary report, the Human Factors Process Group also stated that funding priorities for RE&D programs resulted in human factors research programs that do not complement or support the needs of acquisition programs. We believe that

FAA should focus more of its human factors research and development resources on new decision support systems that the controllers will be using in the future.

FAA AND NASA RESEARCH EFFORTS

FAA and NASA have a long-standing relationship in working together in aviation research. The two agencies have worked together for many years but it was not until 1990 that FAA and NASA Administrators took actions to bolster ties between the two agencies. FAA and NASA now coordinate aviation research programs and planning through a joint committee and have established seven Memoranda of Understanding (MOU) in areas of mutual interest, such as air traffic management, human factors, severe weather, airworthiness, and environmental issues. In addition to the MOUs in place, the agencies are in the process of finalizing a new MOU for safety research.

Traditionally, the NASA role had been to conduct basic research designed to provide a technology base for future air transportation systems that focus on long-term ventures. FAA complemented this approach by applying these technologies specifically to nearer-term civil aviation issues. In response to the Gore Commission, NASA plans to spend about $500 million for aviation safety research and about $250 million for air traffic management research from Fiscal Years 1998 to 2002. For air traffic management research, the agencies have developed a joint program with common goals to better coordinate their efforts and are working on a similar plan for aviation safety.

Despite MOUs and coordinated plans, concerns have been raised over the years by the U.S. General Accounting Office (GAO) and others about the need for better

coordination between FAA and NASA.[12] Less than a year ago before this Committee, an industry official cautioned that problems existed in coordinating research between FAA and NASA and that NASA researchers were unaware of previous FAA work in some key areas.[13] The Modernization Task Force was also concerned about the effectiveness of the coordination to ensure NASA and FAA programs reflect FAA requirements.

Therefore, we are examining and exploring ways FAA and NASA could better coordinate and manage aviation research. Specifically, we will review goals and objectives, planning and project selection, staffing, funding, and schedules to evaluate the coordination efforts. We have begun work and expect to complete our review, which is being conducted jointly with the NASA Office of the Inspector General, later this year and will submit our report to this Subcommittee at that time. Given the importance of FAA and NASA efforts in aviation-related research, we share this Subcommittee's belief that the two agencies' roles should be clearly defined to develop synergy between projects, focus resources, and prevent duplication of effort.

[12] See Aviation Research: Issues Related to FAA's Research Activities (GAO/T-RCED-93-68, July 29, 1993) and Federal Research and Technology for Aviation, Office of Technology Assessment (Report Number OTA-ETI-610, September 1994.)

[13] See The Role of Research and Development in Improving Civilian Air Traffic Management, Hearing before the Committee on Science, Subcommittee on Technology, US House of Representatives (105th Congress, June 24, 1997).

Core Technologies Identified by the Modernization Task Force and other Users

The following describes the core technologies that have been identified thus far.

- **Collaborative Decision Making (CDM):** is a collection of projects that include the involvement and exchange of information by pilots, dispatchers, and controllers in the Free Flight decision making process to ensure all needs are incorporated into actions taken. The goal is to provide FAA and users with a shared view of current and predicted air traffic situations.

- **User Request Evaluation Tool (URET) Conflict Probe:** allows en route controllers to safely and efficiently accommodate traffic that is not on predefined routes by providing advanced warning of potential aircraft-to-aircraft conflicts so that a controller can take action and resolve the conflict. URET is currently in limited operational use at the Indianapolis and Memphis Air Route Traffic Control Centers.

- **Traffic Management Advisor (TMA) Build II :** provides for more accurate prediction of arrival times through the improved sequencing and spacing of traffic as aircraft transition from enroute to terminal airspace. TMA has been demonstrated at Dallas-Fort Worth Air Traffic Control Center.

- **Passive Final Approach Spacing Tool (Passive FAST)** provides for improved arrival rates at airports through more efficient spacing of arrivals on final approach to the runway to provide a greater arrival rate at the airport. Passive FAST has been demonstrated at Dallas-Fort Worth Terminal Radar Approach Control.

- **Controller/Pilot Data Link Communications (CPDLC)** provides digital communications between the pilots and controllers to share information, enhance situational awareness, and reduce voice congestion in order to improve safety and efficiency.

- **Surface Movement Advisor (SMA)** provides information from FAA Terminal Radar Approach Control facilities to users at the airport for improved airport surface operations and gate operations. SMA has been demonstrated in Atlanta.