1.0 OVERVIEW

1.1 Research, Engineering, and Development Program Objectives

The Federal Aviation Administration's (FAA) mission is to provide a safe, secure, and efficient aerospace system that contributes to national security and promotion of U.S. aerospace safety. As the leading authority in the international aerospace community, the FAA is responsive to the dynamic nature of customer needs, economic conditions, and environmental concerns. Key mission elements are: (1) the regulation of civil aviation and commercial space transportation to promote safety; and (2) the safe and efficient use of airports and the airspace by both civil and military aircraft.

To accomplish this mission, the FAA's Research, Engineering, and Development (R,E&D) program develops and validates technology, systems, design, and procedures that directly support six of the agency's principal operational and regulatory responsibilities: acquisition, air traffic services, certification of aircraft and aviation personnel, operation and certification of airports, civil aviation security, and environmental standards for civil aviation

The FAA's R,E&D program has made significant contributions to ensure the safety, efficiency, capacity, and cost-effectiveness of the national aviation system. Today, that system is under heavy pressure to keep pace with rising air traffic and commercial space transportation demands, needs for essential safety and security improvements, airspace user requirements for more flexible and efficient air traffic management operations, and demands for further mitigation of the environmental impacts of aircraft operations.

As air travel increases, the agency's R&D work will take on added significance. To meet these future challenges, the FAA employs a comprehensive, agencywide R,E&D investment analysis process to assure that available resources remain customer-focused (in terms of the Government Performance and Results Act concepts of "outcomes" and "outputs") and targeted on the highest priority activities.

The agency's first priority is safety. The accident rate has dropped dramatically over the past 20 years because of the introduction of new technologies and procedures based on research and development (R&D) contributions from the FAA, NASA, and, to a lesser extent, the Department of Defense (DOD). As traffic doubles over the next 15 to 20 years (and with an even higher growth rate forecast for commercial space transportation), it will be necessary to reduce the current accident rate by 50 percent to hold the annual number of accidents at today's level. The R,E&D program supports essential initiatives to reach the goal of reducing fatal accidents by 80 percent by the year 2007.

The R,E&D program also supports the goals and objectives of the agency's strategic plan, as well as the requirements associated with the evolving air traffic system architecture. A major FAA challenge today is modernizing an aging infrastructure of air navigation facilities. A major infusion of new technology and procedures is essential if air traffic services are to continue to support safe and efficient flight operations in the future. The system architecture provides the roadmap for this continuing modernization process, and the R,E&D program provides the necessary system development initiatives.

A safe and efficient air transportation system also is essential to both the Nation's economic prosperity and for national defense. In 1993, aviation and related industries contributed almost $700 billion to the U.S. economy (6 percent of our gross domestic product) and accounts for over 8 million jobs. Aviation is the largest export sector of our economy, with a $25-billion trade surplus in 1994. The industry expects to deliver over 14,000 transport aircraft valued at $1 trillion over the next 20 years. A viable FAA R,E&D program is critical to assure the continued safety and efficiency of the air transportation system and continued U.S. technical and economic leadership in aviation.

The FAA's R,E&D program is functionally divided into seven areas: air traffic services, airport safety technology, aircraft safety, system security, human factors, environment and energy, and R,E&D program direction.

1.2 Forecasted Needs of Civil Aviation

Increasing Demand

The FAA's mission is to provide support and guidance to the aviation industry to ensure responsiveness to the needs of the aviation community. The Nation's defense and economic prosperity rely heavily on the stability of the aviation industry. Aviation and related industries contribute almost $771 billion to the U.S. economy (6 percent of our gross domestic product) while they provide over 8 million jobs (See Figure 1-1). With a $425 billion trade surplus in 1994, aviation remains the largest export sector of the economy. U.S. aviation industries hope to deliver over 14,000 transport aircraft valued at $1 trillion over the next 20 years.

However, aviation-related research and development is accelerating in other nations, and increased foreign competition is showing some signs of eroding our international position. A strong FAA R,E&D program is critical not only to our national interests in improving the safety and efficiency of air travel systems, but also to safeguarding U.S. interests through adoption of our own technologies and products.

According to FAA Aviation Forecasts, between fiscal years 1997–2008, the demand for commercial air services is expected to escalate. (See Figure 1-2.) Domestic air carrier revenue passenger miles are expected to increase 3.8 percent annually in these same years. Projections assume that domestic passenger yields will increase 1.7 percent annually over the forecast period, and international air carrier revenue passenger miles and enplanements will increase 5.3 percent annually. Air transportation is expected to continue to dominate all other transportation modes in both long-distance domestic intercity and international passenger markets. Growth in commuter/air taxi aircraft activity should be somewhat larger than forecasted for the larger commercial air carriers. This projected growth will increase the strain on the air transportation system's capacity, safety, and security.

Security

The increased sophistication of terrorist activity and recent aircraft disasters have heightened public awareness and demand for better security systems and improved procedures affecting both security and safety. The public must feel secure in using the air transportation system. The Gulf War has shown that, without a sense of security, air travelers will change their mode of transportation or dramatically decrease their travel. Statistics may not bear out the flying public's fears and concerns, but these perceptions must be addressed. The FAA R,E&D program is focusing on developing methods and innovations that will produce the assurances that the public demands.

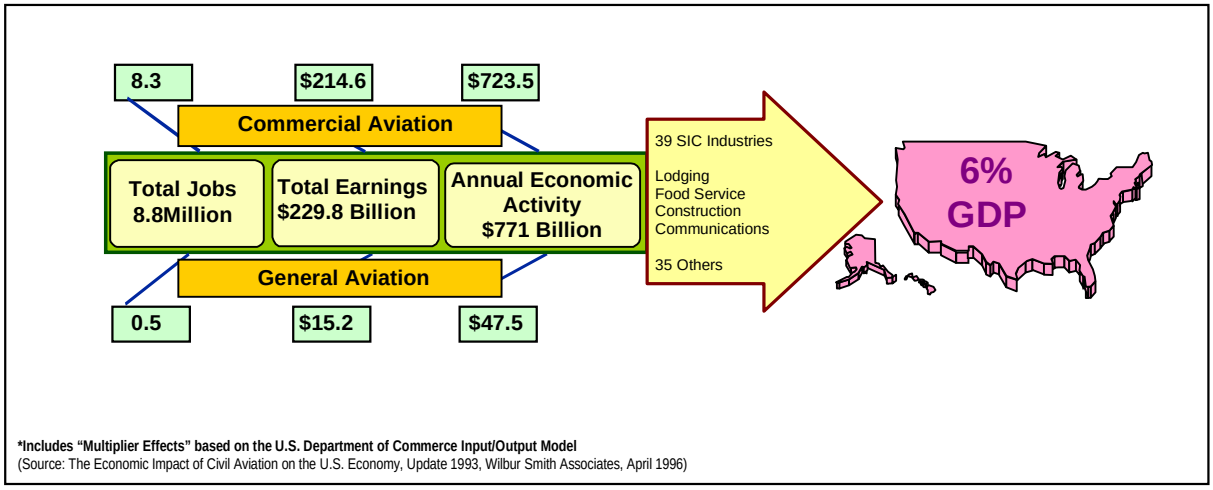


Figure 1-1 Aviation Impact on the Economy

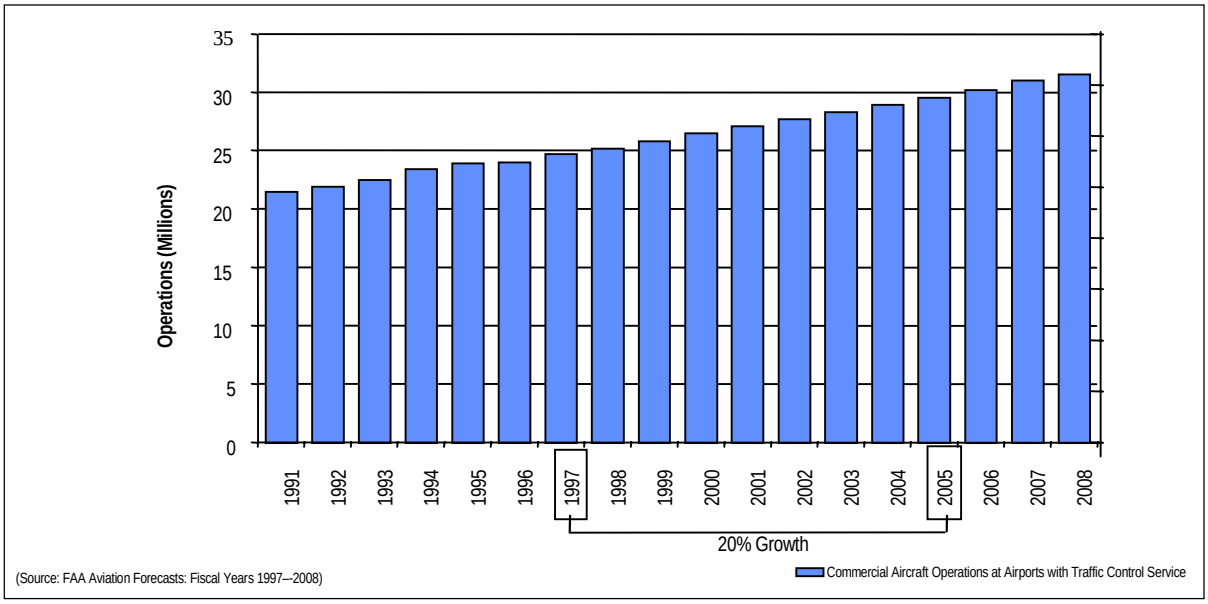


Figure 1-2 Commercial Aircraft Operations

Navigation/Surveillance

The Global Positioning System (GPS), a satellite-based positioning system, is revolutionizing the FAA's current and future infrastructure plans. However, its successful incorporation into air traffic services requires technical answers to such questions as: What redundancy is needed for a space-based system; what information security measures are required; what certification is required for GPS-derived services such as the Wide Area Augmentation System; and how present air traffic management procedures and air traffic services systems can best be modified to take full advantage of the GPS information. The R,E&D program must address these and other questions immediately to avoid delaying GPS's application and expected economic and safety benefits.

Changing world economic, technical, and social environments result in new challenges to the FAA and recent initiatives have focused the R,E&D program on future enterprises discussed in the following paragraphs.

1.3 R,E&D Advisory Committee

FAA's Research, Engineering and Development (R,E&D) Advisory Committee (REDAC), established in 1989, advises the Administrator on research and development issues and coordinates the FAA's research, engineering, and development activities with industry and other government agencies. The committee considers aviation research needs in air traffic services, airport technology, aircraft safety, aviation security, human factors, and environment and energy.

Up to 30 members may serve on the Committee. They serve two-year terms and represent corporations, universities, associations, consumers and government agencies. The FAA's Director of Aviation Research, serves as the executive director of the committee. The REDAC meets three times throughout the year.

REDAC recommendations are in Appendix A.

1.4 Motivation for Modernization

1.4.1 White House Commission on Aviation Safety and Security (Gore Commission)

In August 1996, the White House issued Executive Order 13015 establishing a commission on Aviation Safety and Security. Chaired by Vice President Al Gore, the commission is often referred to informally in the aviation community as the Gore Commission. Included in its initial man-

date was the requirement to review the current status of National Airspace System (NAS) modernization efforts and recommend changes if required.

As noted in the Commission's final report, dramatic changes loom on the horizon for the aviation industry. Information technology presents opportunities that will again revolutionize aviation in ways as significant as the introduction of the jet engine 40 years ago. Digital technology will replace analog systems, making communications with and among aircraft dramatically faster, and more efficient and effective.

Among key recommendations on new initiatives and funding to improve safety and security, the commission also concluded that "In the area of air traffic control, the commission believes that the safety and efficiency improvements that will come with a modernized system should not be delayed and recommends that the program be accelerated to achieve full operational capability by 2005."

This recommendation represents a significant challenge and opportunity for R,E&D—one that can be met only with a renewed sense of dedication and expanded partnerships with industry and academia.

1.4.2 President's Commission on Critical Infrastructure Protection

The President's Commission on Critical Infrastructure Protection (PCCIP) was the first national effort to address the vulnerabilities created in the new information age. The Commission, established in July 1996 by Executive Order 13010, was formed to advise and assist the President of the United States by recommending a comprehensive national strategy for protecting and assuring critical infrastructures from physical and cyber threats.

The Commission, chaired by aerospace industry leader Robert "Tom" Marsh, included senior representatives from private industry, government and academia. An advisory committee of industry leaders advised the Commission, and a Steering Committee of cabinet-level officials reviewed the Commission's report before forwarding it to the President. The Commission submitted its report, *Critical Foundations*, to the White House in October 1997.

Critical infrastructures are systems whose incapacity or destruction would have a debilitating impact on the defense or economic security of the Nation. They include telecommunications, electrical power systems, gas and oil, banking and finance, transportation, water supply systems, government services, and emergency services.

The Commission was divided into five teams, representing the eight critical infrastructures. Each team evaluated the growing risk, threats, and vulnerabilities within its sector. The sector teams and their industries include:

- Information and Communications—telecommunications, computers and software, Internet, satellites, fiber optics
- Physical Distribution—railroads, air traffic, maritime, intermodal, pipelines
- Energy—electrical power, natural gas, petroleum, production, distribution and storage
- Banking and Finance—financial transactions, stock and bond markets, Federal Reserve
- Vital Human Services—water, emergency services, government services.

1.4.3 National Civil Aviation Review Commission

In its report, the Commission recommended broad and sweeping changes in the ways the FAA is managed, sets its priorities, assesses and achieves performance outcomes, and is financed. The Commission made five broad recommendations:

- FAA's funding and financing system receive a Federal budget treatment ensuring that revenues from aviation users and spending on aviation services are directly linked, and shielded from discretionary budget caps.
- Air traffic control services should be placed in a performance-based organization (PBO) that is managed by a chief operating officer and overseen by a board of public interest directors.
- FAA should adopt a cost-based revenue stream to support its air traffic system activities, including capital investments.

- FAA operating costs could be better managed and controlled and that investments in air traffic control modernization should be increased.
- AIP should be funded at a minimum of $2 billion annually over the next 5 years.

1.5 Recent Aviation Community Initiatives

1.5.1 NAS Architecture

The FAA, through the Office of System Architecture and Investment Analysis, has defined a comprehensive and realistic system architecture for the air transportation system infrastructure. The NAS Architecture Version 4.0 is the culmination of an intense effort undertaken by the FAA, industry representatives, pilot and owners' organizations, and DOD. The *NAS Architecture Version 4.0* document, approved by the Joint Resources Council (JRC) on September 14, 1998, was published in February 1999. The NAS Architecture responds to the requirements of the *Government/Industry Operational Concept for the Evolution of Free Flight* (CONOPS).

The CONOPS provides an evolutionary concept of operations from the perspective of NAS users. This concept covers the transition from the current NAS through three distinct time frames: 2000; 2005; and the time when mature Free Flight occurs. It incorporates the needs and requirements of NAS users and serves as the basis for an incremental, benefits-driven approach towards Free Flight. The concept also forms the basis for FAA and user community plans calling for procedural, investment, and architectural decisions to support the operational capabilities needed to achieve Free Flight.

A thorough review of all current and proposed R,E&D initiatives in the Air Traffic Services (ATS) area was conducted in support of the NAS Architecture. This effort validated ATS research efforts with the NAS modernization model provided by the NAS Architecture. As a result, some ongoing research activities were restructured and new requirements were identified. Details of how ATS research activities map to NAS modernization appear in the *NAS Architecture Version 4.0.*

1.5.2 Safer Skies

In 1997, both the White House Commission and the National Civil Aviation Review Commission (NCARC) recommended a concentrated effort to reduce accidents fivefold over the next decade. The NCARC also recommended that the FAA and industry work jointly on safety data analysis. In the fall of 1997, Administrator Jane Garvey made a commitment to develop a 5-year plan to focus FAA resources on the accident prevention steps that hold the most potential.

This led to the initiative "Safer Skies—A Focused Agenda," which was introduced by Vice President Gore on April 14, 1998. The FAA, based on a comprehensive review of the causes of aviation accidents, has adopted a focused priority safety agenda designed to bring about a fivefold reduction in fatal accidents. The FAA will concentrate its resources on the most prevalent causes of aircraft accidents and use special teams of technical experts to pinpoint the leading causes of aviation disasters and recommend safety advances. In partnership with industry, Safer Skies will use the latest technology to help analyze U.S. and global data to find the root causes of accidents and determine the best actions to break the chain of events that lead to accidents.

On September 22, 1998, Deputy Administrator Monte Belger gave a speech at the Global Aviation Safety and Security Conference that described the Safer Skies program and the new Air Transportation Oversight System (ATOS), which complements the Safer Skies agenda.

1.5.3 Free Flight Phase 1

In 1994, RTCA formed the Free Flight Select Committee. In 1995, RTCA formed Task Force 3, which issued recommendations in October 1995. In 1996, the FAA committed to Free Flight, and RTCA formed the Free Flight Steering Committee, and in 1997, the FAA Administrator formed the NAS Modernization Task Force. In January 1998, the FAA Administrator requested RTCA to define Free Flight Phase 1 (FFP1). In March 1998, the RTCA Select Committee set the focus for FFP1 and the Administrator accepted the recommendations. In July 1998, the Administrator

established the FFP1 Program Office as the direct reporting organization.

The basic concepts of FFP1 are to: (1) provide near-term measurable benefits; (2) focus on early delivery of operational capability by the year 2002; (3) integrate the capabilities with procedures; (4) utilize "low risk" technologies; (5) use an evolutionary development paradigm; (6) include operational, technical, and financial considerations; and (7) determine accountability.

The selected capabilities are:

- Traffic Management Advisor (TMA): A tool that aids the controller in making decisions regarding sequencing and spacing of en route arrival aircraft.
- Passive Final Approach Spacing Tool (pFAST): A tool that aids the controller in making decisions regarding sequencing and runway assignment of terminal arrival aircraft.
- Controller/Pilot Data Link Communications (CPDLC): A tool that enables the exchange of selected non-time-critical messages between pilots and controllers.
- User-Request Evaluation Tool (URET): A tool that aids the controller in efficiently managing en route traffic, supporting user request decisions, and strategically detecting potential conflicts.
- Collaborative Decisionmaking (CDM): A collection of tools that: (1) allows the FAA and participating airlines to electronically exchange and analyze flight, NAS capacity, and status information; (2) enhances the traffic flow management (TFM) process; and (3) monitors and analyzes the performance of the TFM system.
- Surface Movement Advisor (SMA): A collection of tools that provides terminal data to participating airlines and permits data exchange to support surface movement efficiency.

1.5.4 Fielding Security Equipment

Through the Aviation Research Grant Program, the FAA and InVision Technologies, Inc., have partnered to increase aviation security for the traveling public. The FAA Security Equipment IPT (SEIPT) has purchased over 70 InVision CTX 5000 explosives detection systems (EDS) to date. The second-generation CTX-5500, also developed under the Aviation Research Grant Program, screens baggage faster with a lower false alarm rate. It was fielded in the fall of 1998.

1.5.5 Enhance Safety of Aging Aircraft Systems

On October 1, 1998, Secretary Rodney Slater and Administrator Jane Garvey announced a new initiative that will help ensure that aircraft systems such as wiring and fuel do not fail as they become older. This program, called the Aging Transport Nonstructural System Plan, includes stepped-up inspections of wiring, a long-term research program, and a model-by-model assessment of each aircraft type. As Secretary Slater noted, "This initiative continues our work to fulfill the mandate of the White House Commission on Aviation Safety and Security, chaired by Vice President Gore, which is a blueprint to help us make the world's safest aviation system even safer."

The FAA's Aging Transport Non-Structural Systems Plan responds to a recommendation by the FAA Aging Systems Plan and combines regulatory actions, focused inspections, research, training, and advice from the aviation community. It includes seven initiatives to enhance the safety of nonstructural aircraft components:

1. Establish an Aging Transport Systems Advisory Committee to coordinate the Plan's initiatives.
2. Conduct an indepth review of the aging transport fleet and make model-specific safety recommendations related to airplane systems.
3. Enhance airplane maintenance to better address aging airplane systems.
4. Add aging systems tasks to the FAA research program.
5. Improve reporting of accident/incidents and maintenance actions involving aircraft wiring system components.
6. Evaluate the need for additional maintenance of transport airplane fuel system wiring and address any unsafe conditions.

7. Improve wiring installation drawings and instructions for continuing airworthiness.

1.5.6 RTCA

The RTCA Free Flight Steering Committee (FFSC) endorsed the NAS Modernization Task Force approach to NAS Modernization. The FFSC applauded the FAA's plan to identify risk areas and work collaboratively with industry to mitigate the risk, and implement the resulting communication, navigation, and surveillance (CNS) components of the NAS. The FFSC agreed that Safe Flight 21 should be the vehicle for removing risk and defining a path toward implementing enhanced CNS elements of the NAS. The FFSC endorsed the plan to deploy a core set of capabilities at limited sites by 2002.

1.5.7 Safe Flight 21

Safe Flight 21 is a major research activity that is being organized to significantly affect the pace and ultimate success of NAS modernization. Safe Flight 21 is an initiative to build a credible program with FAA, industry, and Congress to demonstrate and validate integrated flight system capabilities in a real operational environment. It brings together the systems, procedures, and training necessary to provide improved NAS safety, productivity, and efficiency at affordable operations and maintenance costs. At this time there are nine operational enhancements being discussed. Each enhancement will be considered on its own merit.

1.6 Research Partnerships

1.6.1 National Science and Technology Council

President Clinton established the National Science and Technology Council (NSTC) by Executive order on November 23, 1993. This Cabinet-level Council is the principal means by which the President, who chairs the NSTC, can coordinate science, space, and technology among the diverse parts of the Federal research and development enterprise. Council members include the Vice President, Assistant to the President for Science and Technology, Cabinet Secretaries and Agency Heads with significant science and technology responsibilities, and other White House officials.

A key NSTC objective is establishment of clear national goals for Federal science and technology investments to strengthen and improve areas ranging from information technologies and health research to transportation systems and fundamental research. The Council prepares research and development strategies that are coordinated across Federal agencies to form an investment package aimed at accomplishing multiple national goals. In a report titled "*National Research and Development Plan for Aviation Safety, Security, Efficiency, and Environmental Compatibility*", to be released soon, the Council will provide a description of the coordinated long-term research initiatives to bring about the advances in aviation that will be required in the opening decades of the next century.

The NSTC Committee on Technology provides overall technology policy, program, and budget guidance and direction to the Executive Branch. Composed of senior-level representatives from the Federal Government's R&D departments and agencies, the Committee advises and assists the NSTC to increase the overall effectiveness and productivity of Federal R&D efforts in technology. The Committee addresses significant national policy matters that cut across agency boundaries and provides a formal mechanism for interagency policy coordination and development of Federal technology activities.

The Committee places particular emphasis on promoting technology partnerships to leverage Federal R&D budgets more efficiently. Partnership programs under the auspices of the Committee include the Partnership for the Next Generation of Vehicles, the U.S. Innovation Partnership, the Partnership for Advanced Technology in Housing, and programs in Computing, Information, and Communications as authorized under the High Performance Computing Act of 1991.

The NSTC Committee on Transportation Research and Development chaired by Deputy Secretary Mortimer Downey has developed the rationale and framework for guiding Federal initiatives that will make the transportation system safer, more productive, and more efficient. Considering the likely future, the Transportation R&D

Committee has defined these strategic goals for transportation R&D:

- Provide a safer transportation system
- Achieve a high level of transportation system security
- Improve environmental quality and energy efficiency
- Foster economic growth and productivity through more effective and flexible global passenger and freight services
- Ensure improved access to and increased mobility on the Nation's transportation system.

The FY 2000 FAA R&D budget supports these strategic goals for transportation R&D in the NSTC plan. The FAA is a uniquely visible member of the transportation community, and these investments are critical to meeting the national goals and sustaining the prosperity of the national economy.

1.6.2 FAA/NASA Integrated Plan for Air Traffic Management

Research and Technology Development

On September 11, 1995, the FAA and NASA Administrators signed a memorandum of understanding (MOU) on Airspace System User Operational Flexibility and Productivity. In this document, the two agencies commit to an integrated effort to provide an air transportation system that facilitates user operational flexibility and productivity throughout the airspace while maintaining or enhancing safety.

The MOU established an FAA/NASA Inter-Agency Air Traffic Management Integrated Product Team (IAIPT) responsible for planning, oversight, and management of joint efforts. The principal defining documents for the IAIPT are the *Integrated Plan for Air Traffic Management Research and Technology Development* and the *Inter-Agency Air Traffic Management Integrated Product Team Management Plan*.

The mission of the IAIPT is to plan and facilitate the integrated FAA/NASA Air Traffic Management (ATM) research and development into operational concepts and associated decision-support tools, which, when implemented, will maximize the safety, efficiency, and flexibility of the operations for the current and future NAS. Efforts will encompass air-based and ground-based air traffic control and traffic flow management decision-support tools and procedures.

The IAIPT manages, advises, directs, decides, advocates and influences, and accomplishes ATM-related research and development (R&D).

As illustrated in Figure 1-3, the IAIPT is organized under joint FAA/NASA leadership into an Inter-Agency Integrated Management Team (IAIMT), six Area Work Teams, and related staff. The composition and role of the various IAIPT elements are described below.

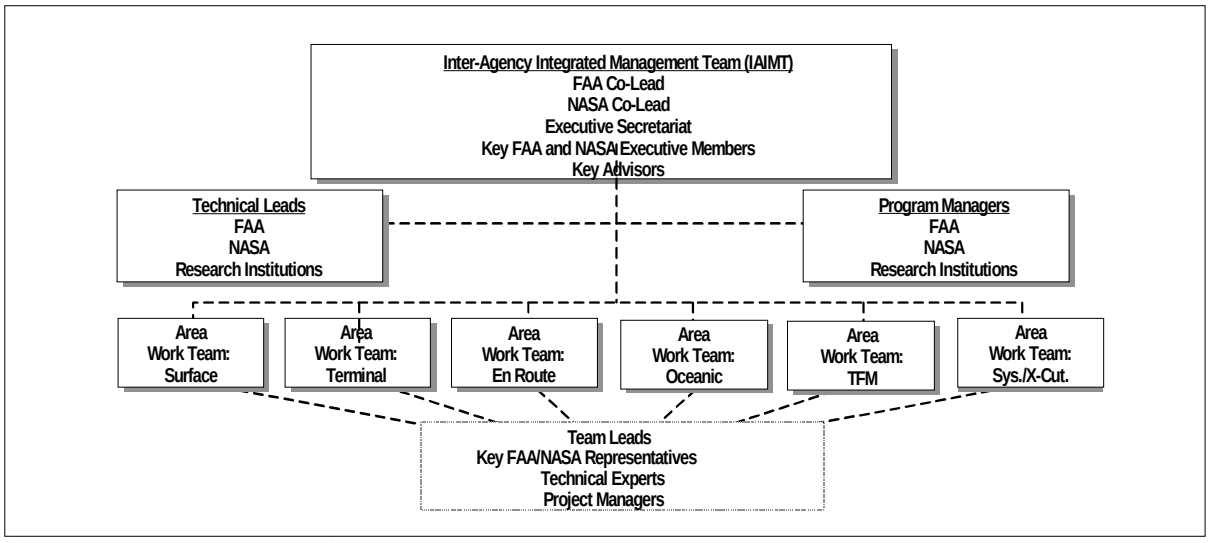


Figure 1-3 IAIPT Organization

The IAIMT, the senior management advisory body for the IAIPT, has both FAA and NASA co-leads. A careful balance of other participants represent major organizations within these agencies. Key FAA and NASA research support organizations are represented on the team. These private-sector interests include MITRE/CAASD and the Massachusetts Institute of Technology Lincoln Laboratory.

The role of the IAIMT is to:

- Provide high-level vision and direction.
- Establish strategic outcomes consistent with FAA, NASA, and industry strategic goals (i.e., Government Performance and Results Act (GPRA) outcomes, etc.).
- Provide integrated strategic planning for ATM R&D, and communicate the plan in an *Integrated Plan for ATM Research and Technology Development.*
- Periodically review the status of ATM R&D and integration and report to the FAA-NASA Coordinating Committee.
- Make decisions and set priorities for overarching issues, especially those affecting R&D technical and resource needs.
- Be the focal point for related program, policy, and budget issues internal and external to the FAA and NASA.
- Initiate and explore research and technology options.

Collectively, the Area Work Teams (AWT) form the operational body of the IAIPT. Individually, AWT representation reflects the same concern for balance as shown in overall IAIPT membership. The FAA lead of each team is the same person who is responsible for the transfer of the developed technology into FAA's new systems and operational procedures, and members from NASA and the private sector are similarly designated by their organizations based on a combination of their relevant experience and their currently assigned duties.

The current IAIPT has six AWT's, one for each technical domain of ATM R&D, namely: Surface, Terminal, En Route, Oceanic TFM, and System/ Cross-Cutting. The individual AWT's may augment their basic membership with other program participants, as required, to support the mission of the AWT.

The role of the individual AWT's, within their designated areas of responsibility, is to:

- Integrate FAA and NASA ATM R&D planning and project execution, including budgets, work, and priorities.
- Be responsible to the co-leads and the IAIMT for performance against key project milestones and program outcomes (i.e., GPRA), including making recommendations to the IAIMT regarding scope, direction, and content of integrated ATM R&D.
- Foster technical exchange, alignment, and integration of ATM R&D programs among participating organizations and the ATM R&D community.

Products of this integrated research are shown in Table 1-1. Some (as noted) have already been delivered and are being incorporated in the Free Flight Phase 1 program for limited deployment in the NAS. Research products being developed by the FAA are part of this interagency IPT and are further discussed in the program information sections on Traffic Flow Management, Operational Concept Validation, Air Traffic Control/Airway

Facilities Human Factors, and Center for Advanced Aviation System Development.

FAA/NASA Executive Committee

Under an agreement signed on October 9 1998, the FAA and NASA will establish an agency partnership to pursue:

- Aviation safety improvements
- Airspace system efficiency
- Aircraft environmental concerns.

The pact creates an executive board of senior managers from both agencies to monitor progress and ensure that complementary aviation and commercial space transportation goals are achieved through coordinated planning. The agreement basically reconstitutes the FAA/NASA Coordinating Committee on R&D and redesignates it as the FAA/NASA Executive Committee. The Committee will be responsible for executive direction and oversight of the FAA and NASA joint aviation and future space transportation R&D efforts.

The committee will be chaired by the Associate Administrator for Research and Acquisition (ARA-1) and NASA's Associate Administrator, Office of Aerospace Technology. Permanent members from FAA will include the Associate Administrators for:

- Air Traffic Services (ATS-1)
- Regulation and Certification (AVR)
- Airports (ARP-1)
- Commercial Space Transportation (AST-1)

the Directors of:

- Aviation Research (AVR)
- The William J. Hughes Technical Center

Table 1-1. IAIPT Products

IAIPT Products	
System/Cross Cutting	Support to Operational Concept Development/Validation Airspace Design Technology Benefits/Metrics Development Human Factors System Evaluation Tools ATM Collaborative Decisionmaking Tools for Flight Crews
Traffic Flow Management	Ground Delay Program Enhancements Collection and Distribution of NAS Status Information Collaborative Routing Interactive Flight Planning System Performance Assessment Tools Dynamic Density Monitor
Surface Area Work Team	Airport Surface Movement Advisor Airport Collaborative Departure Scheduling Tool Integrated Surface Advisory Tool
Terminal Arrival and Departure	Single Center Traffic Management Advisor Final Approach Spacing Tool Dynamic Wake Vortex Spacing Tool Dynamic Rerouting Tool for Weather Avoidance Collaborative Arrival Planning Tool Expedite Departure Path Terminal Routing Using Speed Techniques
En Route/ Cruise	Conflict Probe Enhancements Mulitcenter Traffic Management Advisor En Route and Descent Advisor Aircraft Integration
Oceanic	(Research Program To Be Developed)

and the:

- Federal Air Surgeon.

NASA counterparts on the committee will include the Directors of:

- Langley Research Center
- Lewis Research Center
- Dryden Flight Research Center
- the Marshall Space Flight Center
- Goals, Programs, and Commercial Technology Divisions.

1.6.3 Cooperative Research

The work described below is representative of cooperation between the FAA, NASA, and primary DOD components.

Traffic Management Advisor (TMA). As part of the Center Terminal Radar Approach Control (TRACON) Automation System (CTAS), TMA Single Center Metering provides en route/terminal controllers with automation tools to meter aircraft flow rates in the terminal environment. Specific TMA controller tools include an automated miles-in-trail-based scheduling capability, a time-based scheduling capability, and the display of meter lists derived from these functions on en route ATC displays.

Development of the TMA functions for airport arrival flows are planned for and controlled by en route sectors in more than one Air Route Traffic Control Center (ARTCC). Scheduled activities include: (1) continued operation of existing prototype systems, (2) deployment of additional prototype systems that can be used in ATM operations, and (3) full-scale development and implementation of functionality for arrival traffic at up to 24 TRACON's/20 ARTCC's.

TMA is in the prototype development phase. Prototypes are deployed at the ARTCC's/TRACON's located at Dallas-Fort Worth, Denver, Atlanta, Los Angeles, and Miami.

pFAST. As part of the CTAS, FAST provides the runway assignment and sequence numbers that TRACON air traffic controllers need to maximize airport arrival capacity. Scheduled activities include: (1) functional system testing for pFAST prototype deployment at sites with complex airspace; (2) initiation of prototype deployment activities for sites with complex airspace; (3) operation of existing and new prototype systems; and (4) full-scale development and implementation of the functionality at up to 24 TRACON's. pFAST is in the prototype development phase, with a prototype deployed at the ARTCC/TRACON at Dallas-Fort Worth.

Conflict Detection and Resolution. Automatic Conflict Detection (ACD) will provide ATC specialists tools to automatically detect potential future aircraft/airspace conflicts by using a continuous conflict probe feature and a trial planning capability. ACD enables a controller to determine whether a requested or changed altitude, speed, or route is conflict-free. The system's functionality provides tools to the controller that assist in implementing Free Flight in the en route environment. ACD will also be integrated with CTAS descent advisor functionality to provide a tool that extends across the en route domain and into the descent phase of flight. CTAS and ACD are essential to increasing NAS capacity and efficiency and satisfying many RTCA recommendations for transition to Free Flight.

Operations Concept Development and Validation. The FAA will provide a detailed validated operational concept and an integrated system specification encompassing the roles of both the FAA and the users. Validated operational concepts are being developed in cooperation with the RTCA Select Committee for Free Flight implementation. Validation analysis will include both FAA and NASA simulation capabilities, with a great likelihood of user and DOD participation as part of the Free Flight joint implementation.

Aircraft Modification and Improvement Research. FAA programs to improve the initial and continuing airworthiness and survivability of aircraft have benefited from the interest and support of the DOD service branches. The Aging Aircraft program develops information and procedures for using technologies that can predict the onset of failures of aircraft structures under a range of operating conditions.

In addition to FAA and NASA sponsorship, this program receives significant U.S. Air Force funding. The Air Force and FAA are co-participants in funding the Fire Research and Safety program and its efforts to standardize and improve the test-

ing of fire-resistant materials for use in aircraft interiors. Similarly, the Aircraft Hardening program relies on significant U.S. Navy participation to develop protection for aircraft against catastrophic structural or critical system failures resulting from in-flight explosions or the effects of electronic interference.

DOD also is vitally interested in the development of flight standards underlying the Safety Performance Analysis System (SPAS), which provides FAA stakeholders with critical safety-related data on the design, maintenance, and operation of their aircraft.

Human Factors Research. Along with FAA and NASA, DOD is a primary participant in publishing the *National Plan for Civil Aviation Human Factors—An initiative for Research and Application*. This document outlines a coherent national agenda for human factors research and application leading to significant improvements in NAS safety and efficiency. Programs stemming from this and similar research plans have developed and provided useful information to FAA stakeholders on the effects of human performance on successful navigation, aircraft maintenance, and other matters of importance to commercial and military aviation.

1.6.4 Centers of Excellence

Air Transportation Centers of Excellence (COE) are established through cooperative agreements among academic institutions, their affiliate partners, and the FAA. COE's are established to assist the FAA in the pursuit of mission-critical research in technologies that are pertinent to developing and maintaining a safe and efficient national air transportation system. Centers may be funded in 3 phases over a period of 3 to 10 years. Thereafter, they are expected to be self-supporting.

Center of Excellence in Airworthiness Assurance. The FAA has established a new Center in Airworthiness Assurance with Ohio State University and Iowa State University as leads and seven additional core members. There are more than 100 academic, industry, and government affiliate partners.

The Center, established in September 1998, conducts research in the areas of:

- Maintenance, inspection, and repair
- Crash-worthiness
- Propulsion and fuel systems performance;
- safety
- Landing gear systems performance and safety
- Advanced materials.

Funded through contracts and grant awards, this center has a $100M contract cap over the next 10 years and is making a $500K per year commitment to fund basic and advanced research through a cooperative agreement.

Center of Excellence in Operations Research. The FAA-selected team of the University of California (Berkeley), Massachusetts Institute of Technology, Virginia Polytechnical Institute, and the University of Maryland (College Park) are the leads for the Center of Excellence in Operations Research. This team includes 10 university affiliates and 20 industrial partners. The COE program, using its new hybrid funding vehicle (i.e., a grant and sole-source contracting authority) awards contracts for rapid prototyping and engineering development.

Center of Excellence for Airport Pavement Research. The Center of Excellence for Airport Pavement Research was established with the University of Illinois (Urbana-Champaign) in April 1995 and is supported by Northwestern University. Pavement research focuses on new technologies to handle the estimated stress loads foreseen in the next generation of high-volume, commercial aircraft, such as the Boeing 777. This research, including rehabilitation and non-destructive testing and evaluation of existing pavement, is conducted at the former Chanute Air Force Base, Rantoul, Illinois.

Center for Computational Modeling of Aircraft Structures (CMAS). Congress established the Center for Modeling of Aircraft Structures (CMAS) as a joint effort between the Georgia Institute of Technology and Rutgers University. Since its beginning in 1992, CMAS has conducted research in micromechanics, structural and material fatigue, data management, and aging aircraft.

Aviation research has highlighted software and engineering methods that can be transferred to industry and used by the FAA to address aircraft structure issues relating to the certification and

regulation of the commercial airline fleet. Research is currently being funded by the agency on an as-needed basis.

1.6.5 European Activity

Global harmonization of communication, navigation, surveillance, and air traffic management (CNS/ATM) technologies and standards holds the key to the future success of all aviation systems. The United States (through the FAA) continues to position itself to be a leader in international efforts to maintain the safety, security, efficiency and effectiveness of civil aviation. Progress towards a globally harmonized CNS/ATM system has accelerated since the adoption of the Global Plan for CNS/ATM Implementation by the International Civil Aviation Organization's (ICAO) Tenth Air Navigation Conference.

The FAA has continued to support CNS/ATM implementation by participating in ICAO technical panels, committees, study groups, and regional planning groups as well as by entering into numerous bilateral cooperative research and development agreements with countries and civil aviation organizations in every region of the world. These ICAO forums and international agreements provide the FAA opportunities to work directly with key research, engineering, and development organizations and decisionmakers in order to make significant contributions toward international coordination of air traffic services.

The FAA also works closely with internationally recognized standards developing organizations such as RTCA and the European Organization for Civil Aviation Equipment (EUROCAE) to reach consensus with industry and the user community on standardizing and certifying evolving aviation technologies.

1.7 Government Performance and Results Act of 1993

R,E&D program development fully supports the concepts and recommendations set forth in the GPRA of 1993. This year, the FAA is emphasizing GPRA concepts (outcomes and outputs) in descriptions of the R,E&D program. Explaining the research program in GPRA terms ensures use of simple and measurable concepts. Figure 1-4 illustrates how FAA outputs (R,E&D products) are directed toward specific customers. The FAA R,E&D program, explained in detail in Section 2 of this report, is described in GPRA terminology. Each program area is described in terms of outputs that will be used to achieve the desired outcomes.

The primary challenge in the FAA R,E&D process is understanding how to package emerging technology into R&D outputs (products) that provide value to internal FAA users (Air Traffic Services, Aircraft Safety, etc.), as well as external customers (Air Transport Association, NASA, Air Line Pilots Association, etc.). The secondary challenge is to understand the impact and influence of emerging technologies on the present R,E&D program and to adapt the program to meet future needs.

Additional information can be found in Appendix B.

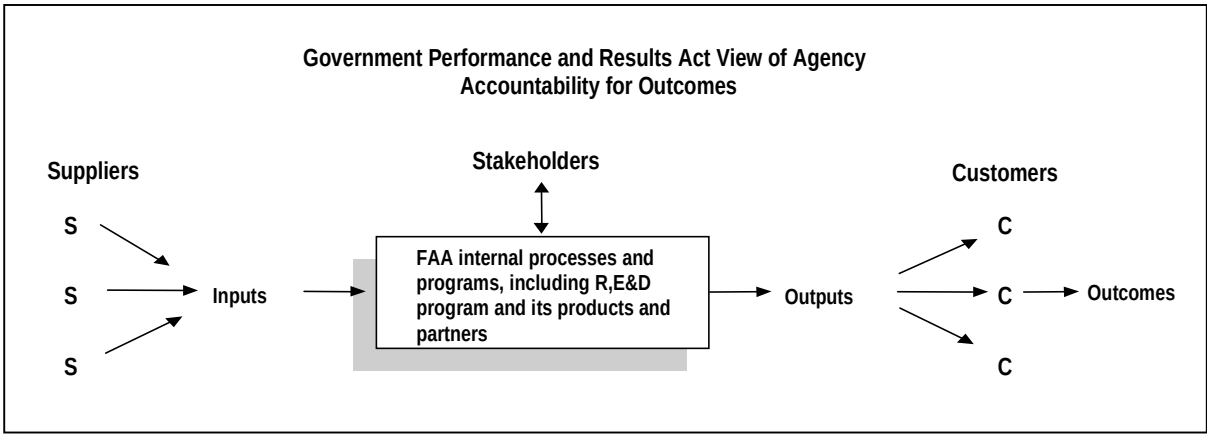


Figure 1-4.

1.8 Overview of the R,E&D Program

The FAA R,E&D program is divided functionally into seven areas: Air Traffic Services, Airport Technology, Aircraft Safety, Aviation Security, Human Factors and Aviation Medicine, Environment and Energy, and R,E&D Program Management.

- *Air Traffic Services R,E&D* focuses on increasing system safety and capacity and enhancing the flexibility and efficiency of air traffic management operations. A key element in achieving these objectives is developing decision support tools that will enable FAA air traffic specialists to manage traffic flows more efficiently while collaborating with the user community in making decisions affecting their operations.

  The R,E&D program is also working to reduce the risks of runway incursions, midair collisions, and aircraft encounters caused by the effects of wake vortices and hazardous weather. Research is developing new technologies that will improve navigational accuracy and provide improved landing guidance. Communication research develops technologies that improve the reliability of pilot-controller communications and permit the exchange of large data files, such as weather data, to pilots.

  The FAA also is working to introduce new technologies to support a Free Flight system, in which aircraft operators could vary their speed and flight path to increase operational efficiency while air traffic controllers ensure that safety is maintained.

- *Airport Technology R,E&D* develops and evaluates technologies designed to ensure and improve safe and efficient operations on the airport surface and in the immediate vicinity of an airport. Research focuses on developing and evaluation of advanced, innovative technologies involving pavement design, construction, and maintenance; airport visual and navigation aids; rescue and firefighting equipment and procedures; runway friction; and wildlife control techniques. Research results are used to update FAA standards for the design, construction, and operation of airports and airport equipment, and are incorporated into guidance material used by airport operators, consultants, and equipment manufacturers.

- *Aircraft Safety R,E&D* focuses on ensuring the safe operation of inservice aircraft. It addresses the hazards that face all aircraft in service, as well as the special hazards endemic to select portions of the civil aircraft fleet. Older aircraft are more susceptible to structural problems associated with fatigue and corrosion. New aircraft with digital flight control and avionics systems and associated imbedded software are more susceptible to disruption from external electromagnetic interference. Research focuses on developing technologies and standards for maintenance and modification of inservice aircraft to ensure continued airworthiness. It includes research in structural integrity of airframes and engines, maintenance and repair of composites, atmospheric hazards, crash-worthiness, fire safety, and forensics capabilities to support accident investigations.

- *Aviation Security R,E&D* develops technologies and standards that counter the threat of terrorism and criminal acts targeted at aviation. Research focuses on developing and evaluating passenger-, baggage-, mail-, and cargo-screening devices to detect concealed explosives and weapons; aircraft hardening techniques to increase aircraft survivability in the event of an inflight explosion; human factors aspect of detection and alarm resolution; and integration of airport security technologies and procedures.

  An important consideration in this research is to develop effective, reliable technologies and procedures that have minimal impact on airport and airline operations.

- *Human Factors and Aviation Medicine R,E&D* directly supports the National Plan for Civil Aviation Human Factors and the validated needs of the FAA's lines of business and NAS users. The program addresses major human factors priority areas related to the flight deck, ATC, flight deck/ATC system integration, airway facilities, aircraft mainte-

nance, and aeromedical aircraft cabin environments.

- *Environment and Energy R,E&D* develops technical information, standards, and procedures to mitigate the environmental impact of aircraft operations (in particular, noise and air pollution emissions), and to better understand and manage the impact of FAA operations on the environment.
- *R,E&D Program Management* includes the management, planning, control, and support activities associated with formulating the FAA R,E&D program. These efforts ensure that the program is a cohesive and integrated effort, consistent with the FAA strategic goals and objectives, and fully coordinated with stakeholders and customers.

  It also ensures outside assessment of the FAA R,E&D investments through active participation of the FAA R,E&D Advisory Committee. The members of the committee represent industry, academia, and other government agencies. R,E&D Program Management also facilitates research partnerships with industry, universities, and other government agencies that enable the FAA to leverage its research dollars.

1.9 Long-Term Research

The Research, Engineering, and Development Management Reform Act of 1996 directed the FAA to identify the allocation of resources among long-term research, near-term research, and development activities.

Long-term research, as defined in the Aviation Safety Research Act of 1988, is a research project that is "unlikely to result in a final rule-making action within five years, or in the initial installation of operational equipment within 10 years after the date of the commencement of such project."

The FAA's R,E&D is principally associated with applied research. That is leveraging off new technologies identified by research programs in space, aeronautics, communications, computer science, and other related fields of exploration. Developmental activities beyond this stage are found in the Engineering, Development, Test, and Evaluation activity of the FAA's Facilities and Equipment (F&E) appropriation.

Of the $150M appropriated for R,E&D efforts in FY 1999, 30% of these funds are earmarked for long-term research, with the remainder devoted to developmental/near-term efforts. Similarly, the $173M FY 2000 Congressional budget submission for R,E&D designates 35% of the total request for long-term research.

2.0 PROGRAM INFORMATION

2.1 Air Traffic Services Program Area Description

Mission

The overall mission of Air Traffic Services (ATS) is to ensure the safe and efficient operation, maintenance, and use of the air transportation system today and to meet tomorrow's challenges to increase system safety, capacity, and productivity. ATS continually seeks to improve its services by undertaking initiatives to meet current and future demands. The ATS R,E&D program is an overt initiative to ensure a structured and evolutionary improvement of services that keeps pace with the global growth in aviation. The mission of the R,E&D program is to develop technology, practices, and procedures to ensure continued improvement in delivery of air traffic services.

Intended Outcomes

The ATS R,E&D program is one part of an integrated strategy to increase the value of the air traffic services. The ATS R,E&D program is a vehicle for making long-term investments in improving services, procedures, and infrastructure, and integrating new concepts and technology to meet the increasing demands of safety, capacity, efficiency, and productivity. Human factors considerations are central to all program outcomes for a totally effective solution. The ATS R,E&D program contributes to the ATS performance outcomes contained in the *Air Traffic Services Performance Plan* and the strategic goals of the Government Performance and Results Acts (GPRA). The program is also consistent with the goals delineated in the *FAA Strategic Plan*, the *Research and Acquisitions Performance Plan*, and the *Regulation and Certification Performance Plan.*

The ATS R,E&D program contributes to the seven ATS performance outcomes described below and represents increased value to system users and the American public.

Increase System Safety. Safety is the FAA's foremost priority, and the ATS R,E&D program plays a critical role in the development of procedures and technologies for safety improvement.

Aircraft separation based on a well-defined set of standards is the keystone of ATS' safety-related service. The ATS R,E&D program invests in projects to determine safe separation distances under varying conditions and ways to more accurately determine and predict aircraft positions and to reduce weather-related accidents and passenger injuries. The effects of weather phenomena on the aircraft, including clear-air turbulence, cause a large percentage of aviation accidents and passenger injuries. Additionally, an investment in airborne collision avoidance systems is included to provide a safety net beyond traditional separation methods.

Overall technological improvements in information displays, automation tools, decision support systems, communications, navigation, and surveillance will support better determination of aircraft position and resolution of potential conflicts both in the air and on the airport surface.

Decrease System Delays. A traditional measure of the efficiency of the Air Traffic Management (ATM) system is delay. Delays can be caused by various factors; however, weather is recognized as a chief cause. The ATS R,E&D program is addressing the effects of weather-caused delays by investigating better weather-detection and forecasting tools. The program also addresses throughput of airways and airport infrastructure, as well as the accuracy of information exchanged by ATM systems.

Increase System Flexibility. National Airspace System (NAS) users expect more from the ATM system than reduction of delay. Users want to optimize their operations through increased flexibility during the flight planning process. Flight management and enhanced flight planning systems using new technologies have enabled users to dramatically improve the efficiency of air transportation by allowing them to operate at the altitudes, speeds, and routes that they desire. As ATS services evolve toward Free Flight, the ATS R,E&D program supports development of technologies and procedures in support of Free Flight and initiatives such as Flight 2000.

Increase System Predictability. Predictability represents the variation in the ATM system experienced by the user. Improving predictability is

one of the most effective ways to add value to the ATM system. Weather is a significant contributor to the uncertainty in the ATM system. Sixty-five percent of the flight delays and 30 percent of aircraft accidents and incidents can be attributed to weather.

The ATS R,E&D program seeks improvements in acquiring and disseminating weather products. High-resolution weather forecasts in both space and time are feasible; but to be of use, it requires rapid, effective graphical display of the associated information to the users. Manual analysis and identification of specific aviation weather impacts, such as icing and turbulence, cannot provide the information quickly enough or with sufficient clarity to significantly reduce related delays. Research in this area is intended to improve system responsiveness by increasing user accessibility to weather observations, warnings, and forecasts. Any reduction in the impact of weather on operations results in a fundamental increase in the predictability of the system.

Increase User Access. Access to the NAS and ATS services is the basic need of all airspace users. The fundamental point through which most users gain access to the NAS is airports. Navigation and Landing are core services allowing access to airspace and airports under varying conditions. The ATS R,E&D program includes initiatives to provide access to airspace, airports, and landing services available to a wide variety of users under varying conditions. Thousands of airports and runways become inaccessible when weather conditions prohibit visual navigation. The widespread availability of the Global Positioning System (GPS) signal-in-space, along with published GPS instrument approach procedures, will enhance access to these capital assets.

Research will ensure that the GPS-derived Wide Area Augmentation System (WAAS) and Local Area Augmentation System (LAAS) services will have high availability. The expanded use of satellite-based navigation systems will result in precision approaches being available at more airports, which will increase all-weather access to an increasing number of airports.

Additionally, research into the integration of flight-deck state, intent, and weather data with ground systems can reduce excess spacing buffers between arriving aircraft.

Increase Availability of Critical Systems. ATS has traditionally used an overall equipment availability rate as an indicator to represent basic trends of NAS equipment. While this indicator consistently runs over 99 percent and offers some insight into the quality of operational services, ATS is taking a more detailed look at overall service availability. Increasing service availability results from taking a multifaceted approach that requires improvements in the aging NAS infrastructure and better methods of system operation and maintenance. A modernized ATC system is critical to the aviation community, and a significant growth in aviation cannot be safely accommodated without significant breakthroughs in modernization. The ATS R,E&D program is responsive to these goals in that the key elements of NAS modernization are addressed in several areas by research into technology improvements, such as the effective use of modern displays, automation tools, and decision support tools.

Increase Productivity. Given the increasing level of services demanded and the decreasing number of scarce resources at the disposal of ATS, it is more important than ever to make more effective use of available resources and to undertake cost savings and containment initiatives. R,E&D investments allow for better use of personnel through initiatives that provide ATC personnel with support tools to enhance their level of control and decrease their workload. Productivity improvements are expected through automation, improved decision support systems, and procedural and process improvements. Current cost savings and productivity initiatives include investments in human factors, modeling and simulation, and software engineering activities.

Program Area Outputs

The outputs of the ATS R,E&D program vary, from development of operational prototype equipment to development of operational concepts, modeling and simulation studies, emergent technology evaluations, to development of procedures, standards and guidance. Examples of expected program outputs are:

- Timely delivery of high-resolution information for icing, winds, temperature, and turbulence to improve aviation advisories and forecasts used by the National Weather Service
- Human factors guidelines for shared information displays in air-to-ground communications
- Selection criteria and training methods for operators and maintainers that reflect changes in the operational environment and automation
- Support to industry development of advanced avionics for small airplane and rotorcraft single pilot instrument flight rules (IFR) to meet FAA requirements
- Improved processes and practices in software development for the aviation industry and the FAA
- Guidelines for an effective, accelerated system/software to production process
- Refinement of airborne collision avoidance technologies and procedures.

Program Area Structure

The ATS R,E&D program has been structured to systematically support these intended outcomes:

- Increase system safety
- Decrease system delays
- Increase system flexibility
- Increase system predictability
- Increase user access
- Increase availability of critical systems
- Increase productivity.

The ATS R,E&D program addresses these outcomes with the objective of making efficient and effective use of R,E&D resources by adding value that benefits NAS users, operators, and the American public.

Customer and Stakeholder Involvement

The ATS R,E&D program reaches a broad spectrum of the aviation community and supports several aviation community interests, including Challenge 2000, the *Aviation Safety Plan*, the *RTCA Free Flight Action Plan*, the NAS System Architecture Development, and the *ATS Concept of Operations for the National Airspace System in 2005*. Specific examples of customer and stakeholder involvement include:

- The R,E&D Advisory Committee (REDAC) provides guidance on the FAA's ATS investments. The REDAC Subcommittee for ATS reviews the ATS program and provides recommendations on ATS R,E&D investments. This program has seriously considered the Subcommittee's recommendations and has adopted much of its advice.
- The National Plan for Aviation Human Factors represents a cooperative effort between the FAA, National Aeronautics and Space Administration (NASA), and Department of Defense (DOD) to establish a coherent national agenda for human factors research and development to improve NAS safety and efficiency.
- The National Aviation Weather Users' Forum provides a process to develop a Federal/industry consensus on the needs and priorities for aviation weather information. Forum participants are from:
  - The Airline Pilots Association (ALPA)
  - Airline Dispatchers Federation (ADF)
  - Air Transport Association of America (ATA)
  - Aircraft Owners and Pilots Association (AOPA)
  - Experimental Aircraft Association (EAA)
  - Helicopter Association International (HAI)
  - National Air Transportation Association (NATA)
  - National Association of State Aviation Officials (NASAO)
  - National Business Aircraft Association (NBAA)
  - Regional Airline Association (RAA)
  - American Airlines
  - Delta Airlines
  - Industry.

The forum serves as a basis to set research and development priorities.

Accomplishments

Following is a partial listing of recent past accomplishments of the ATS R,E&D program:

- Developed numerous tools and information exchange mechanisms (e.g., the Center TRACON Automation System (CTAS), User Request Evaluation Tool (URET), and Surface Movement Advisor (SMA) research projects) by the Traffic Flow Management Research and Development program. These resources, embodied in collaborative decision making (CDM) packages #1 and #2, facilitate the dissemination of information to industry and establish CDM processes
- Developed and implemented GPS nonprecision IFR Helicopter approaches at the Mayo Clinic, Wisconsin Medical Center, Erlanger Medical Center, and western Pennsylvania, which has been attributed to saving over 500 lives in medical emergencies
- Conducted a comprehensive human factors study of controller-pilot communications
- Achieved Aviation Gridded Forecast System (AGFS) initial operating capability at the Aviation Weather Center (AWC) to improve advisories and forecast capability
- Evaluated convective weather storm growth and decay algorithm at Memphis testbed
- Completed a significant upgrade to the Traffic Alert and Collision Avoidance System (TCAS) program (TCAS II). The upgrade, known as Version 7, will make TCAS II fully compliant with international standards and will improve system safety by 5 percent while reducing the nuisance alert rates by 30 percent
- Implemented traffic information service (TIS), providing Mode S data link cockpit displays of aircraft traffic based on terminal ground radar surveillance
- Completed a joint FAA/NASA Runway Incursion/Low Visibility Surface Operations demonstration at Atlanta Hartsfield International Airport
- Evaluated two commercially available low-cost airport surface detection sensors for runway incursion reduction
- Developed ionosphere algorithms that meet WAAS availability requirements
- Implemented first phase of Reduced Vertical Separation Minima (RVSM) in the North Atlantic between FL330 through FL370
- Completed initial SMA operational assessment

R&D Partnerships

The ATS R,E&D program has established and continues to maintain and pursue the establishment of partnerships with U.S. Government agencies, international organizations, academic institutions, the airline industry, industry and industry user groups, and non-profit organizations. Following is a list of some of the current partnerships.

- U.S. Government Agencies:
  - Department of Commerce
  - DOD
  - NASA
  - National Science Foundation
  - National Weather Service (NWS)
- International Organizations:
  - British Civil Aviation Authority
  - European Organization for Safety of Air Navigation (EUROCONTROL)
  - French DGAC
  - International Civil Aviation Organization (ICAO)
- Academic Institutions:
  - Embry Riddle Aeronautical University
  - Massachusetts Institute of Technology
  - Ohio State University
  - Pennsylvania State University
  - San Jose State University
  - University of Maryland
  - University of Oklahoma
  - University of Quebec at Montreal
- Nonprofit Organizations:
  - Advanced General Aviation Transport Experiment (AGATE) Consortium
  - RTCA

- Airline Industry:
  - America West
  - American
  - Continental
  - Delta
  - Northwest
  - Southwest
  - Trans States
  - TWA
  - US Airways
  - United
- Industry and Industry User Groups:
  - ALPA
  - AOPA
  - ATA
  - NBAA
  - SAMA.

Long-Range View

The essence of the ATS R,E&D program is to maintain a long-term view of the research requirements for continued safe and efficient operation, maintenance, and use of the air transportation system today and in increasing system safety, capacity, and productivity.

The ATS R,E&D program is a continuing effort that will have continuing funding expectations at or beyond the current level. Although the composition of the R,E&D program portfolio will change over time as some efforts come to fruition and transition to a relevant F&E or O&M environment, continued investment in ATS R,E&D will ensure that the FAA stays current with the ever-increasing demands on the air traffic system. Further, continued investment in the ATS R,E&D will ensure that the FAA has an effective risk-identification/mitigation strategy for the high-risk areas of the future NAS architecture.

A02a Traffic Flow Management — [*Program moved to 1999 Aviation System Capital Investment Plan (CIP) as A05 Air Traffic Management Program*]

GOALS:

Intended Outcomes: The FAA intends to improve flexibility and reduce delays while maintaining or improving the level of safety through new traffic flow management (TFM) capabilities. The following capabilities will enable NAS users to optimize operational schedules and reduce operating costs associated with system constraints:

- FAA/industry data exchange capabilities enabling implementation of collaborative TFM operational concepts.
- Collaborative decisionmaking (CDM) methods and procedures that give NAS users greater flexibility and control over operational decisions and improved flexibility for NAS users operating in the ground delay program.
- NAS flow analysis tools offering traffic managers expanded decisionmaking support, performance assessment, and compliance monitoring capabilities.

Each of the above contributes to cost reductions for NAS users, as follows:

- Reduced routine flying times, departure delays, and better responses to system disruptions; reduced scheduled block times; and saved airlines $360 million a year in operating costs (crew and equipment) for the scheduled domestic jet fleet (reference: RTCA Task Force 3 final report, page 92).
- Increased information flow and more CDM; reduced delays during national ground delay programs; and saved airlines $221 million a year in crew costs (reference RTCA Task Force 3 final report, page 94, sum of “most likely” entries”). Savings realized from reduced missed connections/cancellations and improved on-time performance, etc., further increases the savings.

Agency Outputs:

FAA/industry data exchange

- Users and service provider requirements are identified and operational concepts are demonstrated to incorporate emerging technologies. These actions have resulted in improved, more timely electronic distribution and display of user and service provider operational data and better support for FAA/industry collaborative traffic flow planning and decisionmaking.

CDM

- Based on the new information exchange, TFM explores and identifies effective methods and procedures for FAA/industry CDM. This results in automation applications, algorithms, and procedures to reach operational traffic flow planning decisions. These decisions respond to both user and service provider objectives.

NAS flow analysis tools

- TFM researches analytical tools and approaches used in analyzing historical flow patterns and NAS performance data. This provides real-time operational analyses to users and service providers. It also results in near real-time analyses for use in distributed environments for joint user and service provider traffic flow planning.

Customer/Stakeholder Involvement: The TFM R&D program directly supports the following community initiatives:

- Air Traffic Service Plan (ATSP). The plan was created with a 5-year, forward-looking window and with participation from all entities of the aviation community. The need for better operational communications with users is a prominent theme throughout the ATSP.
- Free Flight Action Plan. This Plan includes the following initiatives directly related to the research planned in this area:
  - Recommendation 6. Develop mechanisms to provide predeparture feedback to flight planners on potential impacts of flight plan request changes and on system constraints causing those changes.
  - Recommendation 7. Implement rationing-by-schedule during ground delay programs.

  - – Recommendation 8. Establish more flexible ground delay program procedures and decision support systems.
  - – Recommendation 9. Coordinate military, FAA, and NAS users to define the information and capabilities needed to improve civil use of special use airspace (SUA) during periods when SUA is not used by DOD.
  - – Recommendation 10. Conduct operational trials in one or more SUA's to demonstrate how improved SUA status information exchange can improve civil use during periods when SUA is not used by DOD.
  - – Recommendation 11. Develop and implement real-time SUA notification between DOD and FAA and between FAA and flight planners.
  - – Recommendation 14. Improve telecommunication devices to enhance information flow between users and the TFM system on a machine-to-machine basis.
  - – Recommendation 15. Incorporate airline schedule information (e.g., company delays and cancellations) into FAA decision support systems and decision processes.
  - – Recommendation 16. Enhance or replace the ATM monitor alert function, including, but not limited to, ways to measure controller workload and function complexity.
  - – Recommendation 24. Develop a methodology and tools to measure and predict dynamic density.
  - – Recommendation 25. Develop and implement TFM capability for information exchange among users and the FAA. This enables users to be involved in the FAA's TFM decisionmaking process.
- NAS architecture development. The NAS architecture development effort has produced a target operational concept for the NAS. This concept supports the collaborative partnership philosophy between NAS users and service providers. In principle, the concept states that the responsibility for safe and efficient NAS management should be a collaborative effort between air traffic managers and flight operators.

Accomplishments: The TFM R&D effort accomplished the following during FY 1998:

FAA/industry data exchange

- Aircraft Situational Display for Industry (ASDI) became operational in June 1998
- Completed prototype development and evaluation of initial data exchange for GDP enhancements (CDM Package #1)
- Completed concept development and evaluation of Daily Download and Simplified Substitutions (CDM Package #2)
- Completed the prototype development and evaluation of FSM, ration-by-schedule, and schedule compression capabilities (CDM Package #1) and made investment decision
- Completed concept development and evaluation of Control Time of Arrival capabilities (CDM Package #2)

NAS flow analysis tools

- Completed Prototype Development and evaluation of System Impact Analysis; Schedules (CDM Package #1)

R&D Partnerships:

Airline industry

- The following airlines are actively engaged in the TFM R&D program. They are full partners in determining new CDM functionality, priorities, design, testing, and evaluation:
  - – America WestMidwest Express
  - – American
  - – Southwest
  - – Continental
  - – TWA
  - – Delta
  - – United
  - – Federal Express
  - – USAirways
  - – Northwest
  - – 35 Affiliated Subcarriers

Center of excellence (COE) for Aviation Transportation

- The COE—composed of the University of Maryland; Massachusetts Institute of Tech-

nology; the University of California, Berkeley; and their industry partners—are key players in CDM technologies development and evaluation. In addition, the COE provides an opportunity to explore the potential application of game theory, decisionmaking under uncertainty, and artificial intelligence.

Academia

The TFM R&D group has a long-standing relationship with aviation transportation, operations research, and human factors academic personnel from the following universities:

- University of California, Berkeley
- Massachusetts Institute of Technology
- University of Maryland
- Ohio State University.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

FAA/industry data exchange

- Complete prototype development and evaluation of the data exchange for the initial NAS status information (runway visual range (RVR) data) (CDM Package #2)
- Complete concept exploration for dynamic SUA information capabilities

Collaborative decisionmaking.

- Complete prototype development and evaluation of Control by Time of Arrival capabilities (CDM Package #2)
- Complete prototype development of Post Operations Evaluation Tool (POET)
- Complete concept development and evaluation for Collaborative Routing Coordination Tool (CRCT)
- Complete concept exploration phase of the Dynamic Density analysis function

NAS flow analysis tools

- Complete concept development for System Impact Assessment (Miles in Trail and Routing)
- Complete concept exploration for the performance assessment and Compliance Monitoring capabilities

KEY FY 2000 PRODUCTS AND MILESTONES:

FAA/industry data exchange

- Complete concept development phase for dynamic SUA information capabilities

Collaborative decisionmaking

- Conduct prototype development and evaluation for CRCT
- Complete concept development phase of the Dynamic Density analysis function

NAS flow analysis tools

- Conduct prototype development for System Impact Assessment (Miles in Trail and Routing)
- Complete concept development for Program Analysis/Selection Tool (PAST)
- Complete concept development for the performance assessment and Compliance Monitoring capabilities

FY 2000 PROGRAM REQUEST:

In FY 2000, the TFM R&D program will be in the final stages of providing the initial technical, functional, and procedural enhancements to the operational Traffic Flow Management system that form the basis of an FAA/industry collaborative decisionmaking environment. Concurrently, work will be maturing that will introduce significant additional data exchange, decision support, and near-real-time analysis capabilities that will make the collaborative capabilities envisioned in the Free Flight concept a reality.

A02a - Traffic Flow Management Product and Activities	Program Schedule FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY2004
021-110 Advanced Traffic Management System						
Completed Prototype Development (PD) Phase						
FAA/Industry Data Exchange						
Aircraft Situation Displayed to Industry	◆					
Data Exchanged for GDP Enhancements	◆					
Daily Download		◇				
Simplify Substitutions		◇				
Initial NAS Status Information (NASSI) data exchange (RVR data)		◇				
Enhance NASSI Data			◇			
Advance NASSI Data Exchange			◇			
Collaborative Decision Making (CDM)						
Flight Schedule Monitor (FSM)	◆					
Ration by Schedule (RBS)	◆					
Schedule Compression	◆					
Control By Time of Arrival	◆					
Collaborative Routing Coordination Tool (CRCT)			◇			
Interactive Flight Planning				◇		
Dynamic Density Monitor					◇	
NAS Flow Analysis Tools						
System Impact Assessment (Scheduling)	◆					
System Impact Assessment (Miles in Trail/Routing)		◇				
Program Analysis/Selection Tool (PAST)		◇				
Performance Assessment			◇			
Compliance Monitoring				◇		

Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	962	1,355	2,986	2,332	2,880
Personnel Costs	2,107	2,195	0	916	2,435
Other Costs	431	450	0	39	143
Total	**3,500**	**4,000**	**2,986**	**3,287**	**5,458**

A02b Runway Incursion Reduction — [*Program moved to 1999 Aviation System Capital Investment Plan (CIP) as S09 Runway Incursion Reduction Program (RIRP)*]

Runway Incursion Reduction

GOALS:

Intended Outcomes: Develop technological and nontechnological solutions that minimize the chance of injury, death and damage, or loss of property due to runway accidents/incidents within the civil aviation system. Reduce runway incursions by 15 percent from 1997 baseline.

Agency Outputs:

- Develop low-cost airport surface detection equipment.
- Develop secondary surveillance capabilities for the airport surface.
- Develop conflict-alerting and data fusion platform.
- Investigate alternative options such as visual aids (lights and signs), education, training, and advisory circulars.

Customer/Stakeholder Involvement: The Air Traffic Requirements office has been actively involved in developing requirements to meet objectives of reducing runway incursions. Additionally, the FAA Administrator's goal in her "Safer Skies—A Focused Agenda" is to reduce runway incursions by 15 percent in 1999, from the 1997 baseline of 318 incidents. Reducing runway incursions is second on the National Transportation Safety Board's (NTSB) "Most Wanted List" of safety improvements.

Accomplishments: The following R&D projects were accomplished in FY 1998:

- Completed final report of Raytheon x-band radar at Milwaukee (Phase II)
- Completed final report of self-organizing time division multiple access (STDMA) at Atlanta
- Completed final report of EL-AR Electronics, Ltd., frequency modulated continuous wave (FMCW)
- Awarded contract to AOPA Air Safety Foundation for general aviation (GA) pilots training and education video
- Completed acoustics evaluation/de-installation at Phoenix
- Completed joint FAA/NASA Runway Incursion/Low Visibility Surface Operations Demonstration at Atlanta
- Received Runway Incursion Reduction Program Mission Need Approval
- Completed evaluation of two industry commercial-off-the-shelf (COTS) low-cost airport surface detection sensors
- Received NAS change proposal approval for Dallas-Ft. Worth
- Completed final report of NASA Terminal Area Productivity (TAP) Demonstration at Atlanta
- Completed installation of Vehicle automatic dependent surveillance broadcast (ADS-B) system at Dallas-Ft. Worth

R&D Partnerships:

- Memorandum of Agreement (MOA) with NASA for Low-Visibility Landing and Surface Operations (LVLASO) demonstration in Dallas-Ft. Worth
- Research contracts on airport surface operations in reduced visibility
- Raytheon (x-band radar)
- Dassault (phased-array radar)
- Sensis (Vehicle ADS-B)
- Questech (safety algorithms)
- General Working Agreement with Volpe National Transportation Systems Center (VNTSC)
- Contract with AOPA Air Safety Foundation
- Technology transfer

Currently, runway incursion reduction technologies—including low-cost radar, secondary surveillance systems, conflict alerting systems, and other alternatives with various contractors—are being researched. After system evaluation is completed, specifications will be developed for soliciting competitive bids for production of successfully demonstrated systems. Periodic briefings to industry during the R,E&D phase will also be

conducted to inform industry of FAA's requirements for runway incursion reduction solutions.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

Dallas-Ft. Worth

- ASDE-3, Vehicle ADS-B, Surveillance Fusion Platform (SFP) Integration
- Multilateration/ADS-B system (stand alone)

Low-cost surface detection equipment

- Complete test and evaluation and prepare final report for Dassault ASDE-X
- Complete test and evaluation and prepare final report for Raytheon ASDE-X
- Continue testing technology prototypes including low-cost radar, conflict alerting systems, and other potential runway incursion reduction alternatives

Air Traffic

- Runway Incursion Action Teams
- Program Implementation Plan (PIP)
- Airport modeling/data reduction/facility testing
- Human factors studies
- Tower Simulators

KEY FY 2000 PRODUCTS AND MILESTONES:

- Full System RIRP prototype demonstration at Dallas-Ft. Worth
- FAA/NASA RIRP/LVLASO demonstration at Dallas-Ft. Worth
- Air traffic activities including regional training, modeling/data reduction/facility testing, human factors initiatives, and industry conferences

FY 2000 PROGRAM REQUEST:

- In FY 2000, funding will provide for the Dallas-Ft. Worth Prototype Demonstration, incorporating real-time seamless surface surveillance with data fusion, conflict alerting, call sign identification, and information sharing with air traffic controllers, pilots, and vehicle operators.
- FAA/NASA Runway Incursion/Low-Visibility Surface Operations Demonstration at Dallas-Ft. Worth
- Implementation of activities consistent with the 1998 Airport Surface Operations Safety Action Plan, including Runway Incursion Action Team (RIAT) meetings
- Development of specification for low-cost surface detection equipment

Surface Automation Research and Development

GOALS:

Intended Outcomes: The FAA intends to improve the level of safety, increase airport capacity, and reduce costs and delays for aircraft operating on the airport surface by developing new automation, communications, and information distribution capabilities. These capabilities augment operational decisionmaking processes and improve situational awareness of surface operations under all visibility and weather conditions.

SMA will provide air traffic controllers, airline ramp managers, and airfield operators with unprecedented advisory and information sharing to help minimize congestion and reduce delays on the airport surface. Recipients of this information-sharing will be able to make informed decisions in managing airport surface resources. Specific SMA goals include:

- Facilitate an electronic exchange of flight critical information among airlines, air traffic control personnel, and airport operators
- Provide dynamic real-time data to help increase efficiency of ground movement operations
- Predict surface events that impact operational decisionmaking
- Help achieve at least 10 percent decrease in taxi-out delays

This coordination will improve safety by minimizing the risk of collisions and increasing the efficiency of aircraft movements on airport runways and taxiways. It will help meet system capacity needs by reducing constraints/limitations at the top level V delay/operationally impacted airports while improving the automated infrastructure to provide capacity-enhancing technologies and procedures. It will also create capabilities that ensure

safe separation while imposing minimum constraints on system users.

Low/zero-visibility tower environment R,E&D will develop augmentations to the air traffic tower environment that can provide an operationally useful, enhanced or synthetic view of the airport surface during periods of low- or zero-visibility. This will lead to improved safety and increased use of airport surface capacity under low or zero visibility conditions, and ensure that the airport surface capacity is adequate to manage the increased aircraft landing rates expected in the future.

Agency Outputs: The surface automation research and development program will produce new tower surface management functions and technologies, which will be validated in pre-production prototype systems in an operational tower/airfield environment. Included will be assessments of airport operational effectiveness, performance, and benefits to assist in the investment decisionmaking process. These activities will result in functional packages and specifications that can be transferred for implementation on the appropriate tower automation platform. This program will also result in new air traffic control, airline, and airport operating procedures for managing aircraft on the airport surface.

The low/zero visibility tower environment R,E&D program initiatives will develop prototype systems that provide synthetic views of the airport surface under all restricted visibility conditions. This will lead to the definition of operational requirements, procedures, emerging technologies, and system requirements for continuous operations under all visual conditions.

Customer/Stakeholder Involvement:

- The R,E&D program commits the FAA to increasing airfield safety and reducing runway incursions.
- The surface automation R&D involves the airlines and airport operators through an unprecedented sharing of dynamic, operationally critical information.
- The R,E&D program has involved the customers and stakeholders from concept exploration through development of a prototype system at Atlanta Hartsfield International Airport. air traffic controllers, airport authority, and aircraft operators have contributed to defining the functional performance of surface automation tools and have participated on the program design and management teams.

Accomplishments:

- Completed SMA concept evaluation and development
- Installed SMA prototype at Atlanta Hartsfield International Airport (2/96)
- Brought airport/ramp towers on-line (7/96)
- Completed Support Command/National Air Traffic Controllers Association (SUPCOM/NATCA) testing and initial evaluation (9/96)
- Began operational assessment (10/96)
- Completed operational assessment (05/97)
- Completed SMA benefit analysis (10/97).

R&D Partnerships: The R,E&D program is being conducted in close partnership with the NASA through the interagency ATM integrated product team (IPT), a joint research and technology development program managed cooperatively by the FAA and NASA. The NASA Ames Research Center is a key participant in the program's R,E&D activities.

Benefits to air traffic operators include an increase in terminal area situational awareness and reduced radio frequency congestion.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

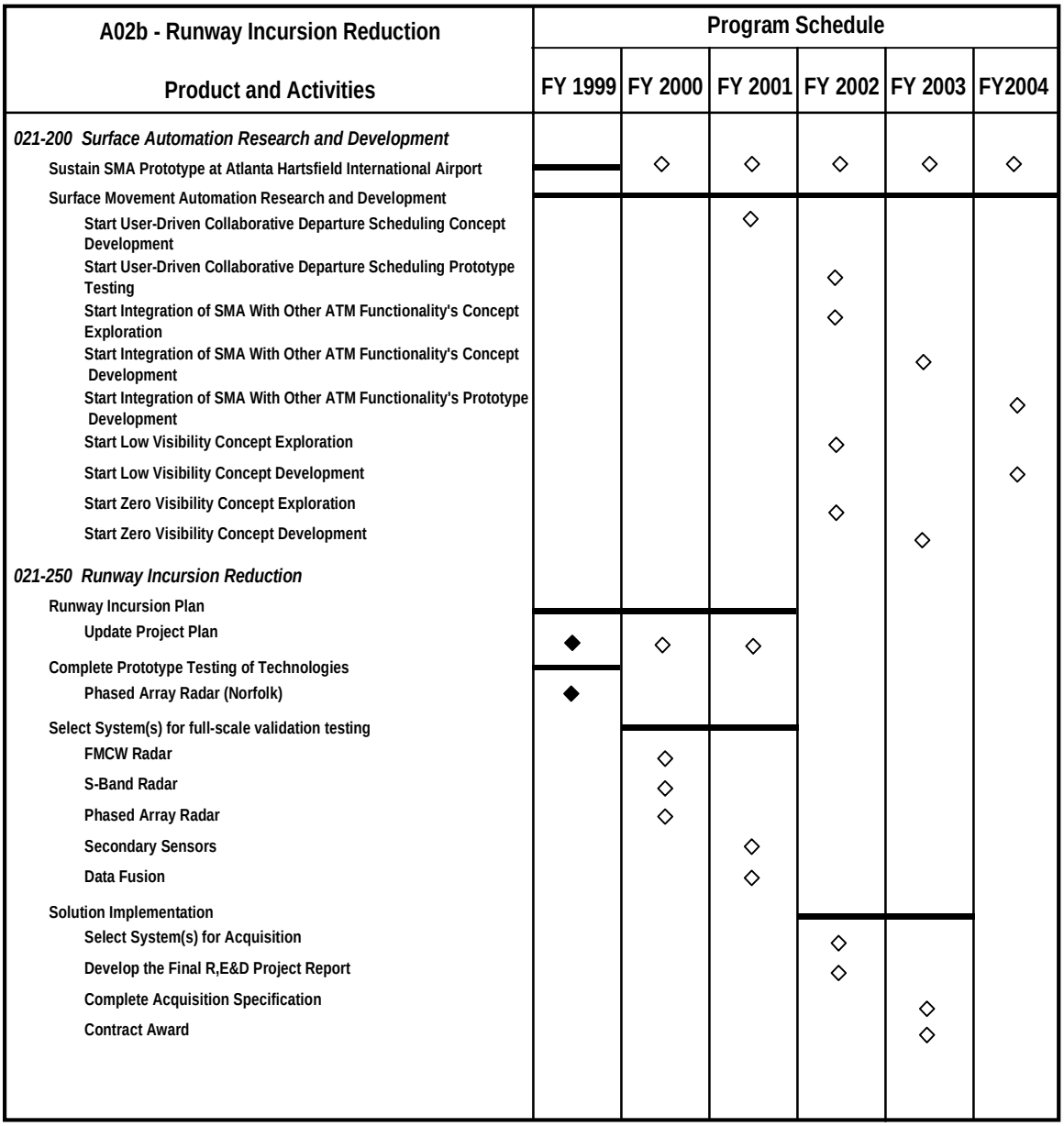
- Sustained operational SMA prototype at Atlanta Hartsfield International Airport

KEY FY 2000 PRODUCTS AND MILESTONES:

- Sustain SMA prototype at Atlanta Hartsfield International Airport

FY 2000 PROGRAM REQUEST:

- Sustain SMA prototype at Atlanta Hartsfield International Airport



Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	2,457	4,950	5,696	2,269	2,978
Personnel Costs	1,281	872	252	870	1,044
Other Costs	262	178	52	29	60
Total	**4,000**	**6,000**	**6,000**	**3,168**	**4.082**

A02c System Capacity, Planning and Improvements — [*Program moved to 1999 Aviation System Capital Investment Plan (CIP) as M08 Continued General Support – Aviation System Capacity Planning*]

GOALS:

Intended Outcomes: The FAA intends to develop an overall strategy to enhance capacity. This includes both terminal and en route airport and airspace assessment of procedures and capacity-related technologies. It also includes developing a performance measurement system for the air traffic system to measure FAA progress against customer expectations. This strategy allows programs and projects, coordinating across budgetary lines, to improve investment decisionmaking to achieve optimal strategic and operational results.

Initiatives are implemented in aviation system capacity planning to increase the number of aircraft operations per hour, reduce both en route and terminal airspace delays, reduce controller workload, and increase savings. As a result, the FAA, and the overall aviation community, will experience lower maintenance/operating costs. This program: (1) complies with the Congressional mandate to produce airport improvement plans; (2) responds to the aviation industry's high-priority initiatives for increased capacity; (3) responds to the Presidential Commission on Improved Airline Competitiveness recommendations; and (4) complies with the GPRA of 1993 and Executive order on infrastructure investment requirements.

Agency Outputs: To comply with GPRA, ATS has developed four areas of capacity-related outcomes: flexibility, predictability, access, and delay. These outcomes provide guidance and a framework to enable any ATS R,E&D program to successfully increase the value of services and, in parallel, reduce the cost of these services to the public. The capacity program strictly adheres to the guidelines of the following four areas:

Flexibility

The FAA estimates that each year operators experience a minimum of $558 million in inefficiencies in the terminal and en route airspace. The capacity program provides models and simulations that assess present shortfalls within the subject airspace. These models and simulations determine the delay, travel time, sector loading, and operating cost effects of all suggested redesign alternatives. Results include:

- The redesign of Salt Lake and Dallas-Ft. Worth terminal airspace
- New arrival routes to Los Angeles and Las Vegas International Airports
- Airspace suggestion changes to Minneapolis/St. Paul, based on construction of a new runway, at the request of the Minnesota State Legislature
- Annual savings to the aviation industry at airports and en route facilities estimated between $450–$500 million annually

Predictability

Because it can impose capacity restrictions at major airports, weather is the most dominant influence on air transportation. Although many airports are equipped with multiple runways (many converging), their resources become extremely restricted due to associated weather minima. The capacity program establishes criteria to develop and improve simultaneous converging instrument approaches and has achieved the following results:

- Reductions in the approach minima, ensuring an average capacity gain of 30 arrivals per hour
- Fundamental increases in the predictability of the system
- Use (anticipated) of GPS
- Combined savings (estimated) to the air carriers $40 million annually

Access

In the capacity program, the outcomes of predictability (the ability to land at a particular airport) and having access to that airport, are often considered the same thing. Work required to accomplish these outcomes, however, is different. Predictability establishes approaches to increase capacity under certain weather conditions. Access models simulate new technologies and procedures to ensure that these technologies are compatible for the airport in question. Examples include:

- Precision Runway Monitor—for closely spaced parallel runways with center lines separated by 3,000 feet (reduced from 4,300 feet)
- Reduced separation of 2.5 nmi on final approach (reduced from 3.0 nmi)
- Dependent staggered approaches to closely spaced parallel runways; stagger angle 1.5 nmi
- Offset Approach Course guidance for simultaneous operations at San Francisco, Newark, and St. Louis airports
- Converging approach standards at Chicago O'Hare International Airport

Delay

The major capacity program emphasis is to minimize the impact of airport and airspace delay on the overall NAS. One primary program focus is responding to near-term, airport-driven capacity issues. It is projected that by 2004, 29 of the top 50 airports will experience 20,000 hours or more of annual delay. This is cause for concern within the aviation industry. Delay reduction initiatives undertaken to date include:

- The capacity program has completed more than 50 airport enhancement projects.
- The program supports development of an overall capacity strategy that considers airport and technology conduct, measurement, and assessment; and electronic tools development and application to aid in forming that strategy.
- Airfield improvements such as new runways and runway extensions, improved approach procedures, and new facilities and equipment such as the precision runway monitor are being investigated.
- The improvements producing the greatest capacity increases, estimated delay reductions, and delay cost savings, are described and recommended for implementation in the final design plans.
- The top recommendations at any one airport are estimated to save the aviation industry $75–$100 million annually.
- Since 1994, based on recommendations, 18 new runways have been constructed at major airports.
- Efforts are underway to accommodate New Large Aircraft into the operational environment.

The FAA's airport and airspace design programs have the dual objectives of (1) addressing tactical improvements, which respond to industry requirement shifts, and (2) large-scale investment analysis and optimization planning. The process problem is identification at the local (regional) level with a high degree of coordination among affected facilities and user groups. Various proposed solutions to the problems are simulated, and the results are then compared to make intelligent investment decisions.

Example

On the Dallas-Ft. Worth Metroplex project, which involved substantial AIP, F&E, and operational investment, the effects on the system of several airspace structures, including a "do nothing" scenario, were compared. Given the industry's plan to expand operations at Dallas-Ft. Worth, the FAA concluded it was best to expand the airport. This meant designing new airspace supported by upgraded navigation and communications capabilities along with entirely new arrival and departure procedures. This approach enabled the community to construct a new runway and ground infrastructure. It also enabled the industry to schedule growth and capital investment.

This plan instilled confidence that there would be a return on investment since the revised system could support anticipated demand. The industry and local community, therefore, could commit this expanded service to the public. The cumulative 20-year (1997–2016) estimated aircraft operating cost savings based on the Dallas-Ft. Worth Metroplex, East Runway, and New West Runway in 2003 is $13 Billion.

Customer/Stakeholder Involvement: Although the FAA directs the entire capacity program, customers and stakeholders play active roles in its success. Airport authorities from all concerned airports, air carrier representatives, aviation interest groups, and FAA regional and local air traffic control personnel are an integral part of every airspace and airport capacity task force/project. Joint American/European airspace study through EUROCONTROL–Maastricht Center.

The capacity program annually publishes the Aviation Capacity Enhancement Plan to keep the aviation world informed of progress and advancements in the capacity arena. Both the national and international aviation community regularly request this document. Scholars, as well as students, in academia also request the document for their aviation studies.

As previously stated in "Goals," the overall capacity program parallels the Congressional mandates concerning airport improvement plans and agency performance and results.

Accomplishments: Airport and airspace recommendations and redesign studies have produced a conservatively estimated $1.2 billion in savings to the aviation industry. An accurate estimate is difficult because the improvements, either combined or treated individually, are a direct cause of the constant increase in traffic.

- Prototyped and tested the initial system performance measures
- Completed more than 50 major airport studies--some of which have been updated due to growth (Estimated annual savings $75–$100 million per airport)
- Completed three major terminal/en route airspace redesigns: (1) Salt Lake Terminal and air route traffic control center (ARTCC), (2) Dallas-Ft. Worth and Ft. Worth ARTCC, and (3) Northern California terminal radar approach control (TRACON)

The program's achievements reach beyond U.S. airspace. Inquiries about our modeling and design methods and requests for assistance have been received from countries in Asia and Europe (i.e., Schipol International Airport, Netherlands, and the new International airport in Seoul, South Korea).

R&D Partnerships:

- In accordance with the annex of the memorandum of understanding between the FAA and Eurocontrol, the capacity program has established a joint airspace technologies and initiatives group to modernize international aviation. The intended outcome is to meet compatibility requirements between the United States and the rest of the aviation world in such areas as Free Flight, the Global Positioning System, flight management system, precision runway monitor, and other emerging technologies.
- The FAA will partner with major air carriers and business aviation aircraft in developing financial management systems approaches.
- The FAA will partner with NASA in using performance measures developed by the capacity program for ATS in compliance with the Congressional mandate for GPRA. The FAA will participate in joint computer simulation modeling for TRACON systems including the CTAS and the Standard Terminal Automation Replacement System (STARS).
- NASA Short Haul Civil Tiltrotor simulation of proposed Simultaneous Non-Interfering (SNI) Approach procedure.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

- Continuously conducted research to develop, refine, and/or enhance high-level outcome performance metrics; integrated these metrics into processes supporting GPRA requirements and investment decisionmaking
- Completed redesign of Salt Lake City terminal and ARTCC airspace in preparation for the 2002 Winter Olympics
- Initiated Offset Approach Course guidance for simultaneous operations at San Francisco, Newark, and St. Louis airports
- Develop new IFR approach and departure concepts and procedures for improving the safety and efficiency of operations at capacity constrained airports
- Identify the impact and develop proposed solutions to the planned introduction of New Large Aircraft in the NAS
- Initiated converging approach standards at Chicago O'Hare International Airport
- Initiated Airport Design Studies at John F. Kennedy and La Guardia airports
- Initiated ground analysis at Phoenix Sky Harbor International Airport; completed at Las Vegas and Salt Lake airports
- Initiated redesign of Phoenix Sky Harbor terminal airspace and Albuquerque and Seattle ARTCC's

- Initiated efforts to accommodate New Large Aircraft into the operational environment
- Completed Newark, La Guardia, Boston, Tampa, and San Diego Airport Design Studies
- Initiated Airspace review for relocation of the Honolulu Center Radar Approach Control (CERAP)
- Initiated Airport Design Study at Baltimore-Washington International Airport

KEY FY 2000 PRODUCTS AND MILESTONES:

- Continue developing new IFR approach and departure concepts and procedures
- Identify and develop proposed solutions to integrate New Large Aircraft into the NAS
- Complete airport design studies at JFK and Anchorage and ground analysis at Phoenix Sky Harbor International Airport
- Redesign Honolulu and Phoenix terminal airspace and Albuquerque and Seattle ARTCC's
- Continue analysis of new and/or additional performance measures for the national airspace system

FY 2000 PROGRAM REQUEST:

In FY 2000, the program will focus on capacity enhancement at all major airports as well as on terminal and en route airspace. Primary focus areas are: (1) airports where construction of suggested improvements can be completed within 2 to 3 years; and (2) air traffic radar facilities where airspace redesign reduces controller workload and provides the aviation industry with additional flexibility and predictability during flight.

In addition, the program will continue to fine tune air traffic system performance measures. These efforts will concentrate on reducing the cost of service delivery by targeting and coordinating investments across appropriations.

A02c - System Capacity, Planning and Improvements Product and Activities	Program Schedule					
	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY2004
024-110 Aviation System Capacity Planning						
Enhance/Design Plans & Consolidated Ops & Analysis Systems						
Aviation Capacity Enhancement Plans (Annual)	◆	◇	◇	◇	◇	◇
Regional/Airport Design Team Plans	◆	◇	◇			
Performance Measurement/Government Performance Results Act	◆	◇	◇	◇	◇	◇
Airspace/Airport Analysis						
Completed Airspace Redesign Las Vegas, Salt Lake Terminal & ARTCC	◆					
Redesign or Analysis of Phoenix, Seattle ARTCC & Albuquerque ARTCC	◆	◇	◇			
Integrated Measures into the Budget Process and GPRA			◇			
Performance Reports for Investment Decisions			◇	◇	◇	◇
Facilities Airspace in Preparation for 2002 Winter Olympics	◆					
Completion of Newark, Las Vegas, Boston, and San Diego Airport Design Studies	◆					
Analysis of New and/or Additional Performance for the National Airspace System			◇	◇	◇	◇
Ground Analysis of Phoenix Sky Harbor International Airport	◆	◇				
Anchorage Design Team Project	◆	◇				
Analysis of Low Level Routes Between Northern and Southern California				◇	◇	
Ground Analysis For Pittsburgh and Kansas City Airport				◇	◇	
San Francisco Ground Task Force				◇	◇	◇
Development of Simultaneous Offset Instrument Approach for San Francisco, St. Louis, and Newark Airports	◆	◇	◇	◇		
Converging Approach Standards at Chicago O'Hare Airport	◆	◇	◇			
Accommodate New Large Aircraft into the Operational Environment	◆	◇	◇	◇	◇	◇
023-120 Separation Standards						
Reduced Horizontal Separation Minimization						
Complete Annual Regional Traffic and Aircraft Performance Monitoring & Analysis	◆	◇	◇	◇	◇	◇

Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	3,602	3,676	1,354	228	6,064
Personnel Costs	4,480	4,377	2,196	2,408	2,891
Other Costs	918	897	450	364	268
Total	**9,000**	**8,950**	**4,000**	**3,000**	**9,223**

A02d Cockpit Technology— [*Program moved to 1999 Aviation System Capital Investment Plan (CIP) as M37 Cockpit Technology*]

GOALS:

Intended Outcomes: The FAA intends to improve system safety by upgrading a viable airborne collision avoidance capability to mitigate the risk of mid-air collisions.

The Traffic Alert and Collision Avoidance System (TCAS) is an avionics capability to warn pilots of proximate aircraft and to provide information and guidance for collision avoidance. TCAS I provides traffic advisory information indicating the range, bearing, and altitude of intruding aircraft. Pilots use this information to visually acquire intruders and maintain separation. TCAS II provides traffic advisory information as well as resolution advisories in the vertical plane. Resolution advisories indicate maneuvers (e.g., "climb") for collision avoidance.

Agency Outputs: The FAA provides the technical characteristics (technical standard orders) for TCAS avionics and certification guidance (advisory circulars) for installation and operation of the system. The R,E&D program develops the technical and operational information to support these products and is working with the TCAS user community to collect and analyze data to maintain and enhance TCAS.

Currently, the principal focus of the TCAS program is completion of the design and implementation of Change 7 to TCAS II. This change incorporates more than 300 detailed modifications to the surveillance and collision avoidance algorithms and displays in TCAS II avionics equipment. These changes have been developed based on 8 years of TCAS II operation in the United States and Europe and have been developed in partnership with industry and users. TCAS II Change 7 has also been selected by ICAO as the worldwide standard for airborne collision avoidance. Timely implementation of Change 7 is essential for the continued safe and effective employment of TCAS II.

The second annual report of TCAS activity will be provided to all interested organizations to review ongoing progress and update future activity. The FAA will develop and implement plans for future applications of TCAS (e.g., Free Flight) in close collaboration with industry and governments.

Customer/Stakeholder Involvement: The FAA has developed TCAS in collaboration with the domestic and international aviation communities. In particular, the R,E&D effort supports RTCA Special Committee (SC) 147 and the ICAO Secondary Improvements and Collision Avoidance System (SICAS) Panel in their efforts to finalize domestic and international standards for airborne collision avoidance systems. RTCA SC 147 provides the principal forum for collaboration among industry, aircraft operators (i.e., TCAS users), and FAA representatives in developing technical standards for avionics. It also provides the principal means for transferring TCAS technology to industry.

The FAA TCAS program responds to the requirements of Public Laws 100-223 and 101-236, which establish requirements and time frames for air carrier equipage with TCAS II. TCAS I also responds to CFR 135.180.

The TCAS program will directly support the RTCA Free Flight Action Plan, Future Air Navigation System (FANS) implementation, reduced aircraft spacing standards, oceanic operation, and in-trail climb.

ICAO has been closely monitoring and assisting in TCAS development for many years. Based on TCAS success in the United States, EUROCONTROL has mandated the use of TCAS in European airspace in the year 2000. Australia has a similar mandate in place for 2000. Several Pacific Rim countries (e.g., Japan, India) will also mandate use of TCAS. The FAA is supporting these activities.

Accomplishments: TCAS II has been installed on all commercial aircraft operating in U.S. airspace with more than 30 passenger seats. TCAS I or TCAS II is installed on all commercial aircraft with 10 to 30 passenger seats. The U.S. military has begun installation of TCAS II on all large transport category aircraft (e.g., C-130, C-147, KC-135, KC-10, etc.) The FAA is working with the services to ensure that their unique military requirements for TCAS are met. More than 15,000

aircraft around the world have TCAS systems on board; about 180 million hours of system operations have been accumulated. TCAS has been credited with averting near midair collisions in a significant number of documented encounters.

R&D Partnerships: The FAA is coordinating TCAS program activities with related international efforts through ICAO and EUROCONTROL. A principal consequence is that technical standards finalized by RTCA SC 147 have been incorporated into ICAO standards and recommended practices that will be used worldwide. ICAO member states, primarily the United Kingdom and Germany, have worked and are working with the FAA on a number of critical developments to ensure that TCAS operates properly in their airspace.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

TCAS I

- Completed TCAS I transition program
- Continued data collection and analysis to support TCAS I implementation

TCAS II

- Began implementing Change 7 within the user community
- Initiated data collection and analysis to support Change 7 implementation
- Continued support to industry to resolve TCAS II implementation and user issues
- Issued first annual report on TCAS II Change 7 performance

KEY FY 2000 PRODUCTS AND MILESTONES:

TCAS I

- Continue support for TCAS I implementation and use by industry

TCAS II

- Continue support to industry and the international community to resolve TCAS II implementation and user issues; identify specific functional TCAS parameters and algorithms that require modification to permit safe and effective implementation of new ATC operational procedures, such as Free Flight
- Prepare second summary report on the operation and effectiveness of TCAS II Change 7

FY 2000 PROGRAM REQUEST:

In FY 1999, the user community began major implementation of Change 7; this effort will continue in FY 2000. While FAA does not fund this implementation activity, FAA resources are required to resolve issues associated with Change 7 installations.

Data analysis efforts supporting TCAS I and TCAS II will continue. These efforts use information provided by industry, users, pilots, air traffic controllers, and FAA facilities describing technical and operational difficulties experienced during system implementation. A team of TCAS program experts follows up on every event reported to identify both the source of the difficulty and a remedy to prevent its occurrence. This analysis and follow-up activity has been essential to the successful introduction of TCAS into operational service.

Working jointly with industry and the TCAS user community, the FAA will initiate an effort will to define the specific changes to TCAS, which will be necessitated because of future changes in ATC operations. This project element will be coordinated with ongoing Free Flight efforts and related work at NASA.

A02d - Cockpit Technology Product and Activities	Program Schedule					
	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY2004
022-110 Traffic Alert & Collision *Avoidance System (TCAS)*						
TCAS I						
Completed TCAS I Transition Program	◆					
Continued Data Collection and Analysis to Support the Implementation of TCAS I	◆					
Continued Support for Implementation and Use of TCAS I by Industry	◆					
TCAS II						
Began Implementation of Change 7 Within the User Community	◆					
Initiated Data Collection and Analysis to Support Change 7 Implementation	◆					
Continued Support to Industry to Resolve TCAS II Implementation and Use Issues	◆					
Completed Summary Reports on TCAS II Change 7	◆					
Continued Support for Implementation and Use of TCAS II by Industry		◇	◇			
Identify specific TCAS Changes needed to support new ATC procedures		◇				

Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	4,256	1,032	1,765	0	1,219
Personnel Costs	1,804	1,633	1,913	1,000	1,498
Other Costs	370	335	392	0	139
Total	**6,700**	**3,000**	**4,070**	**1,000**	**2,856**

A02e General Aviation and Vertical Flight Technology Program — [*Program moved to 1999 Aviation System Capital Investment Plan (CIP) as M35 General Aviation and Vertical Flight Technology*]

GOALS:

Intended Outcomes: The General Aviation and Vertical Flight (GA&VF) technology program supports GA demands through applied research and development, especially for communications, navigation, and surveillance (CNS) technologies. These technologies support cost-effective air traffic services, improve safety, and expand NAS capacity and efficiency, especially where CNS services are not currently available to GA users. GA&VF program products are integral to NAS modernization.

General aviation is one of the most diverse and productive elements of aviation. In addition to the traditional single- and multi-engine airplanes, GA users fly experimental aircraft, helicopters, and tiltrotors (known as "vertical flight aircraft"), business jets, and historic aircraft. The GA community includes lifesaving airborne emergency medical services (EMS) and law enforcement services, and is the first line of response in state and local disaster relief operations. The economic impacts of GA are global, but no other nation in the world produces more GA&VF aircraft and related goods and services than the United States. GA is a gross exporter of goods and services and provides the U.S. economy a positive balance of payments impact.

General aviation users currently rely on existing procedures and air traffic services, but many cannot take full advantage of them because of technological and economic limitations. Helicopters, for example, must operate heliport-to-heliport to support customers and the public more efficiently. For example, they need different instrument approaches that curve and support deceleration to land and depart from small landing areas.

The FAA GA&VF R,E&D program supports research and development across the full spectrum of GA operations. The program's research areas align with the most critical components for GA participation in the NAS-terminal operations: en route communications and navigation, landing facilities, airmen and controller training, and low-cost avionics.

Vertical flight terminal instrument procedures (TERPS) efforts support the terminal flight arena. Low-altitude CNS research provides critical data and evaluations for future low-altitude en route infrastructure to support Free Flight. TERPS capabilities facilitate implementation and use of advanced technology in the cockpit and at the controllers' workstation for GA needs. These efforts are interrelated and support mutual requirements without duplication or added costs.

Intended Outcomes: The GA&VF R,E&D program focuses on the outputs and products of the larger research efforts, as identified in the NAS Architecture planning process and major R&D programs such as GPS Satellite Navigation. The GA&VF R,E&D efforts are not duplicated in these and other FAA R,E&D programs. The GA program area is a collaborative and complementary effort, tailoring the successes and achievements of other, broader-scope efforts into affordable products and tangible benefits for GA. Outcomes of this program support the following strategic goals of the GPRA:

- *Improved level of safety:* ATS R,E&D mitigates the risk of low-altitude airborne collisions by adapting affordable GPS-based surveillance technology at GA airports, heliports, popular resorts and national parks, and in congested terminal areas. This is done by providing traffic information directly to the GA pilot via cockpit displays of traffic information (CDTI).
- *Improved flexibility:* The ATS R,E&D program goals ensure a collaborative and fully integrated air traffic control system. Free Flight technologies and procedures are ideally suited to allow GA users to operate at altitudes, speeds, and routes that provide more support to their missions and recreational uses. The GA&VF R,E&D program identifies, develops, and evaluates technology to satisfy user needs and support the overall goals to maintain a fully integrated air traffic control system focusing on GA use of Free Flight procedures.

- *Improved predictability:* With more access to weather services via data link and short-term weather information to GA users, ATS R,E&D allows more aircraft to operate safely in close proximity during periods of reduced visibility and adverse weather conditions.

- *Reduced delays:* This program researches and develops technology and procedures that enhance the utility of GA facilities. It complements the goals of the air traffic management program and traffic throughput automation systems. Affordable and effective non-radar navigation and communication systems (installed at the more than 17,000 GA airports) will attract more GA users to these facilities and away from the busier hub airports. Also, providing increased IFR capabilities at these airports will reduce GA users' demands at major hub airports during periods of bad weather and poor visibility.

- *Improved access:* This program is a key element in the ATS R,E&D strategic goal to make access to navigation and landing services nearly universal. GPS makes accurate navigation and landing signals available in the large volume of low-altitude airspace not currently covered by land-based landing signals. Investing in the development of GPS instrument approaches planned for use at major medical trauma centers and hospitals nationwide will save hundreds of lives each year.

- *Reduced costs:* This major ATS GA&VF R,E&D program goal contributes to overall goals of eventually phasing out the expensive ground-based infrastructure. The application of low altitude CNS equipment contributes to this cost savings.

Agency Outputs: Although the private sector designs and develops specific technologies to accomplish these outcomes, the ATS R,E&D GA program helps generate design criteria, publish advisory circulars and training documents, and provide for collaborative technology integration with the current and future NAS. This program area also provides technical and management expertise to establish highly successful partnerships.

Rotorcraft IFR procedures and infrastructure development

This research emphasizes the following efforts:

- The Vertical Flight Precision GPS TERPS project is the primary effort producing new precision instrument approaches at heliports and GA airports using GPS. This effort is the key R&D component supporting the overall GPS Satellite Navigation effort leading to full operating capability (FOC) for rotorcraft as part of WAAS. Because existing IFR instrument approach criteria are based on airplane performance characteristics, these existing IFR approaches do not support most of the missions demanded by IFR helicopters.

  This project develops criteria and design parameters that provide more effective and affordable instrument approaches to hospitals and corporate and urban business district heliports. Outputs include vertical flight TERPS criteria; certification procedures for potential supplemental-type certificates (which permit existing aircraft to add new technologies safely); IFR EMS procedures; and IFR EMS training guidelines and design standards such as minimum operational performance standards, minimum aviation system performance standards and technical standard orders. These standards, advisory circulars, and guidelines support planned implementation over the 5-year (1998–2002) schedule for up to 10 medical trauma centers, 150 commercial heliports, 5 DOD aviation facilities, and 3 vertiports (slightly larger heliports designed to accommodate the new civil tiltrotor aircraft).

  This program area supports joint DOD and manufacturers' research. The research evaluates cockpit displays design standards and symbology, air traffic procedures, and airspace requirements for new vertical flight aircraft (i.e., the BB-609 civilian tiltrotor, as well as the military V-22 Osprey tiltrotor).

- The low-altitude CNS infrastructure projects produce route system guidelines, cockpit display guidelines, noise abatement procedures, terminal and en route system integration plans for low-altitude CNS operations, and

cost-benefit analyses to improve NAS efficiency and safety.

Customer/Stakeholder Involvement: The GA program directly supports goals and programs delineated in Challenge 2000, the Aviation Safety Plan, the RTCA Free Flight Action Plan, and NAS architecture development. The program emphasizes GA&VF community's direct needs (helicopters and tiltrotors).

In setting a "zero accidents" goal, Challenge 2000 found that between 1986 and 1994, GA operations accounted for the greatest number of accidents in the NAS (44,102 of 48,164 accidents recorded by the NTSB were attributed to GA). Because flight crew problems accounted for 19,388 GA accidents, the GA program targets flight crew training as a key research element. Other important causal factors were environment (7,146) and facilities (4,867).

The Aviation Safety Plan calls for "implementation of a GPS-based ADS capability . . . that the FAA deems appropriate." The plan sets goals for training airmen and operational personnel in using new technology and for upgrading practical testing standards. The plan identifies goals for GPS-based category CAT I, II, and III landing capability. Work is underway to research rotorcraft GPSCAT I procedures. Specific stakeholders include:

- Helicopter Association International
- American Helicopter Society
- National Business Aircraft Association
- Experimental Aircraft Association
- General Aviation Manufacturers Association
- Small Aircraft Manufacturers Association
- National Association of State Aviation Officials
- Association of Aeronautical Medical Services
- National Emergency Medical Services Pilots Association
- Airborne Law Enforcement Association

Advanced General Aviation Transport Experiment

Accomplishments: Following are FY 1997 and FY 1998 accomplishments:

Air and ground infrastructure development

- Completed initial flight testing for CAT I GPS precision approach TERPS criteria
- Completed initial planning for the Alaska low altitude demonstration project
- Completed obstacle rich environment report (September 1998)
- Developed and published the advisory circular, *Integrating Rotorcraft Assets into Disaster Relief Planning*
- Coordinated development of the advisory circular *Vertiport Design Guide*

Civil tiltrotor technology analyses

- Initiated action to introduce tiltrotor technology into the NAS planning process

Aircraft avionics for single-pilot IFR

- Coordinated and implemented agreement with EAA to jointly explore advanced technology avionics for single-pilot GA aircraft
- Conducted installation and flight test of advanced technology for avionics by GA aircraft in experimental GlaStar aircraft

R&D Partnerships: Historically, the GA&VF R,E&D program has had a unique R&D partnership with industry. A partnership of 12 private sector companies and corporations, working together with GA&VF program teams, developed the initial GPS nonprecision approaches for rotorcraft. The successes of Operation Heli-STAR, an applied technology proof of concept demonstration conducted as part of the 1996 Summer Olympic Games, were due to the effective teamwork of over 230 individuals from over 30 public and private organizations.

This partnership has now evolved to an even higher and more efficient level of integration. Working with the various lines of businesses within FAA (AFS, ATS, ASC, ASY), the GA&VF program is now guided by top level policy and technical direction from the Administrator and Associates. Further, the GA&VF program is the product of very close planning and implementation by the two major CNS research and acquisition product teams, the Satellite Navigation Product Team (AND-730) and the GA&VF Product Team (AND-710), to maximize accomplishments and preclude duplication. Also, the William

J. Hughes Technical Center and the Rotorcraft Certification Directorate are now an integral part of the overall team.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

- Publish CAT I GPS precision approach TERPS criteria for WAAS
- Continue GlaStar Advanced Avionics flight test and demonstration evaluations for single-pilot IFR operations
- Develop Civil Tiltrotor Infrastructure Development Plan
- Develop EMS IFR infrastructure development plan that will support GPS IFR operations at hospitals and trauma centers as part of 5-year program

KEY FY 2000 PRODUCTS AND MILESTONES:

- Establish joint FAA/DOD low-altitude routes system testbed at Quantico, Va
- Develop and publish design and training guidelines for installation and use of advanced avionics for single-pilot IFR based on GlaStar demonstration flight-testing
- Publish initial civil tiltrotor infrastructure planning requirements (terminal operations) for integrating CTR aircraft into urban and congested terminal areas

FY 2000 PROGRAM REQUEST:

- Continue FAA research to safely and effectively introduce tiltrotor technology into the NAS
- Continue research leading to establishing CAT II/III GPS precision approach TERPS criteria for vertical flight aircraft operations
- Continue research supporting use of advanced avionics (including GPS navigation and surveillance systems) for single-pilot IFR operations

A02e - General Aviation and Vertical Flight Technology Product and Activities	Program Schedule					
	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY2004
022-141 Low-Cost Avionics						
Single pilot IFR Advanced avionics for GA&VF						
Developed flight test plans for small airplane and helicopter advanced avionics applications	◆					
Conduct low altitude IFR corridor flight evaluations of WAAS based GPS navigation and non radar surveillance technology		◇				
Conduct EMS IFR flight evaluations using WAAS GPS		◇				
022-142 Rotorcraft Instrument Flight Rules (IFR) Procedures						
Air and Ground Infrastructure Development						
Completed Flight Testing for Category (CAT) I GPS TERPS Criteria	◆					
Completed Obstacle-Rich Environment (ORE) Report	◆					
Develop CAT II Rotorcraft TERPS Criteria		◇				
Complete CAT II & Continue CAT III GPS TERPS Research			◇			
Civil Tiltrotor Technology Analyses						
Develop Civil Tiltrotor Infrastructure Development Plan			◇			
Initiate FAA Research to Safely and Effectively Introduce Tiltrotor Technology into the NAS				◇		

Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	2,085	1,486	0	1,462	681
Personnel Costs	427	925	0	1,240	1,716
Other Costs	88	189	0	200	123
Total	**2,600**	**2,600**	**0**	**2,902**	**2,520**

A02f Safe Flight 21 — [*Program moved to 1999 Aviation System Capital Investment Plan (CIP) as M36 Alaska Capstone Initiative/Safe Flight 21 (FICS 21)] and S10 ADS-B Ohio Valley Prototype Project - Safe Flight 21*]

GOALS:

Intended Outcomes: Safe Flight 21 is a government/industry initiative designed to demonstrate and validate, in a real-world environment, the capabilities of advanced communications, navigation, surveillance, and air traffic procedures associated with Free Flight. The program will be a step in implementing any capabilities that prove to be beneficial. Specifically, Safe Flight 21:

- Enhances safety
- Increases system capacity and efficiency
- Maximizes user equipage costs and FAA operational costs
- Addresses pilot and controller human factors issues
- Develops and assesses new operational procedures and associated training
- Streamlines certification processes and procedures.
- Develops a cost-effective avionics and NAS infrastructure
- Defines a realistic NAS transition path supported by the user community

Agency Outputs: Safe Flight 21 is essential to the risk mitigation and evolution of the NAS. The program will address the risks and challenges of fielding the advanced communications, surveillance, and navigation systems, such as ADS-B, CDTI, Flight Information Services (FIS), and TIS.

Under the leadership of RTCA, user participants have committed to spending resources to accomplish the Safe Flight 21 objective:

> "To show that integrated CNS technological capabilities can provide functional enhancements that will produce operational benefits and sufficient cost/benefit to justify implementation. FAA policies and decisions should be based upon the ongoing results of this program."

This objective will be achieved through the following:

1. Evaluating the three ADS-B links (1090MHz, UAT, and VDL Mode 4)
2. Conducting operational evaluations of the nine operational enhancements identified by RTCA:
   - – FIS for SUA status, weather, windshear, notices to airmen (NOTAM), and pilot reports (PIREP)
   - – Cost-effective controlled flight into terrain (CFIT) avoidance through graphical position display
   - – Improved terminal operations in low-visibility conditions
   - – Enhanced see-and-avoid
   - – Enhanced operations for en route air-to-air communications
   - – Improved surface navigation
   - – Enhanced airport surface surveillance for controllers
   - – ADS-B for surveillance in non-radar airspace
   - – Establishing ADS-B-based separation standards

Customer/Stakeholder Involvement: Safe Flight 21 is the new name for the restructured Flight 2000 program that had many of the same projected outcomes. The change, made in August 1998, resulted from inputs from the RTCA Select Committee on Free Flight Implementation at the request of the FAA Administrator. The Safe Flight 21 program is a jointly developed program and is strongly endorsed by the RTCA Free Flight Steering Committee. The Safe Flight 21 steering committee includes RTCA Select Committee representatives from AOPA, ALPA, National Air Traffic Control Association (ATCA), Cargo Airline Association (CAA), and U.S. Airways.

Accomplishments:

- Established the Safe Flight 21 program office
- Obtained FY 1999 funding to support the CAA work and the Alaska Capstone program

- Began work to provide details for risk mitigation activities, site locations, number of aircraft required, cost, and schedule

R&D Partnerships: The Safe Flight 21 program is based on the principle that government and industry will share in the development of a global air transportation system as we move into the Free Flight era.

The FAA will partner the aviation industry in supporting Safe Flight 21. This will allow the FAA to build on ongoing industry initiatives. It will also allow industry and the FAA to fund avionics and ground systems. Safe Flight 21 will build on the Alaska and CAA activities by addressing:

- ADS-B technology issues
- Cockpit human factors issues
- Use of FIS to receive weather and other information
- An integrated cockpit display of terrain, traffic, and weather information

Work with the CAA will be addressed by a Cooperative Research and Development Agreement (CRDA).

Organizations representing controllers and commercial and general aviation pilots are included in Safe Flight 21 planning and in evaluation of the operational enhancements and data link alternatives.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

During FY 1999, the FAA will accomplish the following tasks to implement the Safe Flight 21 program in the Ohio Valley, which will support the CAA ADS-B evaluation work and the Alaska Capstone program:

- Procure and install ADS-B ground stations
- Procure and install FIS and AWOS in Alaska
- Procure and install avionics in FAA and Alaska aircraft (CAA provides avionics in CAA aircraft)
- Initiate operational evaluation of the first five of nine operational enhancements
- Initiate procedures development
- Evaluate the three ADS-B links

KEY FY 2000 PRODUCTS AND MILESTONES:

Avionics and ground systems

- Complete the above procurement activities, as needed

Engineering and operational evaluation

- Complete the Safe Flight 21 program plan
- Continue operational evaluation for the nine operational enhancements
- Continue procedure development and certification tasks

FY 2000 PROGRAM REQUEST:

FY 2000 funding completes procurement of avionics and ground systems necessary for the operational evaluations. Funding also provides for the operational evaluation, procedures development, and certification tasks.

A02f - Safe Flight 21 (Capstone Initiative/Ohio Valley Product and Activities	Program Schedule					
	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY2004
025-150 Safe Flight 21 (Capstone Initiative/Ohio Valley)						
Operational Enhancements						
Provide Weather and Other Information to the Cockpit	◆	◇	◇			
Provide Affordable Means to Reduce Controlled Flight into Terrain	◆	◇	◇			
Improved Capability for Approaches in Low Visibility Conditions	◆	◇	◇			
Enhanced Capability to See and Avoid Adjacent Traffic	◆	◇	◇			
Enhanced Capability to Delegate Aircraft Separation Authority to the Pilot	◆	◇	◇			
Improved Capability for Pilots to Navigate Airport Taxiways	◆	◇	◇			
Enhanced Capability for Controllers to Manage Aircraft and Vehicular Traffic on Airport Surface	◆	◇	◇			
Provide Surveillance Coverage in Non-radar Airspace	◆	◇	◇			
Provide Improved Separation Standards	◆	◇	◇			
Data Link Evaluation						
Program Management and Support				◇		
Flight Information Services Available (including Graphical Weather)				◇		
ADS-B Surveillance and Separation Services Available				◇		
Micro-EARTS/ADS-B Modification Complete				◇		

Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	0	0	0	0	16,000
Personnel Costs	0	0	0	0	0
Other Costs	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**16,000**

A02g Operations Concept Validation — [*Program moved to 1999 Aviation System Capital Investment Plan (CIP) as M08 Continued General Support – Operations Concept Validation)*]

GOALS:

Intended Outcomes: Integrated guidance will be provided to the aviation community for the development and transition to a modernized NAS, including system specification, roles and responsibilities, and procedures, training, and certification requirements.

The RTCA Free Flight Steering Committee, the FAA's RE&D Advisory Committee, the White House Commission on Aviation Safety and Security, and numerous other members of the aviation community have called for development and validation of a Concept of Operations for Modernization. This concept is to be used as the driver and the integration guidance for the transition from the current rigid procedures and outdated failing infrastructure to a Free Flight environment. The RTCA Task Force 3 provided the modernized NAS capability descriptions sought by the user community. The validated operational concept describes how each part of the NAS, both ground and air, interacts to provide the capabilities while transitioning to a new infrastructure involving planners, pilots, service providers, and systems.

Agency Outputs: The agency provides:

- A well-defined and well-understood "validated" operational concept thoroughly described based on system modeling and simulation
- Validated, integrated, configuration managed requirements for the subsystems of the new target system to provide a coherent, comprehensive framework to guide the associated research and development activities (e.g., specific requirements for ADS-B capabilities, Surface Management capabilities, Advanced Concept Probe, etc.)
- Top-level designs for the major new ATM capabilities and subsystems associated with the operational concept (e.g., the ground-based and airborne information infrastructures required for modernization and the design of a capability to dynamically tailor an air traffic controller's airspace responsibility to more efficiently accommodate traffic demand)
- A system-level safety assessment of the operational concept and associated new capabilities
- A risk-mitigation plan to guide development activities for new capabilities
- A human factors validation plan that provides a comprehensive roadmap of activities to assure that new functionality will be operationally acceptable to flight crews and controllers.

Customer/Stakeholder Involvement: The RTCA Select Committee for Free Flight Implementation cooperates in operational concept development and validation. Its ATM Operational Concept Subcommittee participates to provide the user perspective and detail into both the initial narrative as well as each additional layer of detail. The participation ensures that the concept reflects user community requirements and is essential for validating the concept for a modern NAS based on a shared, integrated infrastructure.

Accomplishments: The vision for the modern NAS has been developed and published in the *Government/Industry Operational Concept for Free Flight* (RTCA, August 1997) and *A Concept of Operations for the NAS Airspace System in 2005* (Air Traffic Services, September 1997). These documents have provided guidance to the development of the NAS Architecture Version 4.0. Additional details appear in the appendices to this document.

Starting in FY 1999, activities to be initiated include validation of concepts and associated top-level designs, risk-mitigation planning, and coordination of a validation plan with the human factors activity.

R&D Partnerships: This work directly relates to the FAA/NASA Memorandum of Understanding (MOU) on ATM research and development. Work under this program is coordinated through the joint Integrated Product Team Plan to ensure NASA's efforts complement and are integrated into the NAS Operational Concept. NASA contributes to the development and validation of flight deck concepts and in the far-term ATM system development.

The concept development and concept validation effort is also coordinated with the European community via agreements with EUROCONTROL. This effort ensures that unique solutions/transitions are not developed in different quadrants of the globe, which would impose an undue burden on U.S. carriers, manufacturers, and other participants in the global airspace system.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

Operational concept development

- Developed task assignment information and information performance requirements based on the operational needs and requirements concept document for 2005
- Performed engineering technical task analysis and developed related concept documents for the 2005 mid-term
- Developed scenario descriptions based on engineering technical task analysis concept document for the 2005 midterm

Concept validation

- Developed executable information flow tool
- Performed operational analysis, including fast-time simulation
- Conducted joint FAA/NASA/user concept validation activities, including human-in-the-loop simulations

KEY FY 2000 PRODUCTS AND MILESTONES:

Operational concept development

- Develop detailed concepts for individual service enhancement and domains to support the development of system level requirements for modernization
- Complete development of quantitative measures and goals for midterm concept capabilities
- Develop task assignments and information performance requirements for 2015 operational concept
- Develop scenarios based on engineering technical task analysis concept document for the 2015 concept

Concept validation

- Develop test-bed for modernization
- Perform operational analysis, including fast-time simulation
- Conduct joint FAA/NASA/user concept validation activities, including human-in-the-loop simulations

Concept system design

- Conduct analysis of en route sectorization strategies to support the midterm design for the Eastern Triangle

FY 2000 PROGRAM REQUEST:

The FY 2000 request expands the initial operational concept validation efforts to the point where detailed information and performance requirements will be established for several of the major modernization initiatives, including the information requirements for the Host software reengineering activities. Human factors research is expected to establish the type, update rate, and display requirements. The facilities for human-in–the-loop will be upgraded to provide a fully configurable test-bed for information performance and requirements analysis. This capability will be used to improve analysis of future controller team configurations to meet traffic growth and evaluate a horizontal versus vertical partitioning of NAS airspace.

Leveraging work is being conducted at NASA Langley for safety assessments, the methodology for safety and reliability assessment for the joint air-ground infrastructure, which will be used to evaluate reliability and safety performance of future concepts.

A02g - Operations Concept Validation Product and Activities	Program Schedule					
	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY2004
028-110 Operations Concept Validation						
Operational Concept Development						
Developed Operational Needs and Requirements Concept Documents for "2005"	◆					
Develop Roles and Responsibilities Based on the Operational Needs and Requirements Documents for "2005"	◆					
Perform Engineering Technical Task Analysis and Develop Related Concept Documents for "2005"	◆		◇			
Develop Scenario Descriptions Based on the Engineering Technical Task Analysis Documents for "2005"	◆					
Develop Operational Needs and Requirements Concept 2015		◇	◇			
Develop Roles and Responsibilities Based on the Operational Needs and Requirements Documents for "2015"				◇		
Perform Engineering Technical Task Analysis and Develop Related Concept Documents for "2015"				◇	◇	
Develop Scenario Descriptions Based on the Engineering "2015" Technical Task Analysis Documents for "2015"	◆		◇			
Concept Validation						
Develop Executable Information Flow Tool	◆	◇	◇	◇	◇	◇
Perform Operational Analysis, Including Simulation Conduct Information Flow Analysis		◇	◇	◇		
Perform Human-in-the-Loop Simulation		◇	◇	◇	◇	◇
Develop Test-bed for Modernization		◇	◇	◇		
Develop Distributed Simulation Standards & Database	◆					
Concept System Design						
Conduct Analysis for End-to-End Certification for Mixed Ground and Air Infrastructure	◆	◇				
Conduct Analysis of Advanced Airspace Sector Design and Dynamic Sectorization	◆		◇			
Conduct Analysis and Develop Service Reliability Methodology for NAS		◇		◇		

Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	0	0	0	3,412	2,531
Personnel Costs	0	0	0	3,099	3,307
Other Costs	0	0	0	307	271
Total	**0**	**0**	**0**	**6,818**	**6,109**

A02h Software Engineering R&D — [*Program moved to 1999 Aviation System Capital Investment Plan (CIP) as M28 Corporate Systems Architecture – Software Engineering*]

GOALS:

Intended Outcomes: The FAA intends to improve NAS and avionics safety and reduce NAS and avionics acquisition, development, and maintenance costs by developing and implementing improved software processes and procedures. These actions will directly benefit passengers as well as all elements of air transportation and greatly contribute to a safe, secure, and efficient NAS.

The FAA has been routinely criticized by the General Accounting Office (GAO) and the R,E&D Advisory Committee for its lack of software competency in acquiring and maintaining software-intensive systems. Deficiencies in this area have increased cost and decreased quality of new software-intensive systems. The agency has placed a priority on this area because most current and future NAS systems are software-intensive systems. For example, eight of the nine high drivers of change in the next 8 years, as identified by the Office of the Associate Administrator for Research and Acquisitions, involve adding or improving software-intensive systems.

The FAA Software Engineering Resource Center (SERC), which was established in June 1998, will be a focal point for research on FAA software-intensive systems. SERC leverages government, academic and industry resources by using interdisciplinary teams, which need not be collocated. SERC is an FAA-wide resource that will address strategic software technology problems that impact mission performance and enhancement of FAA in-house software/systems engineering competencies. The primary SERC facilities have been established at the William J. Hughes Technical Center and at FAA headquarters. Remote tie-ins with other facilities are also planned (e.g., at other research sites such as NASA and the EUROCONTROL Experimental Center).

Agency Outputs: The principal products of SERC efforts will include a series of standards, guidelines, models, and evolvable prototypes that demonstrate, validate, and verify the safety properties, performance, and other critical attributes of new technologies that are to be used within the NAS. SERC also will evaluate and validate improved software processes, methods, and engineering tools that enhance architecture, systems, and software engineering, testing, and certification functions over the life cycle of NAS systems. Finally, SERC will bring together recognized experts and FAA personnel to solve problems related to the certification of software, COTS/non-developmental item (NDI), and the next generation architecture. This will transfer skills to and increase the technical competency of the FAA workforce.

Following are specific focus and outcomes of SERC applied research work:

Software certification research

- Processes for certifying software aspects of safety-critical airborne and ground-based systems within the NAS**.** Current certification processes require a long leadtime and are costly. Resulting delays affect the rate at which aircraft can be equipped with modern, affordable avionics and are a significant contributor to the long leadtime required for NAS modernization. This research is exploring promising techniques for streamlining the certification process without affecting levels of safety.
- Processes for ensuring end-to-end safety and certification of integrated air and ground systems within the NAS**.** NAS air and ground segments are becoming more integrated through the introduction of new services such as data link. The current practice of separately certifying NAS airborne and ground components can no longer ensure safety of the integrated air-ground system. This research is investigating and will validate different approaches for performing end-to-end safety assessments and certification of the integrated air-ground systems.

This research will produce a series of guidelines and processes for improving certification of avionics and ground systems. Specific recommendations will also be provided to the appropriate RTCA committees that develop standards and guidelines for certification of avionics systems.

NAS architecture research

- Evaluation and prototyping of high-integrity, safety-critical architectures to find better and cheaper ways of ensuring that NAS hardware and software are safe, secure, and efficient in the face of challenges from bad code, security breaches, and the like. This may potentially eliminate a need for independent certification of software.
- Architecture definition and description. This research is investigating unified approaches to formal architecture definition and description for cost-effective evaluation and comparison of competing candidate architectures for acquisition.
- Analytical and simulation architecture models for the NAS. This research is investigating the effects of various constraints on NAS operational concepts and optimizing those constraints, including cost and performance, before committing resources to system implementation and deployment.

The specific architecture research outputs will be guidelines and standards for defining, representing, and designing high-integrity architectures for the NAS; and, executable and reusable architecture models and simulations that can be extended or tailored to support domain-specific engineering and product acquisitions for the NAS.

Research on applying COTS/NDI within the NAS ground systems and avionics

- COTS/NDI software assurance research**.** This research directly supports the Flight Controls and Digital Avionics Systems by investigating conditions under which a COTS software product can be certified to a given level of safety, as defined by current standards. It will help establish selection criteria and evaluation guidelines for ongoing work in Information Security Product Evaluation and a number of other related areas, such as NAS Infrastructure. The research also will identify and evaluate techniques for reducing the cost and time needed to ensure that COTS/NDI software, or systems containing COTS/NDI software, are safe and function as required.
- Evaluation and prototyping of systems and software engineering processes and methods for use in COTS-intensive systems. This research will identify and evaluate more effective practices for use in software requirements definition, software/systems analysis and design, and testing that are appropriate for safety-related systems using COTS/NDI software. It will include investigating different methodologies to quantify, characterize, and guard against the risk of accidentally activating unintended COTS functionality/responses for a given system and environment.
- Software estimation models for COTS-intensive systems. Research is seeking to identify/develop better ways of estimating and predicting the life cycle costs of COTS-intensive systems. This study will include consideration of the complex interactions of major cost and schedule drivers that relate to the evaluation, interfacing, integration, product refreshment, and maintenance of COTS.

This research will produce a set of evaluation criteria and guidelines for COTS software proposed for use in safety-related aviation systems. It will also establish the processes and technical methods required to evaluate COTS/NDI-based systems prior to contract awards and ensure that use of COTS/NDI software will not compromise aviation system safety.

Customer/Stakeholder Involvement: The goal of the streamlining software aspects of certification is to assess the cost and schedule drivers of the software aspects of certification for both avionics and ground systems, and to prototype solutions that show promise to reduce cost and schedules. This supports objectives of the Office of the Associate Administrator for Research and Acquisitions (ARA) and the Office of the Associate Administrator for Regulation and Certification (AVR).

Recommendation R-14 of the "Report of the Challenge 2000 Subcommittee of the FAA RE&D Advisory Committee for the Administrator" reads, in part:

> "The FAA should conduct an in-depth analysis of processes within the FAA which are affected by COTS/NDI technologies. . . . 5. Identify new methods to test and validate safety-critical systems that are not dependent on source code

> analysis. 6/7. Investigate ways to reduce cost and time to (re)establish high confidence in a system. . . 18. Promote software technology and process improvement techniques. . . ”

The COTS/NDI software assurance research work is directed toward answering the recommendations of this Subcommittee and also addresses concerns and recommendations contained in the *COTS/NDI in Safety-Critical System* report. This research also supports *Action Plan 5: Validation and Certification Methodology* of the FAA/EUROCONTROL R&D Committee agreements.

The *Subcommittee Report of the NAS ATM R&D Panel to R,E&D Advisory Committee* addresses the entire contents of its section 4.0 to Software Engineering Research and Development. It concludes with a number of critical recommendations concerning the need to initiate research in (1) certification of ground as well as air systems involving critical software; (2) systems/software complexity; (3) various software architectural issues such as reuse and reliability; and (4) software/computer security. This is all captured within several sections, beginning with the Major Recommendation 4.2.1.a #2, “The FAA should establish a Software Engineering Laboratory under the direction of the Chief Scientist for Software Engineering that performs as a center of excellence.” A major purpose of this research initiative is to address the concerns and identified weaknesses noted by the Subcommittee.

Accomplishments: N/A

R&D Partnerships: Partnership agreements are under discussion with EUROCONTROL, NASA, DOD, NIST, and others.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

Establishment of the SERC was initiated in June 1998 using funds earmarked for software engineering operational planning. The center will be fully operational by the end of FY 1999. Several major research activities have already begun in the three key areas outlined above.

KEY FY 2000 PRODUCTS AND MILESTONES:

During FY 2000, the initial guidelines and prototypes for the three areas will be available for preliminary use and test. The SERC will act as a virtual and physical facility to coordinate development and testing of these software engineering research products. Links will be established with remote researchers and research sites.

FY 2000 PROGRAM REQUEST:

The software engineering research programs will initially make use of prior related activities conducted by the Office of Information Technology. The programs will subsequently use resources throughout the United States, particularly those of the SERC and aviation-related programs already underway at several universities. Support has been promised and is being negotiated with a number of FAA organizations.

A02h - Software Engineering R&D Product and Activities	Program Schedule					
	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY2004
028-130 Software Engineering R&D						
Software Engineering Resource Center (SERC)						
Establish/Maintain the infrastructure	◆					
Develop/Implement Operational Plans and Methodology	◆					
Establish/Maintain Working Relations with Other Centers	◆	◇	◇	◇	◇	
Establish/Maintain Working Relations with Contract Researchers	◆	◇	◇	◇	◇	
NAS Architecture Research						
Develop an Architectural Decision Tree	◆	◇	◇	◇	◇	
Prototype the Architectural Decision Tree			◇	◇	◇	
Develop Guidelines for a "Good" Definition		◇	◇	◇	◇	
Develop Guidelines for a "Good" Representation		◇	◇	◇	◇	
Develop Guidelines for Secure Software Systems				◇	◇	
Develop, Test, and Evaluate Analytical Models				◇	◇	
Develop, Test, and Evaluate NAS Simulations				◇	◇	
Research on Safe and Effective Application of COTS/NDI in the NAS						
Develop Standards and Guidelines for COTS/NDI Software/ System Assurance	◆			◇	◇	
Develop Standards and Guidelines for COTS/NDI Software/System Methods				◇	◇	
Develop Standards and Guidelines for COTS/NDI Software/System Cost Estimation	◆			◇	◇	
Software Certification Research						
Develop Standards and Guidelines for Certification of Safety	◆			◇	◇	
Develop Standards and Guidelines for End-to-End Test of Air/Ground Software Intensive Systems				◇	◇	

Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	0	0	0	462	689
Personnel Costs	0	0	0	474	1,001
Other Costs	0	0	0	64	84
Total	**0**	**0**	**0**	**1,000**	**1,774**

A03a Communications— [*Program moved to 1999 Aviation System Capital Investment Plan (CIP) as C20 Aeronautical Data Link (ADL)*]

GOALS:

Intended Outcomes: The FAA intends to increase safety, decrease delays, increase system flexibility and predictability, and increase user access to NAS data base sources by:

- Implementing decision support system services (DSSS) that integrate airborne flight management system capabilities with ground-based decision support automation
- Providing all NAS users a common view of weather and airspace traffic, thus allowing users to better anticipate and plan for flight deviations and/or delays through CDM process
- Increasing system flexibility by using data link services to derive, negotiate, and/or update flight plans both before and during flight

These improvements also reduce air traffic controller workload, increase situational awareness, and alleviate voice traffic congestion.

Providing data link services facilitates the transition from air traffic control to air traffic management and supports the evolution toward a Free Flight environment as envisioned in the RTCA Task Force 3 report and the Free Flight Action Plan. This also advances the concept of the self-reliant pilot described in the future architecture for automated flight service station support. Several government and industry initiatives have identified improved weather information in the cockpit as a key priority and mitigating strategy to reducing weather related accidents. After pilot error, weather is the number one cause/factor cited in aviation accidents. Over one-third of all fatal accidents in all sectors of aviation involve weather, and in general aviation more than 200 fatalities per year are due to weather.

Agency Outputs: The FAA provides cost-benefit analyses for ground processing and uplink of FIS/weather and DSSS.

Standards and guidance material for FIS/weather products and DSSS provide technical characteristics and approval guidelines for operational use and training. RTCA minimum aviation system performance standards (MASPS) and minimum operations performance standards (MOPS) provide guidance for data link avionics. FAA advisory circulars and the Aeronautical Information Manual provide certification guidance for installation and operational use/application. This program develops technical and operational information, including human factors criteria, to support these products.

Specifications for FIS/weather products and DSSS provide/identify requirements for FAA automation and industry implementation.

Customer/Stakeholder Involvement:

Free Flight: The integration of ATM DSSS with controller, pilot, and airline operations center (AOC) facilities systems via digital data link provides enhanced capabilities for trajectory prediction, in-flight planning, and rerouting. ATM DSSS alternatives include CTAS automated en route air traffic control technologies. Using these alternatives will lead to a reduction in the number of current procedural restrictions in the NAS. This is one of the primary goals of the Free Flight initiative, which also includes developing and implementing FIS/weather products in the cockpit.

RTCA: RTCA sponsors many special committees, including:

- SC-169, which formulates a systems-oriented approach to aeronautical data link (ADL) applications and coordinates standards development to integrate data ink functions for air traffic management
- SC-182, which develops standards for modular avionics concepts, which affect cockpit avionics used by ADL
- SC-162 (Open Systems Interconnections)
- SC-165 (Aeronautical Mobile Satellite Service)
- SC-172 (VHF Air-Ground Communication)
- SC-181 (Navigation Standards)
- SC-185 (Aeronautical Spectrum Planning)
- SC-186 (Automatic Dependent Surveillance-Broadcast)
- Task Force 3, Air Transport Association Flight Management System Task Force

ICAO: The International Civil Aviation Organization leads and participates in the following panels:

- The Automatic Dependent Surveillance Panel. which focuses on automated air-ground data exchange
- The Aeronautical Telecommunication Network Panel, which focuses on requirements for a globally interoperable digital data communications network
- The Aeronautical Mobile Communications Panel, which focuses on satellite-based safety services for data and voice, including standards development for high and very high frequency digital communications

Aviation Safety Plan: ADL-related initiatives include:

- Initiative 2.10.2, which deploys data link capability to disseminate alphanumeric and graphical FIS products, including weather, directly to the cockpit
- Initiative 4.2.6, which completes the definition of data link systems to support communications, navigation, and surveillance operations
- Initiative 4.2.7, which establishes two-way data link capability throughout domestic en route and terminal airspace.
- Initiative 4.3.4, which demonstrates/validates risk reduction benefits of weather and traffic products acquired by local surveillance systems delivered to aircraft, ATC facilities, air carriers, and any combination of these.

FANG: The Flight Management System (FMS)-ATM Next Generation (FANG) Team chaired by the ADL product team, focuses on developing DSSS. This team comprises government and industry representatives and is chartered to define an integrated flight management system/air traffic management/aeronautical operational control system.

The FAA participates in and sponsors the communications and surveillance operational implementation team. This is an Administrator-chartered organization established to coordinate the implementation of FAA modernization programs with the aviation industry.

The general aviation (GA) community also has participated in the FAA demonstration and operational suitability assessment of initial graphic and text data link products provided through the mode S-based Graphic Weather Service (GWS) at Dulles International Airport. The user community strongly advocates implementing dissemination of FIS/weather, especially graphics, to the cockpit as demonstrated through the Free Flight Action Plan (1996); the National Research Council report, Aviation Weather Services, A Call for Federal *Leadership and Action* (1995); the National Aviation Weather Program Plan (1992); and FAA order 7032.15 Air Traffic Weather Needs and Requirements. Most recently, in May 1998, the FAA issued an Airborne Flight Information Services Data Link Policy statement supporting a joint government/industry partnership in establishing FIS data link services. The policy statement was a result of a petition submitted by the General Aviation Coalition.

Accomplishments: The FANG Operational Concept has been published. It identifies a preliminary set of services, associated potential benefits, and required functional capabilities of an integrated flight management system/air traffic management/aeronautical operational control system.

The basic requirements and operational concepts for FIS/weather data link applications were jointly developed by industry and government, and published (DO-232) through the RTCA Special Committee 169, Working Group 3.

Terminal weather information for pilots (TWIP) is currently available at all Terminal Doppler Weather Radar locations through the ARINC ACARS vendor data link service.

Predeparture clearance (PDC) and digital-air traffic information service (D-ATIS) is currently available through the tower data link system (TDLS) at 57 TDLS locations. These services are also provided through the ARINC ACARS vendor data link service.

TIS is being deployed at all operational terminal Mode S locations. This service provides cockpit presentations of aircraft traffic to client aircraft based on terminal radar surveillance.

R&D Partnerships: The FAA is coordinating development of NAS improvements, including data

link applications with NASA. An interagency Integrated Product Team, formed between the FAA and NASA, develops future ATM systems. FAA and NASA DSSS-related efforts are coordinated through that mechanism. Also, the joint FAA/NASA AGATE project includes joint testing (ground and flight) with the AGATE partners. Finally, the NASA Aviation Weather Information (AWIN) program includes cockpit dissemination of weather information as a key strategy for mitigating aviation fatalities in a 7-year research program in response to the White House Safety Commission report.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

- Completed Joint FAA/NASA Modeled Analysis of CTAS- and FMS-generated fuel-optimal trajectories
- Published FANG-required functional capabilities document
- Completed Three-Dimensional User-Preferred Trajectories Flight Trials Project
- Began Field Test portion of Joint FAA/NASA CTAS/FMS Data Exchange Field Test (Initial DSSS)
- Established required initial data link capabilities for En Route Aeronautical Telecommunications Network Decision Support Tool
- Established partnership(s) with industry to provide FIS data link services
- Established collaborative FIS data link testbed and test range facilities for developing sound technical data to support publication of standards and guidelines for operational implementation
- Published initial RTCA MOPS/MASPS and FAA advisory circulars and other regulatory materials to support FAA/industry FIS data link services

KEY FY 2000 PRODUCTS AND MILESTONES:

Funded:

- Conduct ground simulation and flight evaluations to analyze cockpit workload and pilot decision-aid impacts for new increment of FIS data link services (i.e., convective weather, AUTOMETS, in-flight icing, turbulence, SUA, and NOTAM's)
- Develop FIS standards and guidelines for the above convective weather and AUTOMET FIS data link services

FY 2000 PROGRAM REQUEST:

Aeronautical Data Link works collaboratively with FAA product teams, including en route, terminal, air traffic management, interfacility telecommunications, and weather to ensure the successful integration of data link services into the NAS.

Decision support system data link enhancement identification and development allows the benefits of advanced ATM automation tools to be fully realized.

Ground simulations and flight evaluations are conducted using the facilities and resources at the William J. Hughes Technical Center and other facilities, including those at the FAA Civil Aeromedical Institute (CAMI), MITRE Center for Advanced Aviation System Development (CAASD), and NASA. These simulations and evaluations identify data link product and system architecture specifications and operational guidance issues. Based on these specifications and operational guidance issues, implementation standards (MOPS, MASPS), operational guidance documents (advisory circulars), and system architecture strategies are drafted.

A03a - Communications Product and Activities	Program Schedule					
	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY2004
031-111 Aeronautical Data Link (ADL) Applications						
Decision Support System Services (DSSS)						
Begin Modeling/Simulation of proposed DSSS		◇				
Complete Cost/Benefit Analysis (CBA) for initial DSSS		◇				
Complete Comprehensive List of DSS Data Link Services		◇				
Complete AMS initial requirements document for DSSS			◇			
Complete CBA for DSSS			◇			
Develop FAA/Industry Consensus on DSSS Implementation				◇		
Implement initial DSSS					◇	
Integrate Advanced DSSS with Flight Management Systems (FMS)						◇
Flight Information Services (FIS)						
Established collaborative FIS data link test facilities	◆					
Established industry partnerships to provide initial FIS data link services	◆					
Developed standards & guidelines for initial FIS data link services	◆					
Conduct simulations/flight evaluations for follow-on FIS services		◇				
Develop standards & guidelines for follow-on FIS services		◇				
Conduct simulations/flight evaluations for advanced FIS services			◇			
Develop standards & guidelines for advanced FIS services			◇			
Develop operational specifications & standards/ guidelines for FIS Services based on Aviation Gridded Forecast System				◇		
Conduct simulations/flight evaluations for transition of FIS services for DSSS/Collaborative Decision Making (CDM) support					◇	
Develop standards/guidelines for FIS services supporting DSSS/CDM services						◇

Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	5,412	1,054	4,706	1,174	3,000
Personnel Costs	3,808	4,105	0	4,129	4,498
Other Costs	780	841	0	566	344
Total	**10,000**	**6,000**	**4,706**	**5,869**	**7,842**

A03b Navigation — [*Program moved to 1999 Aviation System Capital Investment Plan (CIP) as N12 – Augmentation for the Global Positioning System (WAAS/LAAS)*]

GOALS:

Intended Outcomes: The FAA intends to provide time efficiencies and cost savings through satellite-based navigation implementation. This technology allows direct point-to-point navigation, optimum routing, and other capacity improvements. These efficiencies and savings are realized by the airlines, the traveling public, and the FAA and include:

- Increased air traffic control efficiencies and NAS capacity through a restructured airway system to accommodate direct routings between airports as well as reduced separation standards
- Reduced fuel cost to airlines and reduced travel time to the public due to more economical air routes
- Reduced FAA operating costs due to decommissioning existing ground-based navigation equipment
- Simplified GPS augmentation infrastructure through wide area and local area interoperability to provide satellite navigation services at a reduced cost

Agency Outputs: The FAA uses the national satellite testbed (NSTB) as the foundation for all research and development associated with implementing satellite-based navigation technology. The NSTB is essential to the wide area and local area augmentation development strategy needed to implement GPS-augmented navigation technology. Findings from the NSTB help the FAA to develop required user equipment through avionics manufacturers, continue development of GPS user procedures, and gain international acceptance of a seamless global navigation satellite system.

The program is developing and implementing the capability to monitor and evaluate system performance of GPS and GPS-augmented systems, such as NSTB and WAAS, as they are implemented. During these evaluations, large quantities of complex, technical data will be collected, analyzed, archived, and made available to the FAA and other government agencies. Industry, academia, and international entities to further their research use the data, facilitate information exchange, and foster cooperation around the world to achieve a seamless global navigation system. The results of this "live" data collection and analysis will assist the FAA in defining and analyzing air traffic and airway facility requirements for satellite-based navigation technology, as well as connectivity and interoperability requirements for international augmentation systems being developed by other countries. The information obtained from these performance evaluations will also be instrumental in allowing the FAA to monitor the WAAS system contractor performance during interim contractor maintenance and logistics.

The FAA will approve GPS as a primary means of navigation through category I precision approaches by 2001 in all weather conditions by implementing WAAS. This will enable existing navigation equipment across the United States to be decommissioned.

The FAA will validate the capability to perform category II/III precision approaches through research and development efforts associated with LAAS. The FAA will provide a LAAS functional specification, architecture, and MOPS to industry for implementing local area systems across the United States. LAAS prototypes will be developed, and flight tests will be conducted to validate the specification and MOPS.

Customer/Stakeholder Involvement: The program's implementation strategy involves other government agencies, industry, and academia, as follows:

- The FAA establishes and participates on various teams addressing immediate needs for operational implementation issues. These include the Satellite Operational Implementation Team (SOIT), Satellite Procedures Implementation Team, the Air Traffic SOIT, and other teams and working groups at FAA regional offices.
- The FAA participates on the RTCA working groups and subcommittees.
- The FAA has completed 16 bilateral agreements with several countries and participates in ICAO panel sessions to further the accep-

tance of GPS augmentations as a seamless global navigation satellite system.

- The FAA supports the Positioning and Navigation Executive Committee, and the Joint Precision Approach and Landing System Program and interacts with the Department of Defense to establish and promote a national consensus on GPS management and operation.
- The FAA supports the Interagency GPS Executive Board (IGEB) regarding GPS modernization issues.

Accomplishments: During FY 1998, the NSTB continued to provide a MOPS compliant signal in space, allowing development of WAAS aircraft avionics, terminal en route procedures (TERPS) criteria, and user procedures. Research efforts included evaluating new algorithms, hardware, and communication topologies to improve the integrity and availability of the WAAS. Enhancements to the NSTB were made to improve its use as a performance assessment tool for the WAAS and to define the preplanned product improvements for WAAS. In addition, the NSTB conducted initial global navigation satellite system (GNSS) interoperability studies.

The FAA completed development of the LAAS functional specification and the MOPS. Development efforts for LAAS prototypes were initiated to validate and verify the specification and MOPS.

The FAA initiated the requirements definition and analysis of system performance characteristics for the satellite navigation center as the first step toward developing a monitoring network to evaluate GPS and WAAS system performance.

R&D Partnerships: The FAA has approximately 20 grants, interagency agreements, and contracts in place with industry, academia, and other government agencies to leverage their expertise and capabilities in satellite navigation R&D. Principal participants include Stanford University, Ohio University, the Naval Air Warfare Center Aircraft Division (NAWCAD), the Central Intelligence Agency (CIA), the Air Transport Association (ATA), and the Massachusetts Institute of Technology Lincoln Laboratories.

In addition, 16 cooperative bilateral agreements are in place, with additional agreements currently in work, to facilitate and promote the communication and information transfer for a seamless global navigation satellite system. The program also maintains a government industry partnership with the ATA for continued development of performance operating standards for GPS-based navigation with emphasis on local area applications.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

- Performed data collection and analyses using the NSTB to further develop WAAS performance-assessment capabilities
- Continued to conduct ionosphere data collection and analyses to define WAAS final operational capabilities
- Initiated development of WAAS prototype to demonstrate international connectivity
- Continued development of WAAS performance-monitoring network
- Conducted ionospheric data collection and analyses
- Conducted WAAS/LAAS integration studies
- Initiated investigation studies for surface movement guidance, helicopter operations, and advanced LAAS augmentations
- Initiated installation and testing of LAAS prototypes to validate the functional specification
- Continued to coordinate with ICAO to produce SARP's to define LAAS in the international community

KEY FY 2000 PRODUCTS AND MILESTONES:

- Perform data collection and statistical analyses of initial WAAS performance capabilities--including developing WAAS antenna interference mitigation and rejection methods, a safety processor to meet FAA certification standards, and analyzing satellite alternatives for WAAS final operating capability
- Develop a prototype integrity monitor for the WAAS
- Conduct WAAS/LAAS integration studies

- Develop operations and maintenance connectivities
- Prototype international connectivity
- Develop WAAS performance monitoring network
- Establish research database and analysis capability
- Develop real-time simulation methodologies for WAAS components
- Conduct ionospheric data collection and analyses
- Continue research into signal quality monitoring, operations and maintenance, flight control monitoring, and automatic dependent surveillance with participation from Stanford and Ohio Universities
- Continue investigation studies analysis for surface movement guidance, helicopter operations, and advanced LAAS augmentations using pseudolites, instrument landing system glideslope, and low-earth-orbit satellites
- Continue to develop and mature the LAAS integrity algorithms
- Continue installing and testing LAAS prototype systems at several sites to ensure that the systems will validate the functional specification in particularly difficult sites

FY 2000 PROGRAM REQUEST:

In FY 2000, the program will continue to focus on developing and implementing GPS augmentations to further the transition to satellite-based navigation technology. Efforts focus on research and analysis of issues associated with accuracy, integrity, and availability to the users, with specific emphasis on interference to ensure service continuity. Efforts also focus on gaining continued acceptance and support by the international community for an integrated WAAS/LAAS architecture to achieve a seamless GNSS.

The FY 2000 request will focus primarily on the research and development efforts currently being performed by Stanford University, Ohio University, ATA, and MIT's Lincoln Laboratory. This will allow the FAA to continue to meet its objectives to transition to satellite-based navigation.

A03b - Navigation Product and Activities	Program Schedule					
	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY2004
032-110 Satellite Navigation Program						
Wide Area Advanced Research/NSTB						
Ionospheric Data Collection & Analyses	◆	◇	◇	◇	◇	◇
Worldwide Scintillation Monitoring & Analysis	◆	◇	◇	◇		
Develop Worldwide Iono Mode	◆	◇	◇			
Interference Mitigation Analysis	◆	◇	◇			
Develop Worldwide Service Volume Model	◆	◇	◇			
Clock Performance/Time Transfer Analysis	◆	◇				
International Connectivity & Interoperability	◆	◇	◇	◇	◇	
Integrate International Reference Sites	◆	◇	◇	◇	◇	
Conduct Flight Demonstrations	◆	◇	◇	◇	◇	
Data Collection, Distribution, Analysis	◆	◇	◇	◇	◇	
WAAS Performance Assessments	◆	◇	◇	◇	◇	
Minor Contractor Compliance	◆	◇	◇	◇	◇	
Support WAAS Algorithm Validation	◆	◇	◇	◇		
WAAS P3I Definition	◆	◇	◇	◇	◇	◇
Data Collection & Analysis	◆	◇	◇	◇	◇	◇
2nd/3rd Civil Frequency Addition	◆	◇	◇	◇	◇	◇
Local Area Concepts						
Initiate Installation/Test of LAAS Prototypes		◇	◇			
Begin Surface Movement, Helicopter & Advanced Research	◆	◇	◇			
Complete Validation of LAAS Specification/MOPS	◆		◇			
2nd/3rd Civil Frequency Integration						◇
WAAS/LAAS Inter-operability						
Conduct WAAS/LAAS Inter-operability studies	◆	◇	◇			
Develop Interface Control Requirements				◇		
Finalize Architecture Study				◇		
Conduct Prototype Tests				◇	◇	◇
NAS Integration Plan				◇	◇	

Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	10,334	10,772	10,426	10,718	5,665
Personnel Costs	2,213	1,849	2,466	1,844	1,757
Other Costs	453	379	505	433	131
Total	**13,000**	**13,000**	**13,397**	**12,995**	**7,553**

A03c Surveillance — [*Program moved to 1999 Aviation System Capital Investment Plan (CIP) as S10 – Automatic Dependent Surveillance-Broadcast (ADS-B) and ADS-B Ohio Valley Project – Safe Flight 21*]

GOALS:

Intended Outcomes: The FAA intends to improve system efficiency and safety by implementing a low-cost surveillance system that enables Free Flight capabilities, minimizes runway incursions, and provides coverage in existing nonradar areas.

ADS-B is a technique to derive aircraft position by an onboard GNSS receiver or other backup source of navigation data. Aircraft identity, altitude, and position are broadcast directly to ground receivers and to nearby aircraft. Transmitted ADS-B messages, received by nearby aircraft and information is displayed on an airborne CDTI used for situational awareness, conflict detection, and Free Flight capabilities. Accurate and timely updated reports from ADS-B minimize runway incursions, improve safety by increasing a pilot's awareness of nearby aircraft, and improve efficiency and airspace capacity by potentially reducing current separation standards. Its modular design and cooperative nature offer a low cost alternative for surveillance coverage in existing nonradar areas, and potentially in the long term, in some areas currently served by radars.

ADS-B as been identified by both the FAA and the aviation industry as an enabling technology for Free Flight.

Agency Outputs: Current efforts focus on developing standards for ADS-B avionics, ADS-B applications, CDTI, and transponders, and in validating the capabilities of ADS-B. These standardization efforts include minimum aviation system performance standards, minimum operational performance standards, technical standard orders, and design criteria. Outputs will include evaluation of operational procedures, procurement specifications for ground systems, deployment of system prototypes, and revised operational procedures.

Customer/Stakeholder Involvement: Air carrier and general aviation user communities have asked for FAA leadership in developing ADS-B technology. The FAA and the user community are actively involved in the standards development activity at RTCA SC 186. Some of the specific stakeholders include the Cargo Airline Association, Experimental Aircraft Association, Air Transport Association, Airline Pilots Association, Aircraft Owners and Pilots Association, United Airlines, Northwest Airlines, and the ICAO panels and European Work Group on ADS-B.

Accomplishments: Draft ADS-B avionics standards development has been initiated at RTCA. Additional engineering prototype and certification work, including development and test/validation, is required to complete these standards. A cooperative CRDA is being implemented with the CAA for an evaluation of selected operational enhancements and alternative radio frequency data links.

R&D Partnerships: The joint government/industry committees, RTCA SC-186 and SC-159, are tasked with achieving R&D consensus on system standards for ADS-B. Massachusetts Institute of Technology's Lincoln Laboratory and MITRE are also jointly involved in the technical development and integration of ADS-B technology into the NAS.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

- Develop agency roadmap for ADS-B air-to-air, air-to-ground, and surface applications
- Complete development of ADS-B 1090 MHz MOPS with RTCA
- Develop initial draft of ADS-B/CDTI MOPS with RTCA
- Complete spectrum analysis of ADS-B 1090 MHz in high-density environment
- Procure, install and evaluate ADS-B prototype ground station

KEY FY 2000 PRODUCTS AND MILESTONES:

- Complete operational concepts development and alternative analysis, including cost benefit and cost-effectiveness studies
- Continue evaluation of ADS-B operational procedures, including field trials

- Publish draft ADS-B/CDTI standards
- Publish draft engineering specification for ADS-B ground station

FY 2000 PROGRAM REQUEST:

The FAA and RTCA continue to complete the ADS-B avionics standards for CDTI and I-MFD displays as well as standards for ADS-B related enhancements to Mode S transponders. Studies, analyses, and field tests will validate CDTI standards. Operational concept analysis describes proposed features and benefits obtained by implementing and deploying ADS-B. An analysis of ADS-B integration with existing radars and automation systems will be performed.

A03c - Surveillance Product and Activities	Program Schedule					
	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY2004
033-140 Automatic Surveillance-Broadcast (ADS-B)						
Plans, Standards, and Analysis						
Develop/Approval of 1090 MHz MOPS by RTCA	◆					
Develop ADS-B Roadmap	◆					
Support ADS-B Trials	◆					
Conduct ADS-B High Density Simulations	◆					
Complete Operational Concept Analysis for Air-to Air Applications	◆					
Perform/Complete CDTI-1 Field Trials and Analysis	◆					
Avionics Standards for CDTI	◆					
Conduct/Complete CDTI Operational Test & Evaluation (OT&E) for Visual Flight Rules		◇				
Update CDTI Standards		◇				
Validate Application Benefits for Air-to-Air			◇			
Conduct/Complete CDTI OT&E for General Aviation Instrument Flight Rules Applications			◇			
Update CDTI Standards			◇			
Develop Air-to Air and Surface Operations Concept		◇				
Ground Initiated Comm B (GICB) Analysis for Mode S Transponders			◇			
Analysis Report Describing Integration of ADS-B with Existing Radars and Automation Systems					◇	
Procure, Install and Demonstrate ADS-B Ground-Based Engineering Prototypes			◇			
Complete Demonstrations/Publish Ground-Based Systems Demonstration Report				◇		
Develop Integrated Requirements Document for Ground-Based Systems					◇	
Develop Specification for ADS-B Ground Systems					◇	
Develop Specifications for ADS-B Automation/Integration					◇	
Evaluate alternative implementation of ADS-B technologies for long-term applications					◇	
Investment Decision for ADS-B Ground Stations to support air-to- ground and surface ATC application Investment						◇

Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	0	0	0	3,506	2,600
Personnel Costs	0	0	0	701	896
Other Costs	0	0	0	83	48
Total	**0**	**0**	**0**	**4,290**	**3,544**

A04a Weather Program

GOALS:

Intended Outcomes: The FAA intends to provide the capability to generate weather observations, warnings, and forecasts that are more accurate and accessible than existing weather services. These upgrades enhance flight safety, increase system capacity, improve flight efficiency, reduce air traffic controller and pilot workload, improve flight planning, increase productivity, and enhance situational awareness.

In accordance with the Federal Aviation Act of 1958 as amended, the FAA is responsible, in cooperation with the Department of Commerce, to promote and develop meteorological science, and to foster support of research projects using private and governmental research facilities. These duties are further amplified by recommendations contained in an Aviation Weather Services report issued by the National Research Council (1995) and the final report of the Aviation Weather Subcommittee issued by the FAA's Research, Engineering, and Development Subcommittee (October 1995).

The weather program directly supports FAA Strategic Goal #1in the performance area of Safety: "Through research, identify methods that, when implemented would reduce the fatal accident rate, due to weather." The weather program also directly supports Strategic Goal #8 in the performance area of System Efficiency, "Demonstrate the capability of new systems to decrease the rate of delays due to weather."

The weather R,E&D program, in collaboration with NWS and National Science Foundation programs, produces weather algorithms (technology), more rapid forecasting and delivery of forecasts (delivery), and the development of aviation weather instructional material and training courses (education).

Agency Outputs: The weather program focuses on conducting applied research to solve operational problems leading to the development of new and improved algorithms. These models predict weather events that affect aviation as well as procedural and policy changes/updates. The algorithms, developed for implementation on appropriate NAS platforms (including the weather and radar processor, the integrated terminal weather system, and NWS systems) continue to be transferred to private weather service companies that support the NAS. This enables companies to develop specialized aviation weather products based on FAA research efforts. Algorithm development provides the following capabilities that:

- Accurately depict current and forecasted in-flight icing areas to enhance safety, airspace efficiency, and aircraft utilization
- Produce high-resolution and timely gridded information for icing, winds, temperature, and turbulence to improve aviation advisories and forecasts issued by the NWS
- Provide location, timing, and severity of convective weather hazards to improve flight safety and enhance capacity.

Customer/Stakeholder Involvement: The National Aviation Users' Forum has provided a process to develop a federal/industry consensus on user needs and priorities for aviation weather information. Forum participants include representatives from the Airline Pilots Association, United, American, and Delta Airlines, and other industry representatives. The Forum serves as a basis to set priorities for research and development as well as system acquisition. The FAA's weather priorities and plans are consistent with users' recommendations made at this forum, and the plans address industry recommendations.

The weather program analyzes aviation weather service users' needs and requirements found in the Aviation Safety Action Plan. It also addresses industry recommendations, as well as requirements contained in more than six other related documents and publications.

Accomplishments: Following are major weather program accomplishments:

- Completed rapid update cycle analysis and forecast capability providing more accurate and higher resolution upper winds, temperature, and precipitation data, resulting in reduced flight times and/or flight delays because the data on hazardous weather and jet streams are more accurate

- Issued a 'freezing precipitation aloft' forecast at the Kansas City aviation weather center--responding to a rulemaking proposal aimed at turboprops flying in weather conditions conducive to in-flight icing--increasing airspace efficiency, aircraft utilization, and safety, especially for commuter aircraft.
- Commenced flight test of humidity sensor on United Parcel Service (UPS) aircraft, as part of the water vapor sensing system (WVSS) program, leveraged with the National Oceanic and Atmospheric Administration (NOAA)--enabling more accurate in-flight icing and ceiling and visibility forecasts.
- Completed upgrades to next-generation weather radar (NEXRAD) algorithms, storm cell identification and tracking, hail detection, mesocyclone, and tornado detection (leveraged with NWS)--enabling better definition of location, timing, and severity of convective weather hazards, resulting in enhanced flight safety and capacity
- Completed storm growth and decay experiment on data collected in Memphis. This research will result in the accurate, short-term prediction of the beginning, growth, and decay of storm cells--enhancing safety and capacity by improving aircraft avoidance of hazardous weather, resulting in enhanced strategic and tactical flow management planning, and allowing more effective routing of traffic to and from airports and runways
- Operated weather support to deicing decisionmaking (WSDDM) testbeds at La Guardia and O'Hare airports in collaboration with the Port Authority of New York and several airlines providing ground deicing decisionmaking information to the airlines and cities--resulting in increased safety (takeoffs), savings in use of deicing fluids, and associated equipment and personnel costs, efficiencies in runway and off-airport plowing, and efficiencies in departures and arrivals
- Developed initial operating capability of the AGFS implemented at the NWS--providing an aviation-specific weather database for the aviation community
- Under the SOCRATES Project, fabricated and tested a two-beam system for Wake Vortex detection during a 2-week test period in May 1998 at John F. Kennedy Airport

R&D Partnerships: Program activities are closely coordinated and leveraged with industry, academia, and other government agencies. This is done directly through interagency agreements, university grants and MOA'S in conjunction with the National Science Foundation. Principal partners include the National Center for Atmospheric Research, NOAA's Forecast Systems Laboratory and National Severe Storms Laboratory, Massachusetts Institute of Technology's Lincoln Laboratory, NWS Aviation Weather Center and National Centers for Environmental Prediction, NASA Lewis, Office of Naval Research, and UPS, as well as several universities, airlines, port authorities, and cities. In addition, international agreements with the United Kingdom, France, and Canada further leverage FAA efforts.

Research results are transferred to the private sector via cooperative research and development agreements with GTE, Kavouras, WSI, Harris, and AccuWeather.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

- Developed initial integrated in-flight icing algorithm
- Conducted field program to evaluate improved forecasts of in-flight icing
- Developed enhanced AGFS automated tools for forecasters
- Tested radar improvements to provide rapid updates of hazardous weather
- Integrated satellite data into 60-minute storm growth and decay forecast
- Completed technology transfer of WSDDM system to private industry for operational implementation
- Implemented preliminary turbulence forecasting algorithm at the Aviation Weather Center
- Fabricated and tested a two-team system at the FAA/Volpe Center Wake Vortex Site at JFK
- Processed, analyzed, and presented a final report on data obtained in the JFK test of the SOCRATES two-beam system

KEY FY 2000 PRODUCTS AND MILESTONES:

- Incorporate satellite data into an in-flight icing guidance product
- Implement interactive AGFS display-specific flight route forecasts
- Conduct airborne humidity sensor flight demonstration of utility
- Incorporate boundary layer data into 60-minute storm growth and decay forest
- Complete in-situ-based detection turbulence product evaluation
- Develop a 1- to 2-hour marine stratus burnoff forecast for San Francisco International Airport
- Implement wind data ingest and dissemination system at Juneau Airport

FY 2000 PROGRAM REQUEST:

- Develop new algorithms for improved forecasts of freezing drizzle aloft
- Continue to develop automated data analysis and assimilation techniques
- Transition weather research products to NWS, FAA, and industry automation and weather systems

The following activities are based on funding availability for SOCRATES in FY 2000:

- Design and fabricate and test and evaluate a SOCRATES eight-beam system; conduct local tests and prepare for evaluation testing
- Design, fabricate, and test a ground-based SOCRATES Particle Backscatter System and prepare for evaluation testing

A04a - Weather Program Product and Activities	Program Schedule					
	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY2004
041-110 Aviation Weather Analysis and Forecasting						
Develop Aviation Gridded Forecast System (AGFS)						
Developed Tools for Interactive Data Assimilation/Distribution	◆					
Implement Interactive Display Specific Flight Route Forecasts		◇	◇			
Implement Interactive Convective Sigmet/Airmet Ensemble Tools			◇	◇		
Imp/Demonstrate Interactive Forecast/Product Verification Tool					◇	◇
In-flight Icing						
Initial Development of IIFA	◆					
Incorporate Satellite Data into In-flight Icing Guidance Product		◇				
Imp. Yr.-Round Guidance Product & Severity/Type Forecasts			◇	◇		
Develop Terminal-Scale Icing Product & Field Program to Evaluate Radar/Satellite /Radiometer Detection Techniques					◇	◇
Winter Weather Research						
Develop Techniques to Detect/Forecast Precipitation Type and Rate, Incorporate Radar/Satellite Data				◇	◇	
Develop 6-Hour Forecast of Precip. Type/Rate						◇
Convective Weather						
Integrate Satellite Data into 60 Minute Forecast Algorithm	◆		◇			
Incorporate Boundary Layer Data, Transition to ITWS		◇				
Demo 90-Minute Forecast				◇		
Numerical Modeling 2 to 4 Hour Forecast					◇	◇
Turbulence Algorithm						
Implement Prelim. Turbulence Forecast Algorithm	◆	◇	◇			
Complete In-Situ Based Detection Product Evaluation		◇				
Improved Algorithm Using TDWR, Transition to ITWS			◇			
Incorporate Satellite Data into Turbulence Forecast					◇	◇
NEXRAD Algorithms						
Began Dual Polarization Research	◆					
Deliver Dual Polarization Algorithms to OSF				◇	◇	◇
Airborne Humidity Sensor						
Complete Sensor Evaluation/FAA/NOAA Decision on Utility		◇	◇			
Evaluate Combined Temp./Humidity Sensor				◇	◇	◇
Juneau Terrain-Induced Turbulence Project						
Develop Prototype System		◇				
Perform Test and Evaluation			◇			
Implement Operational System				◇		
Project SCORATES						
Completed Final Report of JFK Test Project Using 2-Beam Socrates System	◆					
Develop Eight-Beam SOCRATES System		◇				
Develop Ground-Based Particle Backscatter System		◇				
Complete Airborne System Applicability Demonstration			◇			

Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	5,978	11,683	14,500	17,836	15,100
Personnel Costs	427	1,093	664	817	629
Other Costs	88	224	136	31	36
Total	**6,493**	**13,000**	**15,300**	**18,684**	**15,765**

2.2 Airports Technology

Mission

The U.S. airport system consists of 6 billion square feet of pavement with a replacement value estimated at $100 billion. There are over 600 million passenger enplanements each year at over 17,000 landing facilities with terminal buildings and access roads. Current trends indicate that the aircraft fleet will not only increase in number, but also more importantly, in operating speed, gear loading and configuration, and aircraft size; and airport pavements will need capital improvements costing billions of dollars.

The Airport Technology program's mission is to provide technology solutions that will allow the Nation's airports to accommodate the projected traffic growth and establish an operational environment that is free of accidents or fatalities. This is accomplished by fulfilling the FAA's regulatory obligation (49 U.S.C. 47105(b) 3) to develop standards, criteria, and guidelines for planning, designing, constructing, operating, and maintaining the massive airport system. This includes:

- Airport pavement design
- Airfield design
- Wildlife hazard mitigation
- Visual guidance systems
- Surface traction
- Post-crash rescue and firefighting, and wildlife control.

Intended Outcomes

The most important program outcomes are reducing or eliminating aircraft accidents and lowering the cost of developing and maintaining safe airports.

The Airport Technology program area supports several FAA Strategic Plan goals:

- System Safety: reduce the number of accidents in which airport surface condition is a cause or factor and reduce hazards from wildlife strikes
- System Capacity: enhance airport capacity
- Industry Vitality: enhance the vitality and international competitiveness of the U.S. commercial air transportation industry
- Global Leadership: in cooperation with industry and other Federal agencies, promote U.S. aviation system technologies
- Environmental Responsibility: create an environmentally effective and responsive FAA both domestically and internationally.

System safety. Reduction or elimination of aircraft accidents is supported by a comprehensive R&D program. The program seeks to reduce the risk of aircraft sliding off runways due to the presence of water, snow, and ice, and in the presence of other surface contaminants such as rubber and anti-icing materials. Improved runway traction is the central focus of this research, which will provide improved methods, materials, and procedures for detecting and removing contaminants from runway surfaces.

The effectiveness of soft-material arrester beds has already been proven in stopping an overrunning aircraft and the program is developing national standards for design, but more economical materials and installation methods must be found to encourage more of these installations. Ongoing research seeks methods of reducing hazards from wildlife strikes. This includes cooperative research with the Department of Agriculture in assessing wildlife hazards at airports and maintaining a national birdstrike database.

Industry Vitality, Global Leadership, and System Capacity. These are supported by a comprehensive research and development (R&D) program for airport pavement design with U.S. and international government and industry support and collaboration. The International Civil Aviation Organization (ICAO) has formally agreed to use the results from the Airport Technology program to develop worldwide pavement design standards.

The FAA's pavement research has the potential to provide large benefits. Approximately $2 billion is spent on constructing, rehabilitating, and maintaining airport pavements each year by Federal, State, and local governments and by airport operators; about $4 million is spent on research. Increasing the pavement life by as little as 10 percent through research would result in a 50 to 1 benefit/cost ratio. This is an attainable goal the program is working to achieve.

Continued research in a visual guidance system is necessary to enhance ground operations at night or under low-visibility conditions. Pilots and vehicle operators must receive clear and unambiguous information from lights, signs, and markings. Improvements in this area will help eliminate runway incursions and aircraft collisions on airport surfaces. State-of-the-art light sources and applications are necessary to enhance the safety and efficiency of aircraft operations. ICAO is using the results of United States, United Kingdom, and European research efforts to develop uniform international standards.

Research efforts are required to develop strategies for attacking post-crash fires on new multilevel, high-density seating, passenger aircraft being designed by manufacturers around the world. Elevated waterway and boom penetration devices are examples of ways to provide increased passenger survivability and evacuation protection. Training requirements and firefighting simulators must still be developed to fully utilize the new capabilities. ICAO is using research results to develop international firefighting standards.

Program Area Outputs

The airport advisory circular system is the principal means by which the FAA communicates with the user community—the Nation's airport planners, designers, operators, and equipment manufacturers. Advisory circulars (AC) present the standards used in the design, construction, installation, maintenance, and operation of airports and airport equipment. In all projects funded through the Airport Improvement Program (AIP), project work must meet standards set in one of these AC's. This requirement ensures, for example, that the $100 billion investment in airport pavement is protected, by requiring pavement construction to meet standards for design, performance, and durability. In addition, these circulars provide information that promotes safe and efficient operation under adverse weather conditions.

Over 100 AC's have been published on a wide range of technical subjects, including airport design configuration standards, pavement design and material, lighting and navigational aids, firefighting equipment and procedures, pavement condition weather sensors, wildlife control, terminal building design, snow/ice control, and friction-measuring equipment and procedures.

The FAA updates AC's as and when necessary. The information and data collected in our entire Airport Technology R&D program culminates in the updated AC's.

Program Area structure

Various elements of the Airport Technology program area affect the safety and operation of aircraft at or near the airport. Factors that determine the eventual safety of a flight include:

- Push-back from gate
- Taxi to takeoff runway
- Visibility conditions
- Lighting, markings, and signs to guide the aircraft to the departure runway
- Other ground traffic
- Runway surface conditions
- Presence of birds or deer
- Available overrun area beyond the end of the runway
- Pavement structural integrity

In addition, the potential of rejected takeoff and possible rescue efforts is a safety concern associated with every flight. This program area systematically addresses these issues with a single determination to establish an operational environment that is free of accidents and fatalities.

Customer/Stakeholder Involvement

Airport Technology's major projects support the overall FAA mission of fostering a safe and efficient airport system. Runway traction research directly supports the FAA Challenge 2000 recommendation to develop new technologies and standards for runway friction measurement and safety overrun arrester systems.

Several issues in the Aviation Safety Plan are supported by Airport Technology research. These include preventing runway incursions; improving takeoff and landing performance monitoring; developing environmentally acceptable alternatives for deicing and anti-icing agents; and improving ground navigation technologies, planning, standards, signage, and procedures.

Airport Technology rescue and firefighting research supports an ICAO initiative to replace environmentally harmful Halon 1211 for extinguishing engine fires and other fuel fires.

Aircraft manufacturers and the FAA urgently need new pavement design standards for operating next generation heavy aircraft. Manufacturers need them to assure compatibility of their aircraft on airport surfaces throughout the world. The FAA needs them to assure the public that Federal funds for rebuilding or strengthening runways are being judiciously spent to protect the $100 billion infrastructure investment.

These standards will be developed from data collected on the National Airport Pavement Test Machine—the first-ever of its kind—over the next 10 years starting in late 1998. Both the FAA and the Boeing Company are stakeholders in this important project. Financed through a cooperative R&D agreement between the FAA and the Boeing Company, the design and construction of the Machine has been completed and operation of the facility began in December 1998. Boeing is providing $7 million (one-third of the total cost) towards its completion. The FAA, Boeing, and ICAO will develop pavement design standards for ensuring aircraft-airport compatibility on a worldwide basis.

Accomplishments

During the past 5 years, the Airport Technology Program has provided products that have enhanced the safety of aircraft operations in the United States and around the world. Research underway, and which will continue into the future, will save the public billions of dollars and protect the environment while attempting to provide an operational environment free of accidents and fatalities.

The Airport Technology Program has provided an engineering solution to aircraft overruns by developing the soft ground arresting system. The Port Authorities of New York and New Jersey have authorized installation of up to five systems at New York airports at a cost of $4.5 million. The first installation was completed in December 1996, and the second is underway.

The Airport Technology Program has developed a concept for an advanced taxiway system to automatically guide aircraft to and from runways and ramps during low-visibility conditions by controlling taxiway lights and signs without inputs from radar devices. A field demonstration is planned in FY 1999. This system will reduce inadvertent aircraft incursions.

The program has improved pavement marking performance by adding retro-reflective glass beads and silica, which enhances their visibility, durability, and skid resistance.

The program has successfully tested an innovative technology for aircraft deicing using infrared energy. The first installation was completed at Rheinlander airport in Wisconsin. This technology offers potential cost savings over conventional methods.

The program has introduced a new pavement design standard to accommodate the new Boeing 777. The new standard allows the aircraft to operate without weight penalties on existing pavements. Without this standard, hundreds of millions of dollars would have been needed to strengthen U.S. airport pavements.

The program has developed a Driver's Enhanced Vision System to allow airport rescue and firefighting vehicles to navigate through fog, rain, sleet, and snow. This technology enables quick and effective response to crash sites. Several airports around the country have adopted this technology for their rescue vehicles.

R&D Partnerships

The Airport Technology Program is committed to working closely with airport operators and experts from all branches of the aviation industry and with existing expertise and facilities in the Department of Defense, academics, highway sectors, foreign countries, and the ICAO. The program developed several cost-effective partnerships and agreements, including:

- FAA-U.S. Army Waterways Experiment Station, Interagency Agreement
- FAA-U.S. Army Philadelphia District Office, Interagency Agreement
- FAA-U.S. Air Force, Tyndall Air Force Base, Interagency Agreement
- FAA-University of Illinois/Northwestern University, Center-of-Excellence for Airport

Pavement Research, Partnership through matching funds

- FAA-Boeing Company, Cooperative Research and Development Agreement, Partnership through $7 million influx from Boeing towards the Test Machine
- FAA-Canada (Public Works and Government Services) Project completion of the $21 million Pavement Arrangement for cooperative research in pavement technology
- FAA-National Aeronautics and Space Administration (NASA) Memorandum of Understanding for joint runway traction research

Through these partnerships, research results are published in scientific journals, presented at technical conferences, and discussed at workshops.

Long-Range View

Support for friction testing of new products to eliminate slipperiness as a cause of accidents will continue beyond 2003. Operation of FAA's national pavement test facility began in December 1998 and will continue for 10 years. The data collected from the test machine will allow smooth introduction of new heavy aircraft expected to join the fleet well into the next century. The pavement design standards based on these data will:

- Provide assurance to manufacturers about the compatibility of their aircraft with airports throughout the world
- Provide airport operators precise costs estimates to permit new aircraft operations at their facilities
- Allow airlines to plan for new equipment and routes
- Give airport designers confidence in their designs

This long-range commitment to improving airport technology gives the FAA the tools required to assure the public that Federal funds are being judiciously spent and that public investment in infrastructure is prudently managed.

A05a Airport Technology

GOALS:

Intended Outcomes: The FAA intends to improve airport system safety, efficiency, and capacity through advancements in aircraft technology and air traffic control systems. The FAA will also develop and maintain standards in all airport system areas to:

- Reduce aircraft accidents due to incursions, particularly in low-visibility conditions
- Reduce aircraft accidents due to slipperiness caused by ice and snow on runways
- Reduce environmental impacts due to chemical usage on airports during winter operations
- Reduce the massive investment required for pavements
- Improve post-crash rescue and firefighting capabilities
- Reduce the negative impact of wildlife on airport safety

Agency Outputs: The FAA is required by law to develop standards and guidance material for airport design, construction, and maintenance. The FAA uses the airport advisory circular system as its principal means of communicating with a user community consisting of U.S. airport planners, designers, operators, and equipment manufacturers. AC's cover airport geometric design, pavement design, safety areas, visual aids, access roads, rescue and firefighting, ice and snow control, and wildlife control. The FAA and its regional offices enforce standards and guiding material when administering the AIP.

The Airport Technology program provides the technical information necessary to support and update these agency outputs in a timely manner.

Customer/Stakeholder Involvement: Approximately $2 billion is spent annually to provide operationally safe and reliable airport pavements. About half of this amount is provided by the FAA as AIP grants; the remainder is provided by State and local governments and airport operators. Projects funded under the AIP grants must conform to the FAA AC's or standards.

Aircraft manufacturers need new pavement design standards for operation of next-generation heavy aircraft to ensure compatibility of their aircraft with airport surfaces throughout the world. To accomplish this, the FAA and the Boeing Company have entered into a Cooperative Research and Development Agreement to build a unique full-scale pavement test facility at the agency's William J. Hughes Technical Center. Data collected from the project will be used by the FAA, the Boeing Company, and ICAO in developing international pavement design standards.

The FAA needs these standards to assure the public that Federal funds for rebuilding or strengthening runways are being judiciously spent and also to protect the $100 billion investment in the U.S. infrastructure.

Accomplishments: During the past five years, the Airport Technology research program has provided products to enhance the safety of aircraft operations in the United States and around the world. Research results are published as FAA AC's and made available to users worldwide. Some major accomplishments are:

- Installed soft-ground arresting systems for stopping aircraft overruns at a major international airport
- Installed prototype advanced taxiway guidance system
- Developed improved pavement marking for enhancing visibility, durability, and skid resistance
- Began operations of an aircraft deicing facility using infrared energy at a midsize airport
- Developed driver's enhanced vision system for firefighting vehicles to navigate in rain, snow, and fog
- Developed an environmentally acceptable replacement for the chlorofluorocarbon (CFC) ozone depletor Halon 1211
- Developed specification for 55-foot elevated boom and aircraft cabin skin-penetration system
- Issued new pavement design standards to allow operation of Boeing B-777 without weight penalties
- Established a Center of Excellence (COE) in Airport Pavement Research at the University of Illinois and Northwestern University

- Installed a comprehensive instrumentation system in concrete pavements at Denver International Airport
- Established an airport pavement data base containing field data collected at Denver International Airport, allowing on-line access to researchers worldwide
- Published a technical report, *Intermodal Ground Access to Airports: A Planning Guide*

R&D Partnerships:

- FAA-U.S. Army Waterways Experiment Station*
- FAA-U.S. Army Philadelphia District Office*
- FAA-U.S. Air Force, Tyndall Air Force Base*
- FAA-USDA, National Wildlife Research Center, Sandusky, Ohio*
- FAA-University of Illinois/Northwestern University (COE for Airport Pavement Research)**
- FAA-Boeing Company, Cooperative Research and Development Agreement ($7 million Boeing/$21 million total for National Airport Pavement Test Machine)***
- FAA-Agencies of Canadian Government (for pavement technology and winter operations safety)***
- FAA-NASA (for joint runway traction research)*
- FAA-Port Authorities of New York and New Jersey (for design and construction of aircraft arrestor bed)*
- FAA-industry (to test and develop infrared-deicing facilities and soft-ground arrestor materials)

* Interagency agreement or Memorandum of Agreement (MOA)

** Partnership through matching funds

*** Cost Sharing.

Through these partnerships, research results are published in scientific journals, presented at technical conferences, and discussed at workshops.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

Airport planning and design technology

- Continued data collection for taxiway centerline deviation study at John F. Kennedy Airport

Airport pavement technology

- Continued 3-dimensional finite element model (FEM) development: computational efficiency and model verification
- Updated pavement design program package (layered elastic design)
- Continued joint load transfer and layer interface models and field performance of stabilized base materials
- Continued data collection and analysis at Denver International Airport
- Published report, *Field Performance of Pre-Stressed Fibrous Concrete Pavements*

National Dynamic Airport Pavement Tests

- Completed construction and commenced test operations of the FAA's National Airport Pavement Test Machine

Airport safety technology.

- Published AC on aircraft arrestor beds
- Continued development means to acquire and report runway surface friction values for pilot use
- Completed installation and continued evaluation of prototype advanced taxiway guidance system
- Began designing next-generation airport circuitry/components test bed
- Initiated study on stability of heavy rescue vehicle and anti-rollover systems
- Continued development of the full-scale post-crash interior fire suppression facility to include second-level passenger seating cabin fires

KEY FY 2000 PRODUCTS AND MILESTONES:

- Begin data collection for taxiway centerline deviation study at Chicago O'Hare airport
- Complete pavement response tests

- Initiate performance (life) tests
- Analyze full-scale machine data to relate performance to designs
- Continue 3-dimensional FEM model development
- Continue data collection and analysis at Denver International Airport
- Conduct evaluation of prototype advanced taxiway guidance system.
- Issue specifications for improved airport lighting
- Publish testing standards for airport firefighting extinguishing agents
- Conduct study to develop new standards for anti-rollover and stability requirements for heavy airport rescue vehicles
- Publish specifications for aircraft infrared deicing system

FY 2000 PROGRAM REQUEST:

The Airport Technology FY 2000 research program is a collaborative effort among many government organizations, universities, and industry associations. The program funding requested provides the contract support necessary for an integrated, effective research program that delivers the standards and guidelines for maintaining and enhancing airport infrastructure.

A05a - Airport Technology Product and Activities	Program Schedule					
	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY2004
051-110 Airport Planning and Design Technology						
Continued Data Collection for Taxiway Centerline Deviation Study at JFK Airport	◆					
Continue Data Collection for Taxiway Centerline Deviation Study at Chicago O'Hare Airport		◇	◇			
051-120 Airport Pavement Technology						
Updated LEDFAA Pavement Design Program Package	◆					
Published Report on Field Performance of Pre-Stressed Fibrous Concrete Pavements	◆					
Continue 3D FEM Model Development	◆	◇	◇	◇	◇	
Continue Data Collection and Analysis at DIA	◆	◇	◇	◇	◇	
Analyze Full-Scale Machine Data to Relate Performance to Designs		◇	◇	◇	◇	◇
051-121 National Dynamic Airport Pavement Test						
Complete Construction of the National Airport Pavement Test Machine	◆					
Complete Pavement Response Tests		◇				
Initiate Performance (Life) Tests		◇	◇	◇	◇	◇
051-130 Airport Safety Technology						
Issued Specifications for Airport Signs	◆					
Published Advisory Circular on Aircraft Arrestor Beds	◆					
Designed Next Generation Airport Circuitry/Component Test Bed	◆					
Completed Installation and continued Evaluation Prototype Advanced Taxiway Guidance System	◆					
Initiated Study on Stability of Heavy Airport Rescue Vehicle	◆					
Conduct In-Service Evaluation Prototype Advanced Taxiway Guidance System at a Major Airport		◇				
Conduct Study to Develop New Standards for Heavy Airport Rescue Vehicles		◇	◇	◇		
Issued Specifications for Improved Airport Lighting		◇				
Publish Testing Standards for Airport Fire Fighting Agents		◇				
Publish Specification for Aircraft Infrared Deicing System		◇				
Develop Innovative Methods for Deicing/Anti-Ice Runways			◇			

Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	3,742	2,709	2,604	2,703	4,858
Personnel Costs	1,874	2,068	1,989	2,016	2,141
Other Costs	384	423	407	281	217
Total	**6,000**	**5,200**	**5,000**	**5,000**	**7,216**

2.3 Aircraft Safety

Mission

The mission of the Aircraft Safety program is to provide a safe global air transportation system by establishing safety standards and acceptable practices through development of technical information, tools, and technology to ensure safe operation of the civil aircraft fleet.

This program addresses the many hazards that face all aircraft in flight, as well as special hazards that apply to select portions of the civil aircraft fleet. For example, older aircraft are more susceptible to structural problems associated with fatigue and corrosion. New aircraft—with digital flight control and avionics systems, associated imbedded software, and construction of new nonmetallic materials—present significant challenges in certification, continued airworthiness, and operation. However, all aircraft, old or new, must deal with the hazards of adverse weather.

Intended Outcomes

The Aircraft Safety program supports the FAA's safety mission goal—by 2007, reduce U.S. aviation fatal accident rates by 80 percent from 1996 levels.

The Aircraft Safety program focuses on improving system safety in the following research programs:

- Support aging aircraft by developing technologies, procedures, and practices that ensure the continued airworthiness of aircraft structures in the civil flee
- Prevent catastrophic failure by developing technologies and methods that will assess the risk and prevent defects, failures, and malfunctions of aircraft, aircraft components, and aircraft systems that could result in catastrophic failure of the aircraft
- Promote flight safety and reduce the effects of atmospheric hazards by addressing atmospheric hazards in the design, development, and certification process
- Improve propulsion and fuel systems by enhancing the airworthiness, reliability, and performance of civil turbine and piston engines, their propellers, fuels, and fuel management systems
- Support fire research and safety by developing near-term fire safety improvements to prevent uncontrollable in-flight fires and increase post-crash fire survival rates and conducting long-range research to develop ultra fire-resistant cabin materials
- Promote advanced materials and structural safety by ensuring both the safety of U.S. civil aircraft constructed of advanced materials and passenger survival in the event of an accident
- Enhance aviation safety risk analysis by improving FAA and industry measurement of and accountability for safety performance through risk assessment and operational indicators and sharing safety-related data

Aircraft safety improvements will reduce fatalities and injuries, reduce hull losses, improve aircraft designs, positively affect aircrew performance, and impact maintenance and inspection procedures. Potential significant safety benefits include:

- Reducing the approximately 30 to 35 U.S. fire fatalities per year and 135 worldwide, in otherwise survivable accidents. At an estimated savings of $2.7 million per life, saving 24 lives per year would pay for the entire aircraft safety research, engineering, and development effort.
- Using a more reliable airframe inspection technique, which has been approved as an alternate inspection technique for detecting corrosion at the juncture of wing and fuselage on DC-9's. The new technique will save over 700 person-hours per inspection, compared to the current inspection method. The technique also requires less disassembly of the aircraft part to conduct the inspection, resulting in less chance for damage during disassembly and reassembly. One airline estimates that by using the new inspection technique, it can save over $2 million over the maintenance cycle for its fleet of DC-9s.

Program Area Outputs

The FAA establishes rules for aircraft certification, operation, inspection, maintenance and re-

pair, and publishes advisory circulars to outline acceptable means of meeting the rules. The FAA also disseminates technical information in various forms to agency airworthiness inspectors and to industry to improve aircraft construction and maintenance practices. Technical information is developed to establish criteria for safety systems, such as seat restraints and protective breathing equipment.

The primary objective is to improve system safety based on elimination of causal factors related to aircraft and flight hazards. Aircraft safety research provides the technical information necessary to support agency outputs.

Aircraft Safety program research customers include aviation manufacturers and aircraft and avionics maintenance facilities, aircraft operators, and the general public who use commercial air transportation. The safety research program supports customer requirements by providing tools that can demonstrate compliance and developing advisory information to ensure the safety of the flying public. Aviation safety research sponsors are FAA personnel in Flight Standards (AFS) and Aircraft Certification (AIR). The aircraft safety program supports sponsor requirements by providing the research to aid rulemaking and regulation development and by developing technical data and guidance material to develop standards, rules, and regulations.

Program Area Structure

The Aircraft Safety program includes research in a wide range of areas related to aircraft, crew, and passenger safety. It focuses on eliminating hazards to the air transportation system, by both preventing accidents from happening and by mitigating the effects of those accidents that do occur. Prevention and mitigation activities include:

- Accident and incident prevention
  - – Structural integrity (preventing aircraft structural failure)
  - – Propulsion systems (ensuring reliable aircraft power)
  - – Flight safety (minimizing operational hazards)
  - – Mechanical and electrical system reliability and integrity (reducing aircraft systems failure)
- Accident and incident mitigation
  - – Crashworthiness (maximizing crash survivability and escape)
  - – Fire safety (preventing fire and fire fatalities)

Customer/Stakeholder Involvement

Research programs within the Aircraft Safety program directly support the Aviation Safety Plan (February 1996) through research supporting priority issues associated with the following workshops: safety data collection and use, application of emerging technologies, and aircraft maintenance procedures and inspection.

The Subcommittee on Aircraft Safety, of the FAA Research, Engineering, and Development Advisory Committee, periodically reviews segments of the Aircraft Safety program area. Most recently the subcommittee completed a review of the Aging Aircraft program in 1997. The program described here is fully responsive to the advice of the subcommittee.

The FAA's primary mission, as originally mandated in Sections 312 and 316 of the Federal Aviation Act of 1958, is to develop, modify, test, and evaluate systems, procedures, facilities, and devices to meet the needs of safe and efficient aviation.

The FAA's research mission was expanded when Congress passed the legislation known as the Aviation Safety Research Act of 1988 (Public Law 100-591). The act mandates the FAA to "undertake or supervise research to develop technologies and to conduct data analysis for predicting the effects of aircraft design, maintenance, testing, wear, and fatigue on the life of aircraft and on air safety, to develop methods of analyzing and improving aircraft maintenance technology and practices." The 1988 act also authorized the FAA to generate technology breakthroughs where technology gaps need to be closed while emphasizing the importance of long-range research.

Passage of the Aircraft Catastrophic Failure Prevention program under the Omnibus Reconciliation Act of 1990 (Public Law 101-508) further ex-

panded the FAA research mission. While the FAA mission originally focused on airplane improvements, the 1990 amendment added proactive research to make airplanes free from catastrophic failure.

Safety aviation research will reduce the hazards of operating aircraft, thus providing a high level of safety. Much of the technology developed will also enhance U.S. aviation industry competitiveness, for both manufacturers and operators.

Accomplishments

Research results are disseminated to the agency (aircraft certification and flight standards) and to industry (aircraft manufacturers, operators, and maintainers) as:

- Technical and regulatory guidance for airframe maintenance in the form of handbooks, technical bulletins, aircraft-specific inspection requirements, advisory circulars, and rules
- Validated instrumentation, procedures, and methodologies for aircraft maintenance, inspection, and repair
- Reports that provide relevant technical information for aircraft manufacturers, operators, and maintainers
- Technical data provided to the community at conferences, symposia, workshops, and hardware/software prototype demonstrations
- Criteria to support certification of aircraft and their safety and emergency equipment
- Technical data to support regulatory oversight in inspection, maintenance, repair, and standards development
- Training materials in areas such as damage tolerance requirements, corrosion control, inspection, and maintenance and repair

Several prototype inspection devices developed tested, and validated in this research program have shown significant potential for more accurate, reliable flaw detection in the airframe and in engines. One method for engine component inspection in particular has shown a fourfold improvement in sensitivity for detecting the type of flaw that led to the 1989 Sioux City accident that killed 211 people.

Numerous advisory circulars (AC's) have been developed for a wide range of aviation safety-related activities, including crew resource management, design of composite structures, corrosion control, aircraft deicing, inspection, and repair. AC's controlling aircraft ground deicing for both large transport airplanes (AC 120-58, 9/92) and smaller commuter airplanes (AC 135-17, 12/94) are aimed at ensuring the safe operation of large airplanes and air taxis during icing conditions. These AC's provide guidelines for developing adequate deicing procedures.

Technical data have been developed to support standards development and the certification process and the Airworthiness Directive (AD) and Notice of Proposed Rulemaking (NPRM) issuance. For example, an alternative method of compliance was developed for composite structures that significantly reduced fatigue testing time to ensure required service life. This method has been used successfully in the certification process of many aircraft components (a recent example: General Electric GE90 turbofan engine fan blades) and has been adopted as an international standard.

R&D Partnerships

Program activities are closely coordinated with related initiatives underway within other Government agencies, including the Department of Energy (DOE), the Department of Defense (DOD), and the National Aeronautics and Space Administration (NASA). Formal agreements of cooperation are in place with the Air Force, Army, Navy, NASA, DOE, and in developing standardization data for materials in MIL-HDBKS 5 and 17.

International agreements are in place with Government agencies and research laboratories in the United Kingdom, the Netherlands, France, Italy, Australia, Canada, and Russia.

Numerous grants are in place with universities and research laboratories to leverage their interests and capabilities. Partnerships have been established with academia and industry through consortia and centers of excellence. For example, the Airworthiness Assurance Center of Excellence (AA-COE) was established in September 1997 to conduct research in the areas of:

- Maintenance, inspection, and repair
- Crashworthiness
- Propulsions and fuel systems safety technologies
- Advanced materials

The AA-COE consists of 9 core members, 68 industry partners, 31 university affiliates, and 12 other partners, including other Government laboratories and state organizations. The COE provides matching funds, which solidify a significant COA-FAA partnership. Through this partnership, the Government, academic institutions, and industry leverage the resources available for aviation research.

Technology Transfer

Technology transfer occurs through a variety of mechanisms:

- Technical reports documenting research results
- Conferences on a wide range of subjects designed to disseminate technical information
- Technical organizations, such as the American Society on Testing and Materials (ASTM), Society of Automotive Engineers (SAE), and American Institute of Aeronautics and Astronautics (AIAA), that use study committees to ensure the transition of research results to standards, guidelines, etc.
- Hardware and software prototype demonstrations and technology workshops
- The FAA Aging Aircraft Nondestructive Inspection Validation Center (AANC) demonstrations and validations of cost-effective aircraft inspection equipment and techniques to industry

Long-Range View

The need for safety and safety-related research will continue indefinitely. With the emergence of new and advanced technologies, there will be an ongoing need to improve air transportation system safety. There will always be a need to understand the impact of new technology on operator performance. As air traffic continues to increase, and as aircraft continue to age, there will always be a need to address issues related to aging aircraft.

With new technology, new damage mechanisms may occur, introducing hazards that must be understood and addressed. Similarly, medical advances in diagnosis and treatment force a continuing examination of crew or passenger limitations in existing and future aircraft. Research in aircraft safety must be continued to understand the impact of changes in technology on current regulatory safety standards, certification procedures, and acceptable practices for demonstration of compliance mandates.

A06a Fire Research and Safety

GOALS:

Intended Outcomes: The FAA intends to improve system safety by developing technologies, procedures, test methods, and criteria for preventing accidents caused by in-flight fires and eliminating burning cabin materials as a factor in post-crash fire survivability. The Fire Research and Safety program focuses principally on:

- Long-term research to develop new interior materials that meet fire-resistance criteria mandated in the Aviation Safety Research Act of 1988
- Near-term improvements in aircraft fire detection and suppression systems and interior materials fire test methods and criteria

Agency Outputs: The FAA establishes rules for aircraft fire safety in terms of material selection, design criteria, and operational procedures. The agency also provides advisory material on methods of compliance with fire safety regulations and guidelines. The Fire Research and Safety program is the major source of technical information used to develop this regulatory material. Additionally, the program provides industry with new safety products developed through long-term applied research. These products are typically embodied by new materials and formulations, new test methods, government-owned patents, reports, and journal publications.

Customer/Stakeholder Involvement: The FAA has broad industry and government participation in each aspect of the Fire Research and Safety program.

- The subcommittee of the FAA Research, Engineering and Development Advisory Committee has repeatedly endorsed the Fire Research and Safety program and placed high priority on its activities.
- Long-term research in fire-resistant materials is required by specific language in the Aviation Safety Research Act of 1988 and is directly supported by the aircraft industry and materials producers through university-based FAA research consortia.
- The aircraft manufacturers and airlines have a need to evaluate halon replacement agents and improve interior material fire tests. Recognizing FAA's unique capabilities in fire safety, the aviation industry actively participates in separate working groups headed by the FAA to develop approval standards for halon replacements and improved material fire tests. Foreign airworthiness authorities are active participants as well, to ensure harmonization of outputs.
- The National Transportation Safety Board (NTSB) relies heavily on program personnel for onsite accident investigation, such as the ValuJet and TWA 800 accidents.

Accomplishments: Fire research and safety results were provided to FAA certification and inspection personnel for use in fire safety regulations and advisory material, approval of regulatory fire test procedures, and approval of aircraft fire protection installations. Recent program accomplishments:

- Supported a major new regulation, issued February 10, 1998, that requires the retrofit of 2,994 transport aircraft with cargo compartment fire detection and suppression systems
- Documented full-scale fire tests, demonstrating significant fuselage burnthrough improvements provided by new or protected thermal acoustical insulation materials
- Documented full-scale fire test findings related to cargo compartment fire protection, including the effectiveness of halon against aerosol cans and oxygen generator fires, and the effectiveness of halon replacement agents
- Published technical report describing initial development of an exploding aerosol can simulator
- Published final report reviewing flammability hazard of Jet A fuel vapor in civil transport fuel tanks
- Developed computer program that predicts the probability of a fuel tank explosion based on input flight and fuel temperature profiles
- Completed large-scale fire tests and recommended a draft thermal protection test standard related to the shipment of pressurized

oxygen bottles in support of pending rulemaking

- Demonstrated near-zero heat release of chlorobisphenol polymers (potential for entire family of cost-effective, noncombustible plastics and resins for aircraft cabins)
- Developed accurate, simple model of fuel generation process in burning plastics to guide development of new, low-heat-release materials
- Determined that health hazards of airborne fibers from burning carbon fiber-reinforced aircraft composites are negligible for firefighters and airport personnel
- Determined that fire retardant chemical additives are not effective in heat-resistant polymers

In addition, about 24 reports and published papers are generated yearly from in-house activity. Fire test laboratories are used annually to train FAA certification engineers, and program personnel participate in approximately three major accident investigation yearly at NTSB request. The FAA operates the most extensive aircraft fire test facilities in the world.

R&D Partnerships: The FAA sponsors an international halon replacement working group. The group collaborates in research and development leading to alternate agent selection for aircraft applications as well as test methods and criteria. The FAA also sponsors an international aircraft materials fire test working group. This group strives to improve standardization of material fire tests, such as engaging in round-robin testing to ensure that the lab-to-lab variation in results is acceptably small.

The FAA organized an interagency working group on fire and materials to provide a vehicle for technology exchange among U.S. Government agencies and to prevent unwarranted duplication of work. The FAA has interagency agreements with the U.S. Air Force and the National Institute of Standards and Technology for common-interest research. The agency has a memorandum of cooperation with the British Civil Aviation Administration for a variety of fire safety research efforts and separate letters of cooperation with Canadian, Japanese, and European aviation authorities.

The Fire Research and Safety program also has grant programs with many educational institutes. Several Fortune 500 companies share costs of developing new fire-resistant materials at university-based FAA research consortia.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

Fire resistant materials

- Scaled up benzoxazine chemistry and produced fire resistant, nontoxic interior panels for evaluation of heat release rate
- Demonstrated decorative panel with 50 percent reduction in heat release rate
- Demonstrated optimized design, theory, and operation of microscale heat release rate calorimeter for commercialization
- Published heat release rate database on current, new, and developmental fire-resistant polymers

Fire detection and suppression

- Developed performance standards for gaseous halon replacement agents in cargo compartment and engine fire-extinguishing systems
- Evaluated aircraft smoke/fire detector responsiveness and characterized smoke environment during full-scale cargo compartment fire tests

Fire safety design

- Developed a stringent fire test standard for thermal acoustical insulation
- Completed design guidelines for post-crash fire burnthrough resistance hardening of aircraft fuselages
- Published upgraded *Aircraft Materials Fire Tests Handbook*

KEY FY 2000 PRODUCTS AND MILESTONES:

Fire-resistant materials

- Demonstrate thermoplastic for molded parts with 50 percent reduction in heat release rate

- Determine heat-release rate of chlorobisphenol-based polymers

Fire detection and suppression

- Complete cargo compartment water mist fire suppression system evaluation
- Complete full-scale test evaluation of solid propellant gas generator technology for application in engine fire extinguishing systems
- Develop smoke/fire simulants for use in cargo detector approval testing
- Determine fuel tank explosive hazards of fuel pump sprays

Fire safety design

- Initiate study of aircraft hull losses and fatalities caused by oxygen system malfunction or damage

FY 2000 PROGRAM REQUEST:

In FY 2000, long-range research on ultra fire-resistant aircraft interior materials will focus on synthesizing and evaluating the heat-release rate of an entire class of promising polymers based on a chlorobiphenol monomer. Also, as part of a multiyear endeavor to demonstrate interim improved material performance, thermoplastics for use in molded parts with a 50 percent reduction in heat-release rate will be identified. Near-term fire safety improvement testing will concentrate primarily on fire detection and suppression. Solid propellant gas generator technology developed by the military will be evaluated for application in civil transport engine fire-extinguishing systems. The effectiveness of water mist systems against various types of cargo compartment fires, including those fires involving aerosol cans, will also be determined. Additionally, smoke and fire simulants will be developed and evaluated for use in smoke detector certification testing. New research and testing related to fuel tank explosion will determine the hazards of fuel pump sprays commonly used in fuel tank systems. Finally, work will commence related to oxygen system fire safety by initiating a study to document and analyze past aircraft fire fatalities and hull losses caused by the malfunction or crash impact damage of oxygen systems.

A06a - Fire Research and Safety Product and Activities	Program Schedule					
	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY2004
061-110 Fire Research & Safety						
Fire Safety Design						
Initiated Study of Aircraft Hull Loses and Fatalities Caused by Oxygen System Malfunction or Damage	◆					
Published Upgraded Material Fire Test Handbook	◆					◇
Completed Design Guidelines for Postcrash Fire Burnthrough Resistance Hardening of Aircraft Fuselages	◆					
Evaluate In-flight Flame Spread Characteristics of Thermal Acoustical Insulation		◇				
Fire Resistant Materials						
Scaled-Up Benzoxazine Chemistry and Produced Fire Resistant, Non-toxic Interior Panels for Evaluation of Heat Release Rate	◆					
Demonstrated Decorative Panel with 50% Reduction in Heat Release	◆					
Published Database on Heat Release Rate of Current, New and Developmental Fire Resistant Polymers	◆					
Demonstrated Optimized Design, Theory and Operation of Microscale Heat Release Rate Calorimeter for Commercialization	◆					
Demonstrate Thermoplastic for Molded Parts with 50% Reduction in Heat Release Rate		◇				
Determine Heat Release Rate of Chlorobiphenol-based Polymers		◇				
Fire Detection and Suppression						
Completed Cargo Compartment Water Mist Fire Suppression System Evaluation	◆					
Developed Performance Standards for Gaseous Halon Replacement Agents in Cargo Compartment & Engine Fire Extinguishing Systems	◆					
Evaluated Aircraft Smoke/Fire Detector Responsiveness and Characterized Smoke Environment	◆					
Determine Fuel Tank Explosive Hazards of Fuel Pump Sprays		◇				
Complete Full-scale Test Evaluation of Solid Propellant Gas Generator Technology		◇				
Revise Draft Advisory Circular for Smoke/Fire Detection			◇			
Criteria for Approval of Reduced False-Alarm Smoke/Fire Detector Designs				◇		
Assess O2/N2 Separation Membrane Technology				◇		
Draft Oxygen Systems Safety AC						◇

Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	1,999	2,963	3,377	2,098	2,070
Personnel Costs	3,072	3,345	3,001	2,315	3,116
Other Costs	629	685	615	337	342
Total	**5,700**	**6,993**	**6,993**	**4,750**	**5,528**

A06b Advanced Materials/Structural Safety

GOALS:

Intended Outcomes: The FAA intends to ensure the safety of U.S. and foreign made civil aircraft constructed of advanced materials as well as to improve passenger survival of accidents. The advanced materials area focuses on the following technical areas:

- Standardized analysis and test methods for worldwide harmonization
- Better understanding of effects of repeated loads, damage, and joint configurations on remaining strength and life of composite aircraft structure
- Reliability methods, as they apply to the design of composite aircraft components, and criteria for acceptable risk

The structural safety area focuses on the following technical areas:

- Enhanced occupant survivability and reduced personal injury in accidents
- Improved crash characteristics of aircraft structures, cabin interiors, auxiliary fuel tank systems, and occupant seat/restraint systems
- Improved analytical and modeling capabilities to develop improved structural, occupant, and seat restraint systems

Agency Outputs: The FAA establishes rules for aircraft certification and operation and publishes advisory circulars to provide acceptable means of achieving compliance with those rules. While the rules are the same for composite or metal structure, the means of compliance reflect behavioral differences in the structural materials. AC 20-107A, "Composite Structure," has been published, but advances in technologies and materials necessitate periodical update and expansion of the AC.

Technical information is disseminated to regulatory personnel through technical reports, handbooks, and guidance by the FAA National Resource Specialist. The goal is to develop pertinent data so that the regulatory processes keep pace with industry advances, including state-of-the-art test and evaluation for state-of-the-art technology and design.

The Advanced Materials/Structural Safety program provides support in rulemaking and development of guidance material for industry compliance. In structural safety, the FAA revises or updates Federal Aviation Regulations to accommodate new information for overhead stowage bins, auxiliary fuel tanks, and seat/restraint systems.

Customer/Stakeholder Involvement: The FAA has established the need for the Advanced Materials/Structural Safety program through consensus building activities:

- The Aviation Rulemaking Advisory Committee (ARAC) is an FAA/industry forum established to ensure that agency rulemaking is effective in achieving intended results. ARAC is also effective in identifying requirements and priorities for supporting R&D activities.
- The Challenge 2000 report concludes that FAA should enhance its already effective program of gathering data and improving the certification of composite structures.
- A recent National Research Council report highlights the needs related to advanced materials and urges FAA to step up advanced materials research for aircraft community benefits.
- The Advanced Materials/Structural Safety program is responsive to Public Law 100-591, Aviation Safety Research Act of 1988, and House of Representatives Report 100-894 to develop technologies, conduct data analysis for current aircraft, and anticipate problems of future aircraft.

Accomplishments: Program results are provided to aircraft manufacturers, maintainers, and operators in the form of technical reports, handbooks, advisory circulars, and guidance in the process of certification.

In the advanced materials area, the program has updated or issued two advisory circulars and four handbooks; published more than 40 technical reports, articles, and papers; and co-sponsored 3 technical conferences with attendance of approximately 1,200 experts. A three-volume report on test methods for composites was disseminated to industry and government to provide an authorita-

tive compendium on state-of-the-art composites testing with recommendations for usage and identified gaps. An alternative method of compliance to demonstrate repeated load life was developed and now significantly reduces fatigue testing time to ensure required service life. This method has been used successfully in the certification process of many aircraft components (recent example: the General Electric 90 fan blades) and has been adopted on a world-wide basis.

In the structural safety area:

- Four reports on in-house commuter crash testing, as well as reports on aircraft ditching and aircraft flotation, have been widely disseminated.
- Rulemaking has been proposed for commuter seat/restraint systems.
- Inservice overhead stowage bins have been made more resilient to crash impact.
- A workshop on a crash impact modeling code developed by the FAA was held for certification engineers and industry participants

R&D Partnerships: In the advanced materials area, the FAA coordinates with NASA to leverage research expenditures. The FAA concentrates on safety and certification issues, including testing, while NASA has the lead in analysis and design issues. Currently, the FAA supports NASA efforts to develop a composite property data base for general aviation (GA) aircraft under the NASA Advanced General Aviation Transport Experiments (AGATE)/Integrated Design and Manufacturing (IDM) program.

The FAA co-sponsors, with the U.S. Army, MIL-HDBK-17, a primary and authoritative source for statistically based characterization data of current and emerging composite materials. This international reference reflects the best available data and technology for testing and analysis and includes data development and usage guidelines. FAA officials use the handbook as a primary supporting document in structural substantiation in the certification process. On recommendations by the ARAC committee, material data contained in the handbook will be acceptable for use in the certification process. There is also one international agreement to share work on reliability prediction methods for composites.

In the structural safety area, there have been agreements for cooperative programs with the National Highway Traffic Safety Association (NHTSA), the U.S. Army, the U.S. Navy, and NASA Langley Research Center. There has been coordination with the French and Italian Governments through memoranda of cooperation and an exchange of personnel in the crash testing area. A cooperative research program in development of crash modeling software tools is underway with the United Kingdom. The program has also worked closely with Wichita State University to develop crash dynamic models and experimental, energy-absorbing seats. The structural safety area has established working relationships with airframers, such as Boeing Company and Beechcraft, and with manufacturers of overhead bins and auxiliary fuel tanks. A cooperative agreement for research and development is in place with bin manufacturer Northwest Composites.

The advanced materials and structural safety areas are benefiting from a close working relationship with the Airworthiness Assurance Center of Excellence. The research performed under this program is leveraged by the monetary and intellectual contributions of its core universities.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

Advanced materials

- Updated *Composite Materials Handbook* (*Volume 2–Material Properties*) for use by rulemaking and compliance personnel
- Completed research on damage accumulation in composites due to repeated loads. This aids in developing certification criteria for composite structural components
- Verified previously developed risk assessment software using different estimation methods
- Identified the principal risk drivers that control the safety of composite airframes
- Provided data base on test methods for shear loading of composite structures to provide information for an authoritative compendium on state-of-the-art composites testing, with recommendations on test methods

Structural safety

- Completed vertical drop test of one B-737 fuselage section with an auxiliary fuel tank to determine the dynamic loads imposed on fuel tanks

KEY FY 2000 PRODUCTS AND MILESTONES:

Advanced materials

- Establish methodology to predict delamination initiation and growth at critical details in composite structures
- Provide a data base for support to AGATE/IDM on effects of bond thickness on structural performance of small composite aircraft
- Generate a data base for durability of textile forms and stitching as manufactured by resin transfer molding

Structural safety

- Complete vertical drop test of a B-737 fuselage section with overhead storage bins to determine the dynamic loads imposed on storage bins
- Complete assessment of the crash resistance of current rotorcraft, commuter, and transport fuel systems
- Establish guidelines for conducting head injury criteria component testing to supplement full-scale testing
- Complete aircraft crash modeling tool for accident investigators

FY 2000 PROGRAM REQUEST:

In FY 2000, the program continues to focus on the areas listed at the beginning of the "Goals" section above. Specific areas are damage tolerance of sandwich structures applicable to current and future aircraft fuselages, durability of textiles, and developing a data base on effects of bond thickness on structural performance of small bonded composite aircraft.

Within the structural safety area, characterization of crash-induced commuter airplane loads, transport category overhead storage bins, and auxiliary fuel tank systems are continued. Other areas of research to be continued are crash resistance of fuel systems and development of a component tester for head injury criteria compliance.

A06b - Advanced Materials/Structural Safety Product and Activities	Program Schedule					
	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY2004
062-111 Advanced Materials Structures						
Advanced Materials						
Provided Database on Test Methods for Shear Loading	◆					
Verified Developed Risk Assessment Software	◆					
Identified the Principal Risk Drivers of Composite Airframes	◆					
Establish Methodology to Predict Delamination Initiation		◇				
Establish Database on Effects of Bond Thickness		◇				
Generate Database for Durability of Textile Forms		◇				
Update AC-107A Composite Structure for Durability			◇			
Establish Guidelines for Probabilistic Design Certification				◇		
Develop Database on Verified Design Practice for Adhesive Joints				◇		
Develop Database on Damage Tolerance of Sandwich Structure					◇	
Durability and Damage Tolerance Data for Rotorcraft					◇	
Identify Data for Certification of Materials at Elevated Temperatures						◇
Develop Certification Methodology for New Materials and Forms						◇
062-110 Structural Safety						
Structural Safety						
Completed Vertical Drop Test of a B737 Fuselage Section with Auxiliary Fuel Tank	◆					
Establish Guidelines for Conducting HIC Component Testing		◇				
Complete Assessment of the Crash Resistance of Transport Fuel Systems		◇				
Complete Vertical Drop Test of B737 Fuselage Section with Stowage Bins		◇				
Complete Aircraft Crash Modeling Tool for Accident Investigators		◇				
Publish Data on Ditching and Water Impact			◇			
Publish Data on Crash Resistance of Transport Aircraft Stowage Bins			◇			
Identify Transport Ditching Requirements				◇		
Define Rotorcraft Crash Pulse					◇	
Define New Occupant Injury Criteria					◇	
Establish Crash Test Database						◇
Validate Water Impact Model						◇

Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	332	1,249	2,059	809	1,089
Personnel Costs	1,384	1,507	835	803	1,109
Other Costs	284	309	171	122	140
Total	**2,000**	**3,065**	**3,065**	**1,734**	**2,338**

A06c Propulsion and Fuel Systems

GOALS:

Intended Outcomes: The FAA intends to improve system safety by enhancing the airworthiness, reliability, and performance of civil turbine and piston engines, their propellers, fuels, and fuel management systems. The major program outcomes include:

- Continued reliability and safety of general aviation operations by providing a safe transition to a new high octane unleaded aviation gasoline
- A reduction in the number of intrinsic turbine rotor failures by improved and standardized design and life-management procedures
- Improved manufacturing process standards for premium quality titanium alloy, turbine rotor components
- Reduced turbine engine failure/downtime and improved maintenance efficiency through advanced monitoring/diagnostic hardware and software
- Minimized the probability of in-flight fuel tank explosions
- Continued reliability and safe use of Jet A fuel containing red dye contamination

Agency Outputs: The FAA maintains the airworthiness of aircraft engines, fuels, and airframe fuel management systems by issuing certification and advisory standards and by supporting technical society specifications and recommended practices. The FAA also publishes technical information in the public domain in various forms. The agency may also provide technology to the industry through hardware and software prototype demonstrations and technology workshops or various training media. This research program provides the resources and oversight to deliver the necessary propulsion, fuel, and fuel transfer system technology to support these agency outputs.

Customer/Stakeholder Involvement:

- The FAA collaborates with the engine industry to identify and implement cost-effective safety improvements that address incidents and accidents caused by in-service engine failures. This collaboration was initiated by the FAA Titanium Rotating Components Review Team. The team advises on the adequacy of industry standards and procedures to ensure the safety of titanium alloy high-energy rotating components of turbine engines. Industry participates through working committees under the Aerospace Industries Association (AIA), including the Materials and Structures Committee, Rotor Integrity Subcommittee, and the Jet Engine Titanium Quality Committee.
- The AIA committees identify potential improvements in manufacturing process control, manufacturing and in-service inspection, and design and life management of failure-critical rotating engine parts. These improvements are the basis for identifying specific R&D already underway or planned for this program.
- The FAA participates and provides leadership in testing capability for the Coordinating Research Council (CRC) Unleaded AVGAS (Aviation Gasoline) Development Group. The group was formed in February 1995 to oversee research and testing for development of the next generation of high-octane unleaded aviation gasoline. Environmental Protection Agency (EPA) regulations and the Clean Air Act of 1990 mandate removal of lead from all gasoline.

  The critical need for developing this fuel is reflected by the list of CRC development group participants. Active participants and members include: most major oil companies (U.S. and worldwide); general aviation airframe and engine manufacturers; general aviation user groups such as the Aircraft Owners and Pilots Association (AOPA), Experimental Aircraft Association (EAA), and General Aviation Manufacturers Association (GAMA); the FAA New England Region Engine and Propeller Directorate; and the FAA Small Airplane Directorate in Kansas City.
- The FAA-sponsored Technical Oversight Group on Aging Aircraft (TOGAA) ensures effective technical coordination of the airworthiness assurance R&D activities with related activities in DOD and industry. TOGAA has

provided feedback on the progress of the turbine engine program over the last 3 years.

- The Subcommittee on Aircraft Safety of the FAA Research, Engineering, and Development Advisory Committee was briefed on the propulsion program, an initiative that the subcommittee strongly supports.
- The FAA/industry initiative on turbine engine rotor integrity research in this program addresses NTSB recommendations A-90-89 and A-90-90.
- The program addresses recommendations of the FAA Titanium Rotating Components Review Team Report which was presented to industry in a public meeting in May 1991.
- The program supports the ARAC Fuel Tank Harmonization Working Group.
- The Aerospace Industries Association convened an ad hoc group to study the effects of red dye contamination of Jet A fuel and to identify solutions to this problem. This resulted in an effort to be funded by the FAA, Defense Energy Support Center, Internal Revenue Service (IRS), Air Transport Association, American Petroleum Institute, and engine and airframe manufacturers.

Accomplishments: Results of the Propulsion and Fuels Research program provided to engine and aircraft regulatory and industry stakeholders:

- Drafted an advisory circular on the correlation, operation, design, and modification of turbofan/jet engine test cells that provides guidance on the testing of aircraft engines.
- Hosted a joint FAA/Air Force public workshop with published proceedings on the application of probabilistic design methodology to gas turbine rotating components
- Demonstrated integrated titanium alloy probabilistic design code (DARWIN version 2.0) to provide commercial aircraft engine manufacturers a tool to augment their current safe-life management philosophy approach
- Completed vacuum fatigue crack growth testing of titanium alloy
- Determined the fleet octane requirement to be the single most critical parameter for developing high-octane unleaded aviation gasoline
- Completed validation of ground-based procedures for determining octane requirements for developing a new high-octane unleaded aviation gasoline
- Participated in establishing matrix components for developing candidate fuel formulations
- Conducted engine tests on new fuel formulations
- Completed report on engine octane requirements
- Determined and defined detonation detection procedures for proposed ASTM method to test unleaded replacement fuel(s)
- Made final determination of fleet octane requirements for unleaded replacement in high fuel performance piston engines to be greater than 100 octane
- Completed interim report on in-service Jet A fuel sample analysis volatility survey
- Completed interim data report on Jet A fuel vapor ignition characterizations

R&D Partnerships:

- A cooperative grant was awarded to the Southwest Research Institute, which has teamed with major engine manufacturers Pratt and Whitney, General Electric, Allied-Signal, and Allison. This work develops probabilistic-based turbine rotor material design and life management tools for improved rotor integrity. The work is closely coordinated with the Air Force Wright Laboratory, which conducts complementary research, and with ongoing research activities of the FAA Engine Titanium Consortium sponsored under budget item A06e, “Aging Aircraft.” The FAA plans to transfer the completed probabilistic engine design code to the public domain via a training workshop.

  A research partnership has been initiated with Specialty Metals Processing Consortium (SMPC) based at Sandia National Laboratory, which includes Sandia Liquid Metals Processing Laboratory, Allvac, Oremet Titanium Company, RMI Titanium Co., Timet Co., General Electric Aircraft Engines, Pratt & Whitney, and Concurrent Technology Corporation. SMPC will conduct research in tita-

nium and nickel alloy melting technology (purity) enhancements.

- The CRC Unleaded Aviation Gasoline Development Group partnership provides an arena to conduct research that is unprecedented in the aviation gasoline industry. The proprietary and competitive forces inhibiting progress in high-octane aviation gasoline development have been set aside. This allows technology be transferred to and from government and industry to the benefit of all participants. Industry participants include Texaco, Exxon, Phillips Petroleum, Chevron, British Petroleum, Cessna, Raytheon (Beech), Teledyne Continental, and Textron Lycoming.
- Efforts have been initiated to award a contract to Southwest Research Institute to determine an acceptable contamination that allows continuous safe turbine engine operation. The following organizations contribute funding to this effort: FAA, Defense Energy Support Center, IRS, Air Transport Association, American Petroleum Institute, General Electric, Pratt & Whitney, Rolls Royce, AlliedSignal, and Boeing.
- The program is benefiting from a close working relationship with the Airworthiness Assurance Center of Excellence. The research is leveraged by the monetary and intellectual contributions of its core universities.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

- Demonstrated and delivered the final titanium alloy defect deformation micro code for analysis of the turbine disk forging conversion process
- Demonstrated and delivered the integrated probabilistic rotor design code (DARWIN version 3.2) for titanium alloy melt defects
- Conducted DARWIN code version 3.2 FAA/ Industry training workshop
- Issued reference report “State-of-the-Art in Turbine Engine Monitoring Systems”
- Completed laboratory characterization of industry-supplied candidate fuels
- Began engine ground testing of industry supplied candidate unleaded fuels
- Issued final draft report on Jet A vapor ignition characterizations
- Issued final draft report on in-service Jet A fuel sample analysis volatility survey

KEY FY 2000 PRODUCTS AND MILESTONES:

- Deliver a framework definition for probabilistically based rotor design code for nickel alloys
- Introduce damage-tolerant rotor design through a draft advisory circular with analytical software code (DARWIN) and standardized data bases
- Complete benchmark basis for plasma hearth melt modeling
- Characterize titanium defect melt source causes
- Characterize and test industry-supplied candidate fuels using flight test aircraft and engine ground test facilities
- Determine an acceptable concentration of red dye contamination in Jet A fuel for continuous engine operation

FY 2000 PROGRAM REQUEST:

In FY 2000, the program will continue developing a probabilistically-based turbine engine rotor design code with damage-tolerance assessment. This code will be a public-domain, generic-design, life management tool—to augment the current safe-life design approach—for integration into engine manufacturer rotor design procedures. Use of this tool, as an approved design certification standard, is intended to improve turbine rotor structural integrity while reducing the risk of failure.

The program also continues research on industry-provided, lead-free fuel formulation candidates to replace the low-lead aviation gasoline (ASTM D910 100LL) currently in use. These tests evaluate new fuel formulation effects on engine detonation, material compatibility, volatility, engine performance, storage stability, water reaction, emissions, fuel consumption, and engine durability. All parameters impact on safe engine operation and all data support eventual certification of a replacement fuel.

The program continues to develop rotor disk alloy material melt processes to establish commercial manufacturing standards that will eliminate metallurgical defects to produce premium-quality, rotor grade alloy materials. Commercial aircraft accident history has shown that the presence of these defects in rotor disks have been the initiating cause of uncontained rotor failures. These failures are a major contributor associated engine failure fatal accident rate.

A06c - Propulsion and Fuel Systems Product and Activities	Program Schedule					
	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY2004
063-110 Propulsion and Fuel Systems Research						
Turbine Engine Research						
Demonstrated and Delivered Final Titanium Alloy Defect Deformation Microcode	◆					
Demonstrated and Delivered the Integrated Probabilistic Design Code (DARWIN Version 3.2)	◆					
Issued Reference Report "State–of-the-Art in Turbine Engine Monitoring Systems" Monitoring Systems"	◆					
Conducted DARWIN Code Version 3.2 Training Workshop	◆					
Characterize Titanium Defect Melt Source Causes		◇				
Deliver Framework Definition for Probabilistic Rotor Design Code – Nickel Alloys		◇				
Introduce Damage Tolerant Rotor Design through a Draft AC with Analytical Software Code (DARWIN)		◇				
Complete Benchmark Basis for Plasma Hearth Melt Modeling		◇				
Demonstrate Probabilistic Integration Design Code – Surface Flaws			◇			
Demonstrate the On-line Monitoring for Alloy Composition Control in a Commercial Electron Beam Melt Furnace				◇		
Unleaded Fuels and Fuel System Safety Research						
Completed Laboratory Characterization of Industry Supplied Candidate Fuels	◆					
Issued Final Draft Report on Jet A Vapor Ignition Characterizations	◆					
Issued Final Draft Report on In-service Jet A Fuel Sample Analysis Volatility Survey	◆					
Begin Engine Ground Testing of Industry Supplied Candidate Unleaded Fuels	◆					
Complete Determination of Acceptable Concentration of Red Dye Contamination in Jet A Fuel for Continuous Engine Operation		◇				
Characterize and Test Industry Supplied Candidate Fuels Using Flight Test Aircraft and Engine Ground Test Facilities		◇				
Complete Draft and Final ASTM Specification for High Octane Unleaded Aviation Gasoline			◇		◇	
Complete Fleet Evaluation of Candidate Unleaded Aviation Gasoline				◇		

Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	1,716	1,566	3,643	1,761	1,754
Personnel Costs	1,398	1,522	1,126	932	1,230
Other Costs	286	312	231	138	142
Total	**3,400**	**3,400**	**5,000**	**2,831**	**3,126**

A06d Flight Safety/Atmospheric Hazards Research

GOALS:

Intended Outcomes: The FAA intends to improve aircraft safety by developing technologies, technical information, procedures, and practices. These ensure safe operation of the civil fleet in icing conditions and in the electromagnetic environment and address safety issues concerning digital flight controls and avionics systems.

In the area of aircraft icing, the program focuses principally on establishing operating rules and procedures for deicing and anti-icing to ensure a clean aircraft at takeoff. It also focuses on developing technology to determine the existence of frozen contamination and the failure of anti-icing fluids on critical aircraft surfaces. The program addresses characterization of the atmospheric icing environment by collecting and analyzing supercooled cloud and precipitation data. It also develops technology (ice protection and detection), certification requirements, and advisory material to ensure that aircraft meet performance, stability, and control safety standards during or after in-flight operation in icing conditions.

The electromagnetic hazards to aircraft systems program focuses on protecting aircraft electrical and electronic systems from the effects of lightning and high-intensity radiated fields (HIRF). These effects may come from airborne, shipborne, and ground-based emitters, as well as from portable electronic devices (i.e., tape players, laptop computers, cellular phones, etc.).

The Flight-Critical Digital Systems program addresses aircraft safety and certification issues. These issues involve the use of emerging, highly complex, software-based digital flight controls and avionics systems in flight-essential and flight-critical applications.

Agency Outputs: The FAA establishes rules for aircraft operation in icing conditions and the electromagnetic environment. It establishes rules on digital flight controls and avionics systems and on electromagnetic hazards. It also publishes advisory circulars (AC) to outline acceptable means for meeting the rules and disseminates various forms of technical information to agency certification and airworthiness specialists, agency inspectors, and the aircraft and avionics industry. The program also fosters development of promising technologies, such as sensors, to detect frozen contamination and anti-icing fluid failure. The aircraft icing project joins SAE in preparing annual updates to aircraft holdover time guidelines. These provide time estimates of the effectiveness of deicing and anti-icing fluids.

Customer/Stakeholder Involvement: The program directly supports the Aviation Safety Plan by assisting the zero accident goal. It does this through enhancements to aircraft certification, inspection, and maintenance related to atmospheric hazards and advanced digital systems. It also directly supports Challenge 2000 through research and increased awareness of software and standardization efforts among the certification directorates. In addition, it supports the Free Flight initiative, addressing highly integrated avionics and ground-based systems safety and certification issues, using very complex software. A key supporter is the ARAC Electromagnetic Effects Harmonization Working Group (EEHWG).

The ARAC Flight Test Harmonization Working Group (FTHWG) addresses performance and handling requirements standardization, and guidance material for operating in icing conditions. The ARAC Ice Protection Harmonization Working Group (IPHWG) addresses definition of an icing environment that includes supercooled large droplets (SLD) and means, such as ice detectors, to discriminate between conditions within and outside the certification envelope and to warn flightcrews of ice accumulation on critical surfaces.

SAE committees also address aircraft lightning protection (AE4L) and aircraft HIRF protection (AE4R). These two government and industry committees develop advisory circulars, test standards, and related users manuals to improve flight safety. The FAA provides leadership to the SAE G-12 Aircraft Ground Deicing Committee. This committee addresses holdover time guideline updates, standards establishment for deicing and anti-icing methodologies and fluids, and sensor criteria to determine the existence of frozen contamination. It also addresses the failure of anti-icing fluids on critical aircraft surfaces.

Accomplishments: The program provided aircraft icing regulatory guidance and operating procedures to aircraft manufacturers and operators. These consisted of technical reports, handbooks, information bulletins, advisory circulars, and rules. Since 1992, the program has updated or issued two advisory circulars, five technical bulletins, and the *Aircraft Icing Handbook*. It also has published more than 30 technical reports or papers, including reports on ice-phobic technologies.

The program has held international conferences on aircraft ground deicing (more than 600 participants from more than 10 countries attended) and on aircraft in-flight icing (more than 400 participants from 20 countries attended). It has also issued holdover time guidelines for deicing and anti-icing fluids.

In the area of digital systems, the program continued to assess modified condition/decision coverage (MCDC) requirements for avionics software testing. The assessment will also include software mutation techniques. Additionally, the program studied applying formal methods to software partitioning to protect avionics software in highly integrated systems. The program also supported the Streamlining Software Aspects of Certification Project.

In the electromagnetic hazards area, the program completed an analysis of a stochastic evaluation of the HIRF testing environment for aircraft. An update to the FAA research and development electromagnetic data base (FRED) containing lightning strike data and waveforms was published. The update included C-160 aircraft data. A report was completed concerning a feasibility study of a PED detector for civil aircraft, and a HIRF Risk Analysis was initiated to support a Notice of Proposed Rulemaking (NPRM).

R&D Partnerships: The program has established many cooperative relationships, including:

- ARAC, EEHWG international certification authority/industry forum—HIRF environment, User's Guide for AC 20-1317
- SAE -AE4L Lightning Protection of Aircraft, Lightning Environment, Waveforms and Testing Standard, Aircraft Zoning Standard, and User's Manual for AC 20-136
- RTCA Special Committee-182, "A Minimum Operational Performance Standard (MOPS) for an Avionics Computer Resource (ACR)"
- RTCA Special Committee-190, software guidance for issues missed or arising since publication of RTCA DO-178B
- Multiyear FAA/NASA interagency agreement with Langley Research Center to cooperate in the assessment of software-based digital flight controls and avionics systems and electromagnetic hazards research
- Multiyear FAA/DOE interagency agreement with Idaho National Engineering Laboratory in characterization of lightning strike data and development of a lightning waveform database
- Multiyear interagency agreement with Naval Air Warfare Center Aircraft Division to assess the HIRF environment for aircraft
- Letter of agreement to leverage HIRF certification research with Sandia Corporation; the Army Directorate for Applied Technology, Test and Simulation; and ORION International Technologies, Inc.
- Cooperative efforts on aircraft icing activities with the NASA Lewis Research Center
- More than six aircraft icing grants and agreements in place with academia and other government agencies to leverage interests and capabilities
- International agreement with Transport Canada on research on aircraft ground deicing issues
- ARAC IPHWG directly supported with data on and analysis of SLD conditions in the atmosphere

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

Aircraft icing

- Evaluated time-effectiveness of recently developed new and environmentally-friendly deicing and anti-icing fluids
- Completed report on glycol-reduction methods
- Completed report on hot water deicing methods and procedures

- Produced final report on effect of large droplet ice accretions on airfoil and wing aerodynamics and control
- Completed report to ARAC IPHWG on SLD data aloft
- Continued collecting SLD data aloft

Flight-critical digital systems

- Published Report on Analysis of Structural Coverage Requirements of RTCA DO-178B
- Published Report on Feasibility of an In-flight Advisor for General and Commercial Aviation
- Electromagnetic Hazards to Aircraft Systems
- Published HIRF User's Guide for AC 20-1317
- Published Lightning User's Manual for AC 20-136
- Published Report on HIRF Risk Analysis for NPRM

KEY FY 2000 PRODUCTS AND MILESTONES:

Aircraft icing

- Evaluate time effectiveness and aerodynamic performance of environmentally friendly and other modern fluid.
- Complete report on fabrication of active Aircraft Mounted Wide Area Ice Detector prototype system
- Complete report on glycol temperature buffer reduction investigation
- Complete report on consolidation of SLD data at flight altitudes

Flight-critical digital systems

- Publish report on certification techniques for COTS hardware and software
- Publish report on certification techniques for advanced hardware
- Publish acceptance criteria for software reuse

Electromagnetic hazards to aircraft systems

- Publish report on single-event effects and upset
- Publish report on analysis of commercial lightning data base
- Publish aircraft lightning zoning and protection techniques

FY 2000 PROGRAM REQUEST:

Aircraft icing

- Continue to collect and assess the global atmospheric icing environment data with emphasis on the SLD environment
- Determine acceptance criteria and enhancements for icing tankers, tunnels, and analytical icing computer codes; and quantitatively characterize ice roughness, shape, and aerodynamic effect

Flight-critical digital systems

- Continue research related to emerging flight safety and certification issues identified by RTCA SC-190 efforts

Electromagnetic hazards to aircraft systems

- Continue lightning protection, HIRF protection, electromagnetic compatibility, single-event effects/upset and continued integrity research

A06d - Flight Safety/Atmospheric Hazards Research Product and Activities	Program Schedule					
	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY2004
064-110 Flight Safety						
Flight Critical Digital Systems						
Published Report on Feasibility of an In-flight Advisor of General and Commercial Aviation	◆					
Published Report on Analysis of Structural Coverage Requirements	◆					
Publish Acceptance Criteria for Software Reuse		◇				
Publish Report on Certification Techniques for COTS Hardware and Software		◇				
Publish Report on Certification Techniques for Advanced Hardware		◇				
Publish Alternate Approaches to Software Modified Condition/Decision Coverage (MCDC)				◇		
Publish Criteria for Avionics Software Changes						◇
064-111 Atmospheric Hazards						
Aircraft Icing						
Finalized Reports on Effect on Large Droplet Ice Accretions on Airfoils and Wing Aerodynamics and Control	◆					
Reported to ARAC IPHWG on Supercooled Large Droplet (SLD) Data Aloft	◆					
Continued Collecting SLD Data Aloft	◆					
Evaluate Time of Effectiveness & Aerodynamic Performance of Environmentally Friendly Modern Fluids	◆	◇				
Report on Fabrication of Active Aircraft Mounted Wide Area Ice Detector Prototype System		◇				
Report on Consolidation of SLD Data at Flight Altitudes		◇				
Report on Glycol Temperature Buffer Reduction Investigation		◇				
Report on Quantitative Characterization of Ice Roughness and Shape and Aerodynamic Effect			◇			
Report on Global Atmospheric Icing Environment					◇	
Publish Fluid Failure & Holdover Times Procedures for Manufacturers					◇	
Electromagnetic Test and Analysis						
Published High Intensity Radiated Fields (HIRF) User's Guide	◆					
Published Lightning User's Manual for AC 20-136	◆					
Published Report on HIRF Risk Analysis for Notice of Proposed Rule Making (NPRM)	◆					
Publish Report on Single Event Effects and Upset		◇				
Publish Report on Analysis of Commercial Lightning Database		◇				
Publish Aircraft Lightning Zoning and Protection Techniques		◇				

Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	3,535	1,368	705	1,494	1,942
Personnel Costs	530	577	1,127	973	1,744
Other Costs	108	118	231	152	158
Total	**4,173**	**2,063**	**2,063**	**2,619**	**3,844**

A06e Aging Aircraft

GOALS:

Intended Outcomes: The FAA intends to improve system safety by developing technologies, technical information, procedures, and practices that ensure the continued airworthiness of aircraft structures and components in the civil fleet. The Aging Aircraft program focuses principally on:

- Analytical methodologies development and validation—to predict the onset of widespread fatigue damage (WFD) and residual strength of aircraft structures
- Nondestructive inspection techniques development and validation—to detect and quantify damage in the forms of corrosion, cracking, disbonding, and material processing defects
- Flight and landing loads airworthiness standards updates and validation for civil transport aircraft by acquiring/analyzing actual usage data
- Maintenance and repair requirements and establishing procedures for airframes
- Crack-growth-based predictive methodology development—to derive inspection and maintenance programs for nonrotating, safety-critical components of aircraft engines
- Fatigue substantiation methodology, health/usage monitoring methodology, and updated design load spectrums (based on actual usage) for rotorcraft fleet development
- Aging non-structural systems research—development of technology and techniques to ensure continued safe operation of electrical and mechanical aircraft systems

Agency Outputs: The FAA establishes rules for aircraft certification, inspection, maintenance, and repair and publishes advisory circulars to outline acceptable means for compliance. In addition, it disseminates technical information in various forms to agency airworthiness inspectors and industry. This improves aircraft construction and maintenance practices. The objective producing these products is flight safety based on continued aircraft airworthiness. The Aging Aircraft program provides the technical information necessary to support these agency outputs.

Customer/Stakeholder Involvement: The FAA has established an extensive network for collaboration in the Aging Aircraft program.

- ARAC is an FAA/industry forum established to ensure that agency rulemaking is effective in achieving intended results and that the industry resources are used to their fullest. ARAC also identifies requirements and priorities for supporting R&D activities.
- The FAA-sponsored TOGAA ensures effective coordination of Aging Aircraft program activities with related activities in DOD and industry. TOGAA meets several times a year to assess program progress and review research priorities, in light of technical progress and the needs of aircraft manufacturers, operators, and maintainers.
- The Subcommittee on Aircraft Safety of the FAA Research, Engineering and Development Advisory Committee completed a review of the Aging Aircraft program. The program described here is fully responsive to the advice of the subcommittee.
- The Aging Aircraft program directly supports the Aviation Safety Research Act of 1988 (Public Law 100-591). This act increased the scope of the FAA's mission to include research on methods for improving maintenance technology and detecting the onset of cracking, delamination, and corrosion of aircraft structures. In particular, this legislation directed the FAA to focus on maintaining the airworthiness of the aging commercial fleet.
- The Aging Non-structural Systems Research program is the primary vehicle for supporting the recommendations of the White House Commission on Safety and Security, which state that "in cooperation with airlines and manufacturers, the FAA's Aging Aircraft program should be expanded to cover nonstructural systems."

Accomplishments: An on going research effort provides guidance for complying with assessment programs on WFD in both the civil and military aircraft fleets. The research is co-funded by the FAA, NASA, and the U.S. Air Force (USAF) and is conducted by Boeing Company. The integrated

effort includes development of analytical methods by both the FAA and NASA and testing by the FAA and the USAF. This integrated effort continues to validate government-developed analysis codes to predict the onset of WFD.

A small crack detection structured experiment was completed by the FAA's AANC. The experiment demonstrated that commercially available instruments can detect small cracks in aircraft skins under the rivet heads. Prototype instruments developed by Northrop and NASA could detect cracks before reaching the edge of the rivet head. This is significant because these cracks reflect the WFD identified in the Aloha Airlines accident. This information assists the FAA and industry in specifying and approving future inspection equipment.

Civil transport flight and ground loads data collection programs for both large and small transport aircraft were reestablished. Optical quick access recorders have been installed on several B-737/400 and MD-82 aircraft, and usage data are being analyzed. Similar recording technology is being developed for commuter aircraft. Airplane landing contact parameters have been obtained from analysis of video images recorded during surveys conducted at representative high-activity commercial large transport and commuter airports.

A team composed of the FAA, the AANC, Lockheed, Delta Airlines, Textron, and Warner Robbins AFB successfully applied the first composite reinforcement "doubler" on a U.S. commercial aircraft. The doubler replaced the standard reinforcement, which consists of four riveted aluminum sheets. The composite reinforcement improves fatigue resistance and substantially reduces the repair cost.

R&D Partnerships: Program activities are closely coordinated with related initiatives underway at NASA, DOD, and industry. The FAA and NASA, through a Memorandum of Agreement (MOA), have cosponsored several conferences on aging aircraft and airworthiness assurance. Interagency agreements are in place between the FAA and NASA, U.S. Navy (USN), USAF, National Institute of Standards and Technology (NIST), and DOE. International agreements are in place between the FAA and the regulatory authorities in the United Kingdom, the Netherlands, Australia, and Canada.

A center of excellence for airworthiness assurance, established in FY 1997, brings together the monetary and intellectual resources of its core universities and numerous industrial and governmental partners. The Center for Aviation Systems Reliability (CASR) is a consortium of four universities—Iowa State University, Northwestern University, Wayne State University, and Tuskegee University—formed to develop nondestructive inspection techniques. The AANC is partnering with Sandia National Laboratory to test and evaluate inspection techniques in a realistic hangar environment and enhance technology transfer. The Engine Titanium Consortium (ETC)—Iowa State University, Pratt & Whitney, General Electric, and Allied-Signal—was formed to develop methods for inspecting engine components. Numerous research grants have been awarded through the aviation research grants program, and are in place with universities and not-for-profit laboratories to leverage their interests and capabilities. Cooperative research and development agreements (CRDA's) are in place with two airline operators as part of the flight loads data collection program.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

- Developed Supplemental Inspection Document (SID) for the Fairchild Metro airplane
- Developed a crack-growth-based predictive methodology for static engine parts
- Transferred thermal wave imaging technology for corrosion detection to industry
- Developed and validated ultrasonic and eddy current inspection tools for airframe and engine applications
- Conducted video landing parameter survey at Philadelphia International Airport's commuter runway
- Published flight loads data reports for additional aircraft model (i.e., B-767)
- Established permanent video landing loads data facility

- Established a test bed for validation of technologies designed to ensure the safe operation of aircraft electrical and mechanical systems
- Initiated research into the development of an arc-fault circuit interrupter for aircraft applications
- Initiated research into the development of systems that assess the physical and functional integrity of aircraft wiring

KEY FY 2000 PRODUCTS AND MILESTONES:

- Complete development of an engineering manual with guidelines to predict the onset of WFD and residual strength and structures
- Continue enhancement to user-friendly software tool for damage tolerance analysis and design of aircraft repairs for commuter aircraft
- Develop guidelines for developing supplementary inspection programs for commuters
- Continue development and validation of enhanced inspection systems for engine components
- Continue development and validation of inspection techniques to detect damage in airframe structures typical of widespread fatigue damage
- Continue data collection, analysis, and reduction for large transport flight loads and publication of A-320 data
- Transfer pulse eddy current technology for inter-layer crack detection to industry
- Complete Health and Usage Monitoring Systems (HUMS) advisory material and compliance guidance for Part 29 and Part 27 rotorcraft monitoring post flight
- Conduct a video landing loads survey at Denver International Airport to quantify high altitude landing parameters for civil transport aircraft
- Develop first-generation, prototype arc-fault circuit interrupter for aircraft applications
- Complete assessment of feasibility of service life for aircraft wiring

FY 2000 PROGRAM REQUEST:

In FY 2000, the program will continue to focus on the areas listed at the beginning of the “Goals” section above. Near-term emphasis is on better understanding the effects of widespread fatigue damage, developing supplemental inspection requirements to better account for airframe and component damage, and developing and validating enhanced inspection techniques.

A06e - Aging Aircraft Product and Activities	Program Schedule					
	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY2004
065-110 Aging Aircraft						
WFD and Residual Strength Analysis						
Completed Development of a Crack-Growth Based Predictive Methodology of Static Engine Parts	◆					
Complete Development of an Engineering Manual with Guidelines for onset of Widespread Fatigue Damage (WFD)		◇				
Continue Development & Validation of Inspections Techniques		◇				
Publish AC on Inspection and Maintenance of Static Engine Parts			◇			
Commuter Aircraft Inspection Requirements						
Developed SID for the Fairchild Metro Airplane	◆					
Develop Guidelines for Development of Supplemental Inspection Programs for Commuters		◇				
Airborne Data Monitoring Systems						
Publish Technical Report and Continue Data Collection Analysis on Flight Loads	◆	◇	◇	◇	◇	◇
Conduct Video Landing Parameter and Loads Survey at Philadelphia, Denver and Other Airports	◆	◇	◇	◇	◇	◇
Established Permanent Video Landing Loads Data Facility	◆					
Maintenance and Inspection						
Transferred Thermal Wave Imaging Technology for Corrosion Detection in Industry	◆					
Developed and Validated Ultrasonic and Eddy Current Inspection Tools	◆					
Continue Enhancement to User-friendly Software Tool for Damage Tolerance Analysis and Design		◇				
Transferred Pulsed Eddy Current Technology for Inter-layer Crack Detection to Industry		◇				
Continue Development and Validation of Enhanced Inspection Systems for Engine Components		◇				
Complete Development of Ultrasonic Inspection Tools for Engines				◇		
Complete AC on Repair and Maintenance of Engine Propellers				◇		
Release Repair Analysis Software Tool for Commuter Aircraft					◇	
Develop Prototype for Detection of WFD-Size Cracks					◇	
Rotorcraft Structural Integrity						
Complete Final HUMS AC and Compliance Guidance for Part 29 and 27 Rotorcraft		◇				
Update AC 29-2A and 27-1 for Fatigue and Damage Tolerance					◇	

Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	16,615	10,585	18,466	11,945	12,118
Personnel Costs	2,810	2,742	2,251	2,831	3,547
Other Costs	575	562	523	368	333
Total	**20,000**	**13,889**	**21,540**	**14,694**	**15,998**

A06f Aircraft Catastrophic Failure Prevention Research

GOALS:

Intended Outcomes: The FAA intends to improve system safety by developing technologies and methods to assess risk and prevent defects, failures, and malfunctions in aircraft, aircraft components, and aircraft systems that could cause aircraft catastrophic failure.

The Aircraft Catastrophic Failure Prevention program's objective is to ensure safe aircraft operation in the public domain. It focuses principally on using historical accident data to attack known problem areas, such as:

- Turbine engine uncontainment events, including mitigation and modeling of uncontainment and aircraft vulnerability to uncontainment (AC20-128, phase II)
- Examining issues associated with inappropriate crew response to propulsion malfunctions and working with industry to develop solutions to this critical problem
- Examining explosive fuel tank issues

Agency Outputs: The FAA establishes certification criteria for aircraft and publishes advisory circulars to outline acceptable means for meeting these rules. The aircraft catastrophic failure prevention program provides the technical information necessary to support these agency outputs.

Customer/Stakeholder Involvement: The FAA continues to establish collaborative efforts that ensure a balanced, responsive aircraft catastrophic failure prevention program:

- ARAC is an FAA/industry forum established to ensure that agency rulemaking is effective in achieving intended results and that industry resources are fully used to accomplish these results. ARAC also effectively identifies requirements and priorities for supporting R&D activities. The ARAC Powerplant Installation and Harmonization Working Group (PPI-HWG) provides guidance to this program for updating AC 20-128.
- The FAA sponsors an annual workshop on turbine engine uncontainment characterization, modeling, and mitigation. The workshop brings together industry and government (civil and military) to review progress on this matter and to recommend future courses of action.
- The FAA (through Lawrence Livermore National Laboratories) has developed partnerships with Boeing, United Technologies (Pratt & Whitney), and Allied Signal Engines to work collaboratively to develop a modeling toolkit for modeling engine uncontainment events.
- The FAA supports the AIA Transport Committee project on propulsion system malfunction plus inappropriate crew response. This project brings industry and the FAA together to develop recommendations (and associated regulations and advisory material) on the subject of safety concern.
- The ARAC Fuel Tank Harmonization Working Group provides guidance to the program on explosive fuel tank issues.
- The program also responds to Public Law 100-591 (the Aviation Safety Act) and Public Law 101-508 (the Omnibus Reconciliation Act), which specifically established the aircraft catastrophic failure prevention program.

Accomplishments: Certification officials use results of catastrophic failure prevention program research provide the technical basis for rule changes as well as new or modified advisory circulars. Results are also provided to airframe and engine manufacturers and designers. Recent accomplishments:

- Completed uncontained engine failure fuselage damage data base and published reports on large engine uncontainment and small engine uncontainment data bases. These data bases are useful for scientific uncontained engine debris evaluation that will result in significant revision to AC 20-128. Accident investigations indicate debris damage spread angles are larger than current AC materials indicate.
- Developed a baseline aircraft vulnerability model to predict aircraft vulnerability to engine uncontainment events
- Completed beta testing of the aircraft vulnerability model

- Completed a detailed report examining DOD armor technology and its potential application to turbine engine uncontainment mitigation
- Started developing an advanced material DYNA-3D model
- Started developing training materials for propulsion malfunction plus inappropriate crew response
- Started work on determining effects of copper-silver sulfide corrosion on fuel quantity indicator system components

R&D Partnerships: Program activities are closely coordinated with government, academia, and commercial experts to take full advantage of existing expertise through interagency agreements, grants, and contracts.

The following agreements, leveraged on existing facilities and expertise, provide significant program benefits:

- Interagency agreement with the Naval Air Warfare Center Weapons Division, China Lake, which partners with Boeing to modify military vulnerability analysis tools; these tools are used in examining the vulnerability of commercial transport aircraft to turbine engine uncontainment events
- Interagency agreement with Lawrence Livermore National Laboratory, which partners with Boeing, Allied Signal Engines, and Pratt & Whitney, to develop a modeling toolkit to address turbine engine uncontainment events modeling
- Center of excellence contract with SRI, which partners with University of Dayton Research Labs and Arizona State University; in-kind support provided by Boeing and B. F. Goodrich.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

Engine uncontainment research

- Developed an aircraft vulnerability model improvement plan and started model improvements

Propulsion malfunction plus inappropriate crew response

- Developed a plan for producing crew training materials for propulsion-related malfunctions

Explosive fuel tank issues.

- Issued an interim report on problem of copper-silver sulfide contamination on fuel-quantity indicating systems

KEY FY 2000 PRODUCTS AND MILESTONES

Engine uncontainment research

- Begin modifications to vulnerability code based on airframe manufacturers' evaluations
- Complete DYNA-3D model of advanced barrier materials

Propulsion malfunction plus inappropriate crew response

- Develop crew training materials
- Initiate research on crew response to propulsion malfunctions

Explosive fuel tank issues

- Continue research into explosive fuel tank issues

FY 2000 PROGRAM REQUEST:

The program modifies aircraft vulnerability codes to incorporate suggestions obtained from airframe manufacturers' evaluations. It continues developing a calibrated design system, for certification purposes, to examine engine uncontainment by developing toolkit components that model mitigation effects of advanced materials and improve penetration equations for aluminum and titanium.

The program also develops crew training materials to better equip crews to deal with a variety of propulsion malfunctions, reducing the chance for inappropriate response. It examines ways to improve the fidelity of simulator training by more realistically reproducing instrument and sensory cues to propulsion malfunctions.

Lastly, it will continue to be responsive to the ARAC Fuel Tank Harmonization Working Group in examining issues and potential solutions to the explosive fuel tank issue.

A06f - Aircraft Catastrophic Failure Prevention Research Product and Activities	Program Schedule					
	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY2004
066-110 Aircraft Catastrophic Failure Prevention Research						
Engine Uncontainment Research						
Developed an Aircraft Vulnerability Model Improvement Plan and Started Model Improvements	◆					
Begin Modifications to Vulnerability Code Based on Airframe Manufacturers' Evaluations		◇				
Complete DYNA-3D Model of Advanced Barrier Materials		◇				
Complete Vulnerability Model			◇			
Complete Advanced Analytical Uncontainment Mitigation Tool Kit			◇			
Explosive Fuel Tank Issues						
Issued Interim Report on Problem of Copper-silver Sulfide Contamination on Fuel Quantity Indicating Systems	◆					
Continue Research into Explosive Fuel Tank Issues		◇				
Propulsion Malfunction Plus Inappropriate Crew Response						
Developed a Plan for Producing Crew Training Materials for **Propulsion Related Malfunctions**	◆					
Develop Crew Training Materials for Propulsion Related Malfunction		◇				
Initiate Research on Crew Response to Propulsion Malfunction		◇				
Develop Recommendations for Training & Operation of Existing Systems					◇	
Develop AC Material & Recommendation for Future Design Certification					◇	

Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	2,298	2,650	3,289	1,329	1,308
Personnel Costs	338	369	590	397	607
Other Costs	69	75	121	61	66
Total	**2,705**	**3,094**	**4,000**	**1,787**	**1,981**

A06g Aviation Safety Risk Analysis

GOALS:

Intended Outcomes: The FAA intends to improve aviation safety by developing means for industry and the agency's own programs and systems to measure and account for safety performance. This is done through risk assessment and operational indicators and the shared use of safety-related data. The Aviation Safety Risk Analysis (ASRA) program focuses primarily on:

- Developing and/or enhancing safety critical performance measures embedded in FAA analytical systems (e.g., flight standards service Safety Performance Analysis System (SPAS)) and the aircraft certification service safety management program products/risk-based analytical tools. These measures encompass particulars about aircraft design, aircraft maintenance, discrepancy reports, air carriers, air agencies, and air personnel.
- Developing advanced analytical/decision support capabilities and graphical techniques. These allow the FAA to more effectively and efficiently use information contained in various FAA and industry data bases.
- Establishing a forum with industry to exchange aviation safety performance measures and risk models and methodologies.
- Establishing a systems engineering, analysis, and system safety risk assessment effort to support certification, surveillance, and certificate management.
- Developing a safety analysis methodology that will be used in certifying new products and in analyzing continued airworthiness issues, as well as the operational safety of the fleet as experience with the certificated product evolves.
- Developing a risk-based tool to manage aircraft certification workload and prioritize oversight activities related to manufacturers.
- Developing an Internet-based information system for aviation safety related data emphasizing general aviation.
- Developing and/or enhancing the Maintenance Malfunction Information Reporting (MMIR) System with capabilities to track critical helicopter parts, capture part utilization/performance data, and perform trend analysis on the captured data.
- Developing guidelines on evaluation of U.S. military surplus flight safety-critical aircraft parts for installation on FAA U.S. type-certified products.
- Developing a methodology and software-based tool for performing large-scale software system reliability prediction and testing cost measures.
- Developing a Service Difficulty Analysis Tool geared toward analyzing a large number of aircraft of the same type and designing the capability to review trends in SDR submission.

Agency Outputs: The Federal Aviation Act of 1958 and the Federal Aviation Regulation (FAR) provide the FAA the statutory authority and responsibility to conduct surveillance of air operators, air agencies, aircraft, and airmen to ensure conformance with the FAR and aviation safety standards. Research program outputs improve the data, data gathering techniques, and decision support tools related to FAA certification, surveillance, and certificate management processes. The outputs enable systematic potential risk assessment and take proactive steps to reduce the rate of aviation-related accidents and incidents. The FAA increases its leverage of aviation safety inspector and certification engineering resources by targeting these resources based on risk.

Customer/Stakeholder Involvement: The Federal Aviation Authorization Act of 1996 states that the Administrator should give "high priority to developing SPAS." The legislation calls for deployment of SPAS II, initiated in FY 1997, to be completed by December 1999. The ASRA program enhances SPAS decision-support capabilities by providing additional risk analysis/predictive models, expert system capabilities, and critical safety performance indicators.

In 1997, the Flight Standards Service introduced their new business process, the Air Transportation Oversight System (ATOS). ATOS is a system-based approach to FAA certification, surveillance, and certificate management oversight. It is designed to provide the FAA with the people, proce-

dures, equipment, facilities, software, tools, and materials necessary to make surveillance more systematic and targeted to deal with identified risks. In support of this effort, the ASRA program will provide systems engineering, analysis (identification of performance measures through information presentation) and system safety risk assessment research.

The ASRA program responds directly to the Safer Skies Agenda and recommendations in the Challenge 2000 Report and the FAA 90-day safety review. Maximum information sharing alerts both the FAA and industry to pending aviation safety-related problems. Developing a certification and surveillance program built on targeting resources to address safety risks ensures that corrective action is taken much sooner. Thus, the primary beneficiaries of this effort is the general/flying public.

DOD will use several analytical tools, such as SPAS, to oversee defense contract carriers and charters.

The FAA worked with Helicopter Association International to develop and release the maintenance malfunction information reporting system. This software tool improved the collection, storage, and transfer of service difficulty reports and part warranty information.

Data improvement and standardization efforts respond to recent Congressional hearings and the General Accounting Office (GAO) report recommendations that the FAA improve the quality and timeliness of its aviation safety data. More importantly, analytical and decision support tools rely on good quality data to identify potential safety risk areas.

Accomplishments: Full deployment of a production SPAS system (i.e., SPAS II) was initiated in FY 1997 and is scheduled to be completed by December 1999. SPAS is a computer-based analytical tool used by FAA aviation safety inspectors and certification engineers, as well as DOD aviation analysts, to support their oversight activities of FAA certificate holders (i.e., air operators, air agencies, aircraft, and air personnel). A study was initiated to establish baseline risk parameters related to continued airworthiness of aircraft and to analyze the factors that are precursors to aircraft accidents.

R&D Partnerships: The U.S. Air Force/Air Mobility Command provides technical support and assistance in developing safety critical performance measures. The Flight Safety Foundation works with both the FAA and industry to analyze worldwide accidents and serious incidents and to establish and prioritize causal factors. An interagency agreement was established with DOE that enables Sandia National Laboratories to provide technical expertise in system development, system safety, and data quality strategy/data quality improvements implementation. The FAA has arranged with the National Academy of Sciences to develop a generally applicable, structured, safety management program for aircraft certification services. Finally, several university grants have been awarded to support development and testing of aviation safety risk models. The aviation safety digital library prototype, to be released in FY 1999, was developed in cooperation with general aviation groups, such as the EAA, AOPA, and GAMA, under a phase II small business innovative research (SBIR) contract.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

Risk analysis decision support

- Implemented new and enhanced risk analysis models and capabilities
- Developed and implemented safety-critical performance measures into flight standards SPAS II and aircraft certification aviation safety management program initiatives
- Initiated design of flight standards next-generation, safety-critical performance measures and work processes based on a system safety model
- Initiated workshops with industry to discuss aviation safety risk analysis and performance measures
- Initiated development of risk/hazard/accident models and tools
- Continued development of the Intelligent Safety Performance and Evaluation System

Aircraft maintenance: maintainability and reliability

- Released the aviation safety digital library prototype

- Released a report on detailed trend analysis of fatigue and corrosion in 13 transport aircraft models
- Revamped the MMIR system to be Internet based
- Released a report on the methodology for accurately predicting reliability of large-scale software system

Safety analysis methodology

- Initiated data/data analysis improvements to the Aircraft Certification Systems Evaluation program (ACSEP)
- Initiated development of probabilistics safety assessment for aircraft safety

KEY FY 2000 PRODUCTS AND MILESTONES:

Risk analysis decision support

- Continue to develop, test, and validate new and enhanced risk analysis models and capabilities
- Continue to develop safety-critical performance measures
- Continue to develop the safety management program
- Release a report on the work processes to support a system safety model
- Initiate development of statistical analysis methods based on a system safety model
- Continue workshops with industry to discuss aviation safety risk models/methods
- Continue the development of the Intelligent Safety Performance and Evaluation System
- Continue the development of Risk/Hazard/Accident models and tools

Aircraft maintenance–maintainability and reliability

- Initiate analysis in support of Advisory Circular entitled *Eligibility and Evaluation of U.S. Military Surplus Flight Safety Critical Aircraft Parts, Engines, and Propellers.*

Safety analysis methodology

- Continue the development of probabilistic safety assessment efforts that address aircraft safety
- Continue data study supporting ACSEP evaluation frequencies for group II and IV facilities

FY 2000 PROGRAM REQUEST:

In FY 2000, research will continue to focus on the areas listed at the beginning of the "Goals" section above. Data assimilation and analysis that support the ASRA initiatives will continue. Analysts work with government, industry, and academia aviation safety subject matter experts to ensure that safety critical performance measures are properly defined, developed, tested, and evaluated before they are incorporated into decision support systems. The Aviation System Risk Analysis program investigates, tests, and recommends improvements, including standardization, to the quality (and quantity) of data used in the performance measures. It completes studies to identify and verify flight standards and aircraft certification safety information requirements.

A06g - Aviation Safety Risk Analysis Product and Activities	Program Schedule					
	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY2004
060-110 Aviation Safety Risk Analysis						
Risk Analysis/Decision Support (RADS)						
Develop Risk-based Forecasting Methods	◆	◇	◇	◇	◇	
Develop Safety Critical Performance Indicators (i.e. Operator, Air Agency, Aircraft, Air Personnel)	◆	◇	◇	◇	◇	◇
Conduct Workshops to Exchange Aviation Safety Risk Models/Methods with Industry	◆	◇	◇	◇	◇	◇
Continue Development of Intelligent Safety Performance & Evaluation System	◆	◇	◇	◇	◇	
Develop Risk/Hazard/Accident Models and Tools	◆	◇	◇	◇	◇	◇
Develop and Report on Next Generation Work Process Models in Support of ATOS	◆	◇				
Develop Statistical Analysis Methods in Support of Air Transportation Oversight System (ATOS)		◇	◇	◇	◇	◇
Develop User Defined Performance Measures				◇	◇	
Aircraft Maintenance: Maintainability & Reliability						
Released Web-based Digital Library Prototype with Emphasis on General Aviation (GA)	◆					
Released Report on Detailed Trend Analysis of Fatigue and Corrosion in 13 Transport Aircraft Models	◆					
Release Report on Methodology for Accurately Predicting Reliability of Large-scale Software System	◆		◇			
Revamp the Maintenance Malfunction Information Reporting (MMIR)	◆		◇		◇	
Conduct Analysis in Support of Advisory Circular: Eligibility & Evaluation of US Military Surplus Flight Safety Critical Aircraft Parts, Engines, & Propellers		◇	◇			
Release Version 1.0 of (SDR) Analysis Tool				◇		
Aircraft Continued Airworthiness Assessment						
Improve and Conduct Detailed Study of ACSEP Evaluation Frequencies for Groups II and IV	◆	◇	◇			
Continue Airworthiness Assessment of Various Aircraft Classes for each of Accident/Hazardous Incident Major Causes		◇	◇	◇	◇	◇

Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	0	3,619	5,289	5,555	5,286
Personnel Costs	0	316	1,039	794	1,393
Other Costs	0	65	213	122	145
Total	**0**	**4,000**	**6,541**	**6,471**	**6,824**

2.4 Aviation Security

Mission

The FAA's Aviation Security Research and Development (R&D) Division has the lead responsibility within the FAA for R&D programs related to civil aviation security. The division performs R&D to eliminate civil aviation security incidents and provides assistance in anticipating future risks to civil aviation.

Division programs accelerate and expand R&D and implement advanced technologies. Division products provide equipment and methods to counteract terrorist efforts against civil aviation.

Well-integrated, automated, aviation security systems that leverage benefits from a variety of technologies will produce better operational performance. The mission of the future will rely less on human intervention.

Intended Outcomes

The main goal of the Aviation Security R&D program is to mitigate terrorist threats to civil aviation. This promotes public confidence and directly benefits the aviation industry economically. The increasing extent and sophistication of terrorism makes it imperative that the FAA identify and develop practical, effective technologies applicable to aviation security systems. Aviation security systems must be comprehensive, addressing all potential aviation security vulnerabilities in the airport, on aircraft, and in the NAS as directed.

The FAA conducts extensive R&D to detect explosives, weapons, and other more sophisticated devices, to prevent their placement onboard aircraft. The Aviation Security R&D program focuses on automated aviation security systems and screening protocols that are the least intrusive and enable the highest throughput, which minimizes passenger delays and inconvenience. The FAA conducts R&D to identify methods of hardening aircraft fuselages to mitigate damage from explosives, weapons, surface-to-air missiles, and electromagnetic interference.

Program Area Outputs

The FAA, through the Aviation Security R&D program, promotes development of technologically improved products in explosives detection, aircraft hardening, airport security, and human factors. Program outputs include:

- Developing and distributing to FAA R&D security planners a structured, total airport security system definition and concept of operations
- Developing standard test protocols and performance criteria to aid in the operational deployment of improved aviation security systems
- Developing lists of accepted automated explosives detection devices (EDD) and approved explosives detection systems (EDS) for air carriers, airports, and other Government agencies
- Defining standardized, traceable methods of airport security screener training and evaluation
- Testing explosives-resistant luggage containers
- Exploring other blast mitigation techniques that will help ensure that potentially catastrophic terrorist acts do not result in the loss of aircraft

Aviation Security R&D products are EDS, EDD, technologies, specifications, analysis tools, and technology integration plans. These products are used by airports, air carriers, and airframe manufacturers to improve civil aviation security.

Program Area Structure

The Aviation Security R&D organization is divided into the aviation security R&D program into four interrelated areas:

- Explosives and weapons detection
- Aircraft hardening
- Human factors
- Airport security technology integration

Each area makes a significant contribution toward achieving the goals of the Aviation Security system of the future.

Explosives and Weapons Detection. This area develops new, improved methods and technologies to detect explosives in checked and carry-on baggage, on passengers, in air cargo, and in mail. Weapons detection for passengers, personnel, and

their carry-on luggage prevents the armed takeover of aircraft. These methods and technologies are used in airports prior to aircraft boarding. This program area also develops standards and specifications for detection equipment.

Aircraft Hardening. This area conducts research to increase civil aircraft survivability in the case of an in-flight explosion. It also seeks to identify the minimum weight of an explosive that will result in aircraft loss. Another consideration is to protect aircraft avionics and systems from the damaging effects of false electromagnetic or high-energy signal interference.

Aviation Security Human Factors. This area improves the human element of the aviation security system and develops methods to measure and maintain performance levels as aviation security components merge into an integrated system. It emphasizes staffing, personnel, training, performance, human factors engineering, and health and safety aspects of human performance capabilities and constraints.

Airport Security Technology Integration. This area focuses on technologies that prevent unauthorized access to aircraft and airport facilities. Major emphasis is on recommending future system definition and concept of operations. Technology products include state-of-the-art perimeter control, automated access control systems, and passenger baggage-matching systems that prevent unaccompanied luggage from being loaded into aircraft. The program develops simulation and modeling tools. One set of tools performs airport security analysis, while the other set is used to seamlessly integrate, improve, and reduce operating costs for technologies developed by other programs in the Aviation Security area.

The FAA Aviation Security R&D Division conducts six R&D projects to achieve the goals of the four Aviation R&D program areas. Three R&D projects—Checked Luggage, Cargo, and Checkpoint—support the explosives and weapons detection program area. Each of the other three program areas has a dedicated R&D project. These are Explosives Vulnerability and Mitigation Techniques, Human Systems Integration, and Security of Civil Aviation Airports and Air Carriers.

Any one program will not solve all the issues, because technology development has not reached a point where it can operate autonomously. A systems-oriented approach is being adopted, balancing and tailoring the application of people, procedures, and technology to each threat classification.

Customer/Stakeholder Involvement

The Aviation Security Improvement Act of 1990 (Public Law 101-604) provides direction to expand the FAA's System Security Technology program (SSTP) for aviation security as follows:

- Accelerate SSTP over a 36-month period
- Expand SSTP to address current and future threats
- Expand FAA aviation security initiatives in aircraft hardening and human factors

In 1996, the White House Commission on Aviation Safety and Security strongly emphasized continued R&D in all program areas and recommended deployment of existing explosives detection technology. Congress funded further R&D and the FAA's purchase and installation of EDS and EDD. The FAA Security Equipment Integrated Product Team (SEIPT) is currently deploying this detection equipment at various airports throughout the United States.

Other stakeholders include the National Academy of Sciences, the Aviation Security R&D Scientific Advisory Panel, the R&D Advisory Council, and the Aviation Security Advisory Committee, which hold frequent reviews of R&D plans and results. Efforts also include multi-interagency work with the Technical Support Working Group. Their recommendations include changes in the direction or emphasis of research plans.

Accomplishments

In effect since 1974, the FAA Aviation Security R&D program can point to significant accomplishments:

- Certified the CTX 5000 and established a demonstration effort that delivered four certified CTX 5000 explosive detection systems to air carriers for operational testing; with data collected and analyzed at airports in San Francisco, Atlanta, and Manila

- Provided critical input to the SEIPT initial deployment of 54 CTX 5000 explosive detection systems, beginning in January 1997
- Provided critical input to the SEIPT initial deployment of over 210 trace explosive detection devices to 18 airports in FY 97 and about 280 more in FY 98
- Studying additional trace detection prototypes, as a result of testing in airport environments
- Validated and refined explosives detection criteria based on joint U.S./U.K. Boeing 747 explosives testing and a Lockheed L1011 test performed with the manufacturing community
- Deployed trace detection devices and the CTX 5000 system at the 1996 Olympics in Atlanta and will support the 2000 Olympic games in Australia
- Developing and testing a second-generation computer tomography system, in conjunction with L-3 Communications
- Conducting a demonstration effort on hardened LD-3 luggage containers
- Established criteria to limit cross-contamination of explosives used to train and certify K-9 detection teams
- Conducting operational testing of a number of FAA-developed screener training enhancements
- Performed an international study of radio frequency identification tags, making positive passenger baggage matching (PPBM) cost-effective and operationally feasible when deployed in the field
- Completed an economic analysis of PPBM costs and provided the results to both industry and FAA rulemaking teams
- Completed the Blast/FX effects model and is in the process of adding the Toxic Effects model. The Blast/FX model shows the structural effect of explosives on airport facilities and casualties based on explosive weight and airport configuration scenarios.

Research and Development Partnerships

Since its inception, the Aviation Security R&D program has sought to establish productive relationships with many organizations. These organizations include U.S. Government agencies, industry, academia, and foreign countries that promote technology development for improved aviation security. Each of the FAA's partnering organizations contributes to the Aviation Security R&D mission by providing information, R&D, equipment, and/or facilities. The FAA uses these partnership agreements to leverage its Aviation Security R&D project investments. Three recent projects are a testament to this leveraging:

- A partnership with the Defense Advanced Research Projects Agency (DARPA), in which FAA investments were $25,000, resulted in airport Aviation Security R&D efforts exceeding $16 million
- A partnership in the industrial sector with Science Applications International Corporation (SAIC) resulted in a bulk detection effort worth an estimated $35 million from a $5 million FAA investment
- A cost-sharing agreement with two manufacturers to develop additional sources for certified EDS. These systems expected to come to market in FY 1999 will increase the efficiency and effectiveness of available detection options while reducing cost through competition.

Long-Range View

The FAA envisions an integrated aviation security system for the 21st century that incorporates the strengths of a variety of technologies that are continuously being monitored and upgraded to respond to changes in the threat environment. This integrated system will enable aviation security professionals to perform most effectively.

Automated detection technologies will enhance screener performance by providing detection that is constantly vigilant and not subject to distraction or fatigue, as in the case of human or canine screeners. This understanding of the aviation security system of the future guides and directs future Aviation Security R&D efforts and supports decisions for FAA investments.

Terrorist capabilities and techniques will continue to increase and evolve. This ever-changing threat necessitates continued funding of R&D for the foreseeable future. Aviation Security R&D efforts

will continue to focus on modifications and other technical improvements to deployed explosives detection equipment.

Identification and evaluation of explosives mitigation techniques will also continue.

Efforts will continue, expanding to include the entire aviation spectrum, including airports, airplanes, and other areas of the National Airspace System, as needed.

A07a Explosives and Weapons Detection

GOALS:

Intended Outcomes: This program supports goal 2 of the FAA Strategic Plan: "Aviation Security—Zero Incidents." It intends to eliminate the possibility of terrorist ability to conceal improvised explosives devices, weapons, and flammable gas or liquid explosives on aircraft. Specifically, it applies to objective 2B, in that it strengthens the baseline of security through accelerated development and application of advanced technology.

This is accomplished by making improved EDS and devices available to airlines and groups responsible for airline security, both domestic and international. These systems and devices decrease the U.S. air carrier and airport vulnerability to terrorist acts. Specifically, this program:

- Meets increased passenger flow while minimizing cost by developing automated systems
- Enhances the security of the worldwide flying public
- Promotes adaptation of the best existing and emerging U.S. technologies in response to continually evolving threat possibilities

Agency Outputs: The FAA establishes policies and rules for airline compliance to security directives. This rulemaking process depends on research and development, testing and evaluation, and data packages supporting equipment mandating decisions. The object of is to enhance the security of the flying public through continuous involvement in present and future threat detection and mitigation.

The FAA has deployed both Bulk and Trace explosives detection systems through the SEIPT.

Customer/Stakeholder Involvement: The FAA is the world leader in developing explosive detection research and in testing and evaluating related equipment.

- The FAA interacts with industry, academia, other Government agencies, oversight groups, special interest groups, Congress, foreign governments, national laboratories, individual researchers, and the general public.
- The FAA sponsors the National Academy of Science to assess program research initiatives and to review explosives detection research priorities. The Committee on Civil Aviation Security meets several times a year, and special panels address specific crucial areas of interest such as personnel screening and configuration management of explosives detection hardware and software. The committee's findings and recommendations directly affect the E/W program strategy and concepts.
- The explosives detection program must respond to congressional mandates such as Public Law 101-604 and section 303 of the Federal Aviation Administration Reauthorization Act of 1997, as well as the Aviation Improvement Act of 1990, the White House Commission on Aviation Safety and Security, the Aviation Security Advisory Committee Base Line Working Group, and the General Accounting Office (GAO).

Accomplishments: Explosives detection research results are used by the Office of Civil Aviation Security to assist it in the rulemaking process. Since 1991, the Explosives and Weapons Detection program has:

- Certified the world's first explosives detection system
- Established test and evaluation criteria and protocols for checked baggage
- Developed a world-wide accepted trace detection standard for electronic items
- Held two international symposia on explosives detection
- Sponsored three International Society for Optical Engineering (SPIE) conferences on domestic and international explosives detection
- Conducted an International Civil Aviation Organization (ICAO) workshop on trace detection standards for electronics explosives detection
- Completed an airport demonstration of certified explosives detection equipment at San Francisco and Atlanta international airports

- Supported the 1996 Olympic games with explosives detection equipment installations at five airports
- Developed competing technologies to the certified EDS
- Developed and tested personnel portal scanning systems
- Provided technical support to the SEIPT for airport deployment of bulk and trace detection equipment
- Tested carry-on baggage screening with the operator assist function

R&D Partnerships: The explosives detection program works closely with academia, industry, and other national laboratories. Partnerships with organizations reduce costs, where possible, by combining research initiatives that use the same technologies for slightly different purposes. More than 90 contracts, grants, CRDA's, and interagency agreements are in place with industry, academia, and other Government agencies. R&D partnership activities include:

- InVision Inc., working with the FAA, has produced the first certified explosives detection system in the world. It is now available and being sold domestically and internationally. They are currently supported under a cost sharing agreement to develop a more efficient system.
- Industry and the FAA share development in carry-on, checked, and cargo-scanning systems. This involvement includes joint funding agreements, cooperative research and development agreements, and FAA consultation to help companies improve existing systems through joint testing efforts.
- The interagency Technical Support Working Group supports explosives detection projects that can be applied to other agencies. These projects include document scanners, cargo screening systems, miniaturization, and performance improvement of trace detection technologies and industry collaboration with foreign governments' technology development programs.
- Bilateral agreements exist between the FAA and several international counterparts.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

Bulk explosives/weapons detection

- Developed competitive computed tomography-based explosives detection system
- Developed improved quadrupole resonance prototype
- Developed new technologies based on emerging threats
- Set standards for carry-on and cargo-screening systems
- Completed evaluation of non-imaging passenger portal

Trace detection

- Benchmarked contamination levels for personnel and carry-on luggage
- Completed benchmark study for automated trace systems
- Built automated trace baggage system prototype
- Performed operational test of automated ticket screening device
- Set standards for electronics screening

Combined technology

- Developed automatic passenger screening portal for weapons and trace explosives detection

KEY FY 2000 PRODUCTS AND MILESTONES:

Bulk explosives/weapons detection

- Develop new technologies based on emerging threats
- Develop automated carry-on prototype
- Reduce false alarm rate in fielded EDS systems
- Test and evaluate commercially available cargo screening systems

Trace detection

- Determine feasibility of using trace for cargo screening
- Enhance/develop systems to handle emerging threats

- Develop trace detection standards for personnel screening
- Perform R&D to enhance performance of explosives detection canines
- Develop competitive trace automated baggage system

Combined technology.

- Combine explosives/detonator detector development.
- Develop combined technology personnel inspection system using bulk and trace technologies
- Develop NQR/X-ray detection system

FY 2000 PROGRAM REQUEST:

The program develops or enhances technologies that detect or discover emerging threats in both the trace and bulk detection areas. In some cases, capabilities are added to existing systems or completely new technology methods to handle the threats not addressed by current technologies. In each case, standards are developed to characterize the performance of the newly developed systems.

Combined technologies are used that merge a system's ability to analyze and integrate data from multiple sensors, thus providing an improved detection over single-system capability. This applies to baggage, cargo, and personnel scanning devices. The results of this research should increase the probability of detection and decrease the false alarm rates over existing technologies performing similar individual functions. New combinations of devices are being considered for use in environments inaccessible to public view.

Research continues into the development of faster, more automated, and cheaper systems that could more easily be integrated into an airport environment. The program makes maximum use of data and experience gained from deploying existing equipment.

A07a - Explosives and Weapons Detection Product and Activities	Program Schedule					
	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY2004
071-110 Explosives/Weapons Detection						
Bulk Explosives/Weapons Detection						
Developed Competitive Computed Tomography Based Explosives Detection System	◆	◇				
Developed Improved Quadrupole Resonance Prototype	◆		◇			
Develop New Technologies Based on Emerging Threats	◆	◇	◇	◇	◇	◇
Set standards for carry-on and cargo screening systems	◆					
Develop Automated Carry-on Prototype		◇				
Reduce False Alarm rate in fielded EDS System		◇				
Test and Evaluate All Commercially Available Cargo Systems		◇				
Airport Test of Advanced Baggage Screening System			◇	◇		◇
Improve existing 2nd/ 3rd generation Computed Tomography EDS				◇		◇
Trace Detection						
Benchmark contamination levels for personnel and carry-on luggage	◆					
Complete benchmark study for automated trace systems	◆					
Built Automated Trace Baggage System Prototype	◆					
Operational test of automated ticket screening device	◆					
Set standards for electronic screening	◆					
Determine Feasibility of using trace for Cargo Screening		◇				
Enhance/Develop Systems to Handle Emerging Threats		◇		◇		◇
Airport Test of Enhanced systems			◇		◇	
Develop trace detection standards for personnel screening		◇				
Perform R&D for Canine performance enhancements		◇				
Develop Competitive Trace Automated Baggage System		◇				
Upgrade Trace Systems for ICAO Markers				◇		
Develop Chemical Weapons Mitigation Systems				◇		
Combined Technology						
Develop automatic passenger screening portal for weapons and trace explosives detection	◆					
Combined Explosives/Detonator Detector Development		◇				
Develop Combined Technology Inspection Personnel System using bulk and trace technologies		◇				
Develop NQR/X-ray detection system		◇				
Develop Phase 1 Lab Prototype Combined X-Ray/Trace System			◇			
Develop Checkpoint Suite Prototype				◇		◇

Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	25,044	38,629	30,832	37,696	35,370
Personnel Costs	3,283	2,297	2,796	3,462	4,827
Other Costs	673	471	572	542	479
Total	**29,000**	**41,397**	**34,200**	**41,700**	**40,676**

A07b Airport Security Technology Integration

GOALS:

Intended Outcomes: This program supports goal 2 of the FAA Strategic Plan: "Aviation Security-Zero Incidents." Specifically, it addresses plan objective 2A and 2C (which addresses specific aviation security vulnerabilities and reduction of international security incidents through cooperation with foreign governments). To achieve these objectives, the program strives to block terrorist access to the aircraft by analyzing airport vulnerabilities, investigating advanced perimeter control surveillance systems, and developing systems that provide strict accountability for luggage loaded onto an aircraft.

Additionally, the program supports the other aviation security programs by:

- Identifying advanced threats that the aviation community may face in the near future
- Developing sophisticated models to predict the operational effects of inserting security measures into the existing aviation system
- Developing communication protocols that allow advanced systems to work together

Overall progress in meeting these goals results from: (1) providing methods to increase passenger flow and reduce costs associated with security risk mitigation; (2) identifying and developing new technologies, methodologies, and procedures to enhance performance of security professionals; and (3) developing and maintaining an integrated security system approach for countermeasures to use against identified threats to the civil aviation system.

Agency Outputs: The FAA establishes the regulations governing airport and airline security and the rules for security inspections. It publishes these rules and regulations, with guidance for their implementation, in the form of advisory circulars. The Airport Security Technology Integration (ASTI) program also provides reports and other forms of technical information to aid the civil aviation security community in improving security methods.

Customer/Stakeholder Involvement: The FAA collaborates extensively with the domestic and international aviation security communities. The R,E&D efforts include industry participation with the Air Transport Association (ATA) to study the operational costs and effects of PPBM. This effort is designed to prevent the loading of unaccompanied baggage on aircraft. The FAA collaborates with the Société Internationale de Télécommunications Aéronautiques (SITA) and the International Air Transport Association (IATA) in developing standards for baggage tracking and reconciliation systems and tagging technologies.

The program responds to Public Law 101-604, the Aviation Security Act of 1990, the Aviation Security Advisory Committee (ASAC) recommendations, and the recommendations of the White House Commission on Aviation Safety and Security. These provide impetus for security research requirements and dissemination of the research results to industry.

Accomplishments: Results of the ASTI program are used by the aviation community and also by the Office of Civil Aviation Security in its rulemaking process. Among the results, the program has:

- Completed assessments of radio frequency (RF) technology for PPBM
- Completed evaluations of commercial off-the-shelf (COTS) airport vulnerability assessment tools against developed functional requirements
- Developed and implemented baseline methodology for vulnerability analysis of airports
- Provided statistical analysis of findings to industry
- Integrated security vulnerability countermeasures into an operational testbed to validate security benefits and operational impact
- Published functional requirements for an airport vulnerability analysis tool and validated selected COTS vulnerability assessment tools against these requirements
- Completed biannual technical reports that identify and prioritize advanced technical threats against civil aviation. This report drives research requirements and guides current and future research trends

- Completed an airport explosives security survey analysis and correlated information to identify vulnerabilities across 76 domestic airports; feedback on areas of concern and corrective action was provided to airports
- Published guidelines for industry on security revolving doors for use at concourse screening points
- Published functional guidelines for the PPBM system
- Developed guidelines for mitigating risk to blast effects
- Performed testbed studies in feasibility area of personnel access control
- Investigated advanced airport security command and control methods
- Identified opportunities for airport security and operations improvements via information integration

R&D Partnerships: The ASTI program—through partnership with the RTCA Subcommittee (SC) 183, and participation of industry—developed a standard for airport security access control systems. Relationships with ATA and the Regional Aircarrier Association (RAA) focus on the study of economic effects of PPBM on the industry. A yearlong cooperative study culminated with the publication of a project report that analyzed the economic effects of PPBM on the aviation industry. The FAA continues this relationship to fulfill the requirements of the White House Commission on Aviation Safety and Security recommendations for PPBM. The ASTI program determines the operational effects of alternative approaches to, and research of, technologies to increase the efficiency and security of reconciling baggage with passengers.

The program works with Airports Council International-North America (ACI-NA) to integrate operational airport design needs into a PPFM tool. When completed, this software package will be transferred to industry for use as a tool in configuring security systems and technologies into the airport environment.

The program and the State of Illinois are cosponsoring research on the security of cargo shipments in transit from remote cargo facilities to airlines' receiving points. The test will determine the feasibility of a positive driver ID and cargo seal system.

The program has interagency agreements with the DOD Office of Special Technology to coordinate activities relative to technology assessments. Also, the agency coordinates efforts with the U.S. Air Force and the DOD Defense Special Weapons Agency related to simulation and modeling of blast effects and biological and chemical effects on aviation facilities.

The ASTI program is the designated lead for the bilateral agreement with Canada's Department of Transport for physical security of airports. Participation in the General Services Administration, Interagency Advisory Committee on Security Equipment (IACSE) provides a forum for technology interchange.

Additionally, grants, cooperative research and development agreements (CRDA), and memorandums of understanding/agreement with industry, academia, and other government agencies provide leverage to the program in areas of mutual interest.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

Domestic air travel

- Transferred assessments of RF technology for PPBM to industry
- Developed functional specification of cost-benefit model
- Conducted operational test of RF-based baggage-matching system in multiple airports
- Conducted evaluation of security systems to ensure in-transit security of cargo bound for carriage on passenger aircraft
- Developed a protocol standard for explosives detection systems to communicate with baggage-handling systems to ensure accurate tracking of alarmed bags
- Completed passenger and baggage flow model
- Incorporated enhancements to Blast Effects model
- Developed Toxic Effects model

Airport security

- Evaluated COTS airport vulnerability assessment tools and methods
- Refined threat/countermeasures database
- Developed an architecture for security monitoring equipment information integration
- Researched advanced countermeasures
- Developed operational testbed infrastructure in new security operations center

KEY FY 2000 PRODUCTS AND MILESTONES:

Domestic air travel

- Publish a threat analysis report for NAS specific subsystem component
- Publish report on operationally tested RF-based baggage-matching system in multiple airports
- Publish report on systems to ensure in-transit security of cargo bound for carriage on passenger aircraft
- Publish a communication protocol standard for EDS integration into automated baggage handling systems

Airport security

- Integrate EDS and other security vulnerability countermeasures into operational testbeds
- Develop airport vulnerability assessment methods to be used by field personnel
- Perform large-scale demonstration of advanced airport commands and control methods
- Test emerging sensors and systems for low-cost performance intrusion detection

FY 2000 PROGRAM REQUEST:

In FY 2000, the program will complete several key efforts and publish their results for use by the aviation community. These publications will include reports on RF technology that will likely influence establishment of worldwide standards in the field. The program will finalize, in cooperation with industry, a standard for communication between advanced detection systems and automated baggage-handling systems. Such a standard is critical to effective use of the new detection technologies. Additionally, the program will finalize its passenger baggage flow model. Airport and airline planners will use this planning tool to find the most efficient security equipment layout within existing and future terminals. The program will continue to support other aviation security programs by assessing future threats to aviation security, developing sophisticated simulation tools, and addressing new technology integration issues.

A07b - Airport Security Technology Integration Product and Activities	Program Schedule					
	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY2004
073-110 Airport Security Technology Integration						
Domestic Air Travel						
Transferred Radio Frequency (RF) Technology for Positive Passenger Bag Match (PPBM) to Industry	◆					
Update BI-Annual Report on Countermeasures to Identify Advanced Means of Attack Against Civil Aviation	◆		◇		◇	
Publish Threat Analysis Report for NAS Specific Subsystem Components		◇				
Developed Functional Specifications for Cost-Benefit Model	◆					
Publish Report on Operationally Tested RF-based Baggage Matching System in Multiple Airports	◆	◇				
Publish Report on Systems to Ensure In-transit Security of Cargo Bound for Carriage on Passenger Aircraft	◆	◇				
Developed a Protocol Standard for Explosives Detection Systems to Communicate with Baggage Handling Systems to Ensure Accurate Tracking of Alarmed Bags	◆					
Publish a Communication Protocol Standard for EDS Integration into Automated Baggage Handling Systems		◇				
Completed Passenger and Baggage Flow Model	◆					
Developed Blast Effects Model	◆					
Developed Toxic Effects Model	◆					
Airport Security						
Integrate EDS & Other Security Vulnerability Countermeasures into Operational Testbed		◇	◇			
Evaluated Commercial Off The-Shelf (COTS) Airport Vulnerability Assessment Tools and Methods	◆					
Refined Threat/Countermeasures Database	◆	◇	◇	◇	◇	◇
Developed an Architecture for Security Monitoring Equipment Information Integration	◆					
Develop/Refine Airport Vulnerability Assessment Methods to be Used by Field Personnel		◇		◇		◇
Advanced Countermeasures Researched	◆					
Large Scale Demonstration of Advanced Airport Commands and Control Methods		◇	◇			
Testing of Emerging Sensors and Subsystems for Low-Cost Airport Security Devices		◇	◇	◇	◇	◇
Develop/Refine Operational Testbed Infrastructure in New Security Operations Center	◆	◇	◇	◇	◇	◇

Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	490	3,165	1,127	1,832	909
Personnel Costs	423	492	1,127	754	1,258
Other Costs	87	101	231	122	118
Total	**1,000**	**3,758**	**5,000**	**2,708**	**2,285**

A07c Aviation Security Human Factors

GOALS:

Intended Outcomes: This program supports the goal to improve the detection of explosives and weapons in the security portion of the 1998 FAA Strategic Plan. Specifically, the Aviation Security Human Factors program targets the Strategic Plan's focus areas of establishing a security baseline and defining the information security architecture.

This program leverages funding for equipment development by producing usable and effective products:

- Improved aviation security system performance and efficiency through better operator selection, training, and performance monitoring techniques for the various detection technologies
- Optimized human performance contributions to the overall aviation security system performance, merging individual detection systems into a combined technology system, through enhanced machine interfaces and integration

Agency Outputs: The FAA establishes standards for security activities, and this program conducts R&D for technical input essential to:

- Reduce security costs resulting from automation
- Reduce vulnerability to terrorist threats
- Decrease risk of catastrophic financial loss resulting from airplane sabotage
- Increase public confidence in the safety of air travel
- Increase global U.S. industrial competitiveness

Customer/Stakeholder Involvement: This program supports the Office of the Associate Administrator for Civil Aviation Security as mandated by the Aviation Security Improvement Act of 1990 (Public Law 101-604).

- Responds to requirements from the Aviation Improvement Act of 1990, the White House Commission on Aviation Safety and Security, Baseline Working Group on Aviation Security, and the General Accounting Office (GAO)
- Partners with multiple airlines to test and evaluate equipment, personnel, and procedures

Accomplishments: Results of Aviation Security Human Factors research are used by the Office of Civil Aviation Security in its rulemaking process. Among the results, the program has:

- Refined definition of knowledge, skills, and abilities needed for checkpoint screening
- Developed functional requirements for the Screener Proficiency Evaluation and Reporting System (SPEARS) components of screener selection, training, and performance monitoring
- Measured baseline checkpoint security performance.
- Developed screener selection tests for estimating future performance, interpreting both conventional x-ray and computed tomography (CTX 5000) images
- Developed Computer-Based Training (CBT) for both checkpoint operations and checked baggage evaluation with the CTX 5000
- Developed Threat Image Projection (TIP) for both conventional x-ray machines and the CTX 5000
- Developed dupe checklist system
- Developed manual domestic passive profiling system
- Developed Computer-Assisted Passenger Screening (CAPS) profiling system

R&D Partnerships: This program works closely with a variety of agencies and groups involved in aviation, such as:

- The International Aviation Security Human Factors Technical Advisory Group, to ensure effective communication of research results and avoid duplication of efforts
- Lawrence Livermore National Laboratory, through an interagency agreement
- Cooperative research grants, to develop and operationally test SPEARS screener selection, training, and performance monitoring components

- Domestic airlines and research organizations, including:
  - – Alaska Airlines
  - – Delta Airlines
  - – EG&G Astrophysics Research Corporation
  - – Northwest Airlines
  - – Public Computer Systems
  - – Rapiscan Security Products Inc.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

Screener selection/training/testing

- Refined definitions of knowledge, skills, and abilities for using emerging detection technologies
- Improved screener selection, screener machine interfaces, CBT multimedia training, and performance monitoring systems for emerging detection technologies
- Criteria and data for rulemaking about screener selection, training, and proficiency assessment

Human systems integration (HSI)

- Completed evaluations of detection systems involving emerging technologies, such as bottle screening and millimeter wave detection
- Optimized combined detection technologies through component integration within futuristic screener stations
- Integrated new and emerging detection technologies into their operational environment
- Provided HSI evaluations on the manpower, personnel, training, human factors engineering, health, and safety aspects of security systems, especially those involving EDS and weapons detection technologies

KEY FY 2000 PRODUCTS AND MILESTONES:

Screener selection/training/testing

- Determine knowledge, skills, and abilities for using emerging detection technologies
- Improve screener selection, screener machine interfaces, CBT multimedia training, and performance-monitoring systems for emerging detection technologies
- Establish criteria and data for rulemaking about screener selection, training, and proficiency assessment

Human systems integration (HSI)

- Continue to evaluate detection systems involving emerging technologies, such as bottle screening and millimeter wave detection
- Integrate new and emerging detection technologies into their operational environment
- Provide HSI evaluations on the manpower, personnel, training, human factors engineering, health, and safety aspects of security systems, especially those involving EDS and weapons detection technologies

FY 2000 PROGRAM REQUEST:

This program focuses on producing key FY 2000 products to accomplish stated goals. Results emphasize R&D within the areas of screener selection/training/testing, and human systems integration. The program improves screener selection, screener machine interfaces, CBT multimedia training, and performance-monitoring systems for emerging detection technologies.

The research provides the basis for establishing criteria and data for rulemaking. It evaluates detection systems involving emerging technologies, such as bottle screening and millimeter wave detection. It also optimizes detection technologies through component integration within futuristic screener stations and integrates new and emerging detection technologies into their operational environment. Finally, it provides Human Systems Integration evaluations on the manpower, personnel, training, human factors engineering, health, and safety aspects of security systems, especially those involving EDS and weapons detection technologies.

A07c - Aviation Security Human Factors Product and Activities	Program Schedule					
	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY2004
076-110 Aviation Security Human Factors						
Screener Selection/Training/Testing						
Determine Knowledge, Skills, & Abilities Required for Screeners to Use Emerging Technologies	◆	◇	◇	◇	◇	◇
Improve Screener Selection, Screener-Machine Interfaces, Training Programs, and Performance Monitoring	◆	◇	◇	◇	◇	◇
Establish Criteria and Data for Rulemaking	◆	◇	◇	◇	◇	◇
Human Systems Integration (HSI)						
Provide HSI Evaluations on Manpower, Personnel, Training, Human Factors Engineering, Health and Safety Aspects of Security Systems	◆	◇	◇	◇	◇	◇
Evaluate New Detection Systems (e.g. Bottle Screening, Millimeter Wave Detection	◆	◇	◇	◇	◇	◇
Integrate New and Emerging Technologies into Operational Environment	◆	◇	◇	◇	◇	◇
Optimize Combined Detection Technologies Within Futuristic Screener Stations	◆	◇	◇	◇	◇	◇

Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	2,039	4,446	4,723	4,078	4,114
Personnel Costs	423	492	679	1,064	1,032
Other Costs	87	101	138	140	110
Total	**2,569**	**5,039**	**5,540**	**5,282**	**5,256**

A07d Aircraft Hardening

GOALS:

Intended Outcomes: In accordance with the strategic goal of eliminating security incidents in the aviation system, the overriding program goal is to protect commercial aircraft from catastrophic structural or critical system failure due to an in-flight explosion. Secondary objectives are to investigate vulnerability from some spurious electromagnetic or high-energy signal interfering with aircraft electronic systems and to assess the threat presented by manually operated, highly mobile, surface to air missiles.

The program determines and identifies: (1) the minimum size of an explosive that would result in aircraft loss; (2) the methods and techniques that can be applied to the current and future fleet of commercial aircraft to decrease the level of vulnerability to explosive effects; and (3) the threat to aircraft from electromagnetic interference, projected energy, and surface-to-air missiles and practical countermeasures.

Agency Outputs: The program delivers documented explosive vulnerability data to the explosive detection community and, depending on research results, provides recommendations for rulemaking relative to mitigation techniques. In the area of other threats, the program provides reports to the staff of the Associate Administrator for Civil Aviation Security describing specific commercial aircraft vulnerability to threats as well as possible countermeasures. To meet these requirements, the program has been divided into the following three projects: explosive vulnerability and aircraft-design-related mitigation techniques, container hardening, and protection against advanced terrorist threats.

Customer/Stakeholder Involvement: The aircraft hardening program was initiated in 1990 in response to the directives of the President's Commission on Aviation Safety and Security and the mandates set forth in the Aviation Security Improvement Act of 1990. The program is continually assessed by the Security Subcommittee of the FAA R,E&D Advisory Committee and has been subjected to scrutiny and endorsed by the General Accounting Office. The program content directly supports the customer, the Assistant Administrator for Civil Aviation Security, and complies with the aviation security requirements document of the Office of Civil Aviation Security. Additionally, the program, as required, periodically reports technical progress directly to Congress.

Accomplishments:

- Validated established detection standards through analysis and explosive testing of the minimum size, type, and location of explosives that could cause a catastrophic aircraft failure
- Proved the feasibility of and determined the standards for explosive-resistant luggage containers used in wide body aircraft
- Provided prototype containers to the airlines to conduct an operational assessment of the cost and improved security effectiveness of implementing hardened containers as a continuation to the container effort that was suggested by various members of Congress
- Initiated a process, while working with DOD and other Government agencies, to assess the vulnerability of commercial aircraft to terrorist-induced electronic and mobile missile threats

R&D Partnerships: From the outset, the program has used expertise from the U.S. Air Force, U.S. Army, and U.S. Navy, as well as consulted with various Department of Energy laboratories and NASA. Relationships also have been established with the U.S. aircraft and container manufacturing industries, and research efforts have been coordinated with the United Kingdom, Israel, and France. The program also uses the services of many defense- and aircraft-related industries. The prime program objective is to collect data to support rulemaking. As the program uses a wide spectrum of industry experts, the program has transferred or will transfer all developed technologies directly to the appropriate private market.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

Container hardening

- Transitioned container technologies to private industry

- Completed operational assessment of LD-3 hardened containers with airlines

Aircraft vulnerability

- Identified and validated through testing the vulnerability of narrow body commercial aircraft to explosive effects
- Validated, through explosive testing, the blast effects of a variety of different explosives for refining detection criteria

Projected energy, electromagnetic interference, and other terrorist threats

- Identified possible mitigation techniques to counter projected energy and other threats
- Developed procedures/rules for man portable air defense systems (MANPADS)

KEY FY 2000 PRODUCTS AND MILESTONES:

Container hardening

- Investigate and demonstrate protection for limited number of bags on narrow bodied aircraft
- Complete assessment of other than LD-3 size containers; make the decision on rulemaking

Aircraft vulnerability

- Assess security implications associated with the introduction of 800 passenger jets and/or high-speed civil transports
- Validate appropriate new techniques to mitigate explosive effects
- Develop new aircraft certification criteria

Projected energy, electromagnetic interference, and other terrorist threats

- Develop procedures/rules for electromagnetic interface

FY 2000 PROGRAM REQUEST:

In FY 2000, the program will continue focusing on the areas listed at the beginning of the "Goals" section above. As vulnerability assessments evolve, ideas to mitigate blast either through retrofitting the current fleet or instituting new design techniques and materials are being identified. These ideas and concepts are analyzed and tested and recommendations for new specifications are made as required. Special emphasis is placed on assessing and recommending hardening actions regarding the long-term implications of terrorism on new commercial aircraft concepts, such as the 800- to 1000-passenger jumbos and the high-speed civil transport.

In addition, analyses of the impact of electromagnetic interference, projected energy, and MANPADS on commercial aircraft are underway and anticipated to be complete by the end of FY 2000. These research efforts are primarily investigative in nature and involve an assessment of the potential vulnerability of an aircraft to these threats.

A07d - Aircraft Hardening Product and Activities	Program Schedule					
	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY2004
075-110 Aircraft Hardening						
Container Hardening						
Completed Operational Assessment of LD-3 Hardened Containers with Airlines	◆					
Complete Assessment of Other Than LD-3 Size Containers, Make Decision on Rulemaking	◆			◇		
Investigate and Demonstrate Protection for Limited Number of Bags on Narrow Bodied Aircraft	◆				◇	
Develop rules for narrow body protective units					◇	
Transition Container Technologies to Private Industry	◆				◇	
Aircraft Vulnerability						
Assess Security Implications Associated with the Introduction of 800 Passenger Jets and/or High Speed Civil transports		◇		◇		
Identified and Validated through Testing the Vulnerability of Narrow Body Commercial Aircraft to Explosives Effects	◆					
Projected Energy/Electromagnetics/Other Terrorists Threats						
Identified Possible Mitigation Techniques to Counter Projected Energy and Other Threats	◆					
Develop Procedures/Rules for Electromagnetic Interface			◇			
Develop Procedures/Rules for Projected Energy			◇			
Developed Procedures/ Rules For Man Portable Air Defense Systems (MANPADS)	◆		◇			
Publish Reports Identifying Cost-effective Alternatives For Mitigating The Threat Of Electromagnetic, Projected-energy Weapons and MANPADS				◇		
Assess Aircraft Design implications relative to Chemical/Biological Threats					◇	
Develop procedures/rules for Chemical/Biological Threat						◇

Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	2,986	6,268	1,393	1,139	3,371
Personnel Costs	423	492	504	754	1,497
Other Costs	87	101	103	107	133
Total	**3,496**	**6,861**	**2,000**	**2,000**	**5,001**

2.5 Human Factors and Aviation Medicine

Mission

The Human Factors and Aviation Medicine program will:

- Identify, through applied research, methods that, when implemented, help achieve the goal of reducing the fatal accident rate by 80 percent
- Ensure, through innovative research and management initiatives, that human factors issues are addressed in acquiring and integrating all new and modified FAA aviation systems
- Review medical patterns in civilian flight
- Develop recommendations for protective equipment and procedures
- Provide options for FAA regulatory and medical certification staff charged with developing safety standards and regulations addressing all aircraft cabin occupants

The rapid evolution toward increased operational demand, diversity of aircraft and systems, changing technology, and globalization of the airline/aircraft industry challenges the Human Factors and Aviation Medicine Offices to meet the above goals by:

- Ensuring that research is focused on areas directly affecting aviation safety
- Capitalizing on opportunities to leverage government and industry resources
- Forming partnerships with research and university laboratories to rapidly transfer the results of research to the aviation community
- Undertaking major efforts to ensure that human factors expertise is represented across functional disciplines and that human factors considerations are addressed throughout the FAA acquisition process

Intended Outcomes

Human Factors. This research increases NAS safety and efficiency by developing scientifically validated information and guidance for improving performance and productivity of air traffic controllers and NAS system maintenance technicians.

This program responds directly to FAA Strategic Plan goals to "eliminate accidents and incidents caused by human error" and to "implement new decision support systems and associated functional improvements that fully account for the proper role of people in the system." This research also provides human factors support that addresses the FAA goal to "reduce the costs of flying by making the air traffic management system more efficient to use."

Human factors research is developing human-centered flight controls and displays and is increasing consideration of human factors in aircrew training. This research also explores prospects for safety enhancement through automated statistical analysis of flight-recorded data and through certification of new aircraft and equipment design and modification.

In aviation maintenance, human factors research develops more effective methods for maintenance technician and inspector training, and it improves aviation maintenance technician and inspector task performance.

In general aviation (GA), safety is enhanced through understanding and improving pilots' decisionmaking skills.

Aviation Medicine. This research improves the health, safety, and survivability of aircraft passengers and aircrews by identifying human failure modes and developing formal recommendations for counteracting measures.

Through this research, the FAA develops bioaeronautical guidelines, standards, and models for aircraft cabin equipment, procedures, and environments as a basis for regulatory action to enhance appropriate human performance. New medical criteria, standards, and assessment/certification procedures are also developed to ensure full performance capability. Assessing flight attendant and passenger behavior and disease issues will lead to the development of guidelines to protect the health and improve the safety of cabin occupants.

Program Area Outputs

The Human Factors research program:

- Identifies operational needs and problems involving human performance
- Funds and guides research programs to address operational priorities
- Forms partnerships with industry and academia
- Elicits participation by the Nation's top scientists and professionals
- Provides Human Factors guidance to the FAA for development and implementation of new technologies
- Facilitates transfer of research products to the operational community

The Aviation Medicine research program:

- Produces data and other forms of information that support notices and regulations applicable to aircraft occupant health and safety
- Develops output options to solve a public demand (e.g., better restraints for children in aircraft settings)
- Assesses disease transfer and other aircraft occupant health factors

The FAA works to ensure the safety and efficiency of NAS operations, a critical element of which is operator performance. Through guidelines, handbooks, advisory circulars, rules, and regulations, it provides industry with human performance information and guidance critical to the design, operation, regulation, and certification of equipment, training, and procedures. The Human Factors program research provides the technical information necessary to generate these products and services.

Automation has been cited as a contributing factor in aircraft accidents (e.g., Cali: AA965). Human factors research is examining flight deck automation design, operation, and use and has classified the issues to be addressed.

- Air carrier training initiatives such as the Model Advanced Qualification program (air carrier pilot training program that integrates both technical and crew resource management performance requirements) will allow air carriers to develop and use proficiency-based training.
- The Automated Performance Measuring System will provide airlines the ability to analyze routine operations for dangerous trends and tendencies and will provide insight into the details of daily carrier line operations.
- Validated pre-hire assessments for air traffic controllers, electronics technicians, and transportation system specialists will enable the FAA to select persons with appropriate knowledge, skills, and abilities for each occupation, which will reduce training required after employment as well as attrition due to poor person-job fit.
- The Aviation Medicine Office and the National Institute for Occupational Safety (NIOSH) and Health are examining cabin air quality issues and their effect on passengers and crew.
- Aviation Medicine is also developing:
  - Bioengineering criteria to support aircraft seat and restraint system certification
  - Human performance and ergonomic data to support emergency evacuation regulations and standards
  - Biomedical criteria to support protective breathing equipment and operational procedures certification
  - Biochemical and toxicological criteria supporting use or certification of aircraft interior fire, smoke, and toxicity limits.

Program Area Structure

The Human Factors program addresses operational requirements through research in five technical thrust areas that were agreed to by the FAA, The National Aeronautics and Space Administration (NASA), and the Department of Defense (DOD) in the National Plan for Civil Aviation Human Factors:

Human-Centered Automation. This research focuses on the role of the operator and the cognitive and behavioral effects of using automation to assist humans in accomplishing assigned tasks. Research addresses the identification and application of knowledge concerning the relative strengths and limitations of humans in an automated environment. It investigates the implications of computer-based technology in designing, evaluating,

and certifying controls, displays, and advanced systems.

Selection and Training. This research strives to:

- Understand the relationship between human abilities and aviation task performance
- Enhance the measures and methods of predicting current and future job/task performance
- Establish a scientific basis for the design of training programs, devices, and aids for individuals and teams
- Define criteria for assessing future training requirements
- Identify new ways to select aviation system personnel

Human Performance Assessment. Research in this area identifies the intrinsic cognitive and decisionmaking factors for individuals and teams that determine how well they are able to perform aviation tasks; characterizes the impact of environmental and individual factors on human performance; and improves and standardizes methods for measuring human performance.

Information Management and Display. Research in this area addresses the presentation and transfer of information among components in the NAS. It seeks to:

- Identify the most efficient and reliable ways to display and exchange information
- Determine what, when, and how one might best display and transfer information to system components
- Design a system to reduce the frequency of information transfer errors and misinterpretations
- Minimize the impact when such errors do occur

Bioaeronautics. Research involves the bioengineering, biomedicine, and biochemistry associated with performance and safety. The objective is to enhance personal performance and safety by maximizing crew and passenger health and physiological integrity. The program consists of three research initiatives:

- Human protection and survival—Investigates protecting humans in decelerative environments, protective breathing equipment, cabin evacuation, and water survival
- Medical and toxicological factors of accident investigation—Investigates Medical and toxicological factors of accidents, including sudden or subtle pilot incapacitation
- Federal Air Surgeon program support—Current clinical investigation, including new vision-correction methods for aviation personnel, aircraft cabin environmental hazards, and air ambulance medical requirements
- A program to survey the nature of in-flight medical emergencies, particularly the effectiveness of defibrillators carried on airliners, also supports the Federal Air Surgeon

Customer/Stakeholder Involvement

The Human Factors program directly supports a number of aviation community initiatives and Congressional mandates:

- 1998 FAA Strategic Plan Mission Goal for Safety: By 2007, reduce U.S. aviation fatal accident rates by 80 percent from 1996 levels. FAA will work with aerospace community to:
  - Build on currently successful efforts to identify root causes of past accidents
  - Use a more proactive analytical approach, with new data sources, to identify key risk factors and intervene to prevent potential causes of future accidents
  - In partnership with NASA, DOD, and other public and private organizations, study issues and technologies to improve policies, procedures, and equipment.
- Office of the Associate Administrator for Research and Acquisitions (ARA) Performance Plan:
  - Goal 1: Contribute to the FAA goal to reduce the fatal aviation accident rate by 80 percent by 2007 as compared to 1994-1996 baseline data
  - Goal 2: Ensure human factors issues are addressed in the acquisition and integration of 100 percent of FAA aviation systems and applications by 2005, including Free Flight Phase 1.

- *The National Plan for Civil Aviation Human Factors*, published in March 1995, with FAA, NASA, and DOD as signatories. This document, which had extensive aviation community participation in its development, outlines a coherent national agenda for human factors and bioaeronautical research and application leading to significant improvements in NAS safety and efficiency.
- The Aviation Safety Plan, through research supporting priority issues associated with crew training, safety data collection and use, application of emerging technologies, and aircraft maintenance procedures and inspection. The Aviation Medicine program significantly contributes to the application of emerging technologies, as highlighted in the Plan.
- Implementation of the FAA report, *The Interfaces Between Flight Crews and Modern Flight Deck Systems.*
- Public Law 100-591 establishes requirements for human factors research and its application. The FY 1998 Department of Transportation Appropriations Act cites human factors as the greatest cause of aviation accidents. The Aviation Safety Research Act of 1988 requires that human factors research be conducted to "enhance air traffic controller performance." These two Acts support continuing work in human factors analysis of the hazards associated with new technologies, identify innovative and effective corrective measures for human errors, and develop dynamic simulation models of the air traffic control (ATC) system.
- The Radio Technical Commission for Aeronautics (RTCA) "Free Flight Action Plan" specifically addresses recommendations to: establish more flexible decision support systems involving collaborative decisionmaking; conduct human-in-the-loop simulations for assessing controller and pilot perceptions of hazards, risks, and discomfort; measure performance, workload, and situation awareness associated with controller and pilot responses to time and distance; conduct real-time human-in-the-loop simulations to systematically study controller and pilot behaviors, interactions, and effects within NAS environments that represent dynamic densities and sector configurations anticipated for free flight.
- The Aviation Medicine program is an integral participant and research provider under the FAA, Joint Aviation Authorities, and the Transport Canada Aviation Aircraft Cabin Safety Research Plan (established in 1995). The plan sets forth long-term research goals and ensures coordination between international aviation agencies. Programs within Aviation Medicine that study aircraft cabin environmental quality and the nature and extent of in-flight medical emergencies are a direct result of specific Congressional mandates to study these topics.

Accomplishments

- Developed and field-tested with several airlines a prototype Automated Performance Measurement System (APMS) that allows for gathering and analysis of data from aircraft flight data recorders. This information and analysis capability is used by the Flight Operations Quality Assurance program, a joint FAA and airline venture, to enhance aviation safety.
- Validated use of simulator parameters and flight data for evaluating Advanced Qualification program (AQP) effectiveness
- Developed a model AQP for use by training centers to support air carrier participation in AQP, a proficiency-based approach to pilot training
- Provided crew resource management procedure guidelines for regional airlines
- Validated human performance transfer functions for level B full flight simulator
- Provided recommendations for improved use of automated flight management systems
- Produced and presented the FAA Human Factors Course to increase understanding of the importance of considering the "human factor" in design/acquisition of FAA systems
- Produced and distributed handbook for advanced Crew Resource Management training
- Completed a study of the effectiveness of delivering technical information to line aircraft

technicians using wireless, portable, pen-based computers that display technical publications

- Initiated a process to integrate shift-change error identification and mitigation processes into the aircraft maintenance error-detection and reporting system
- Developed pilot performance data through flight simulation for use in establishing certification standards for general aviation autonavigation and control systems
- Directed a large-scale effort to identify and resolve a large number of human factors issues inherent in the STARS display
- Sponsored the National Research Council's two-phase assessment of human factors issues in the air traffic control system and the NAS, and an examination of future automation issues. Distributed two publications: *Flight to the Future—Human Factors in Air Traffic Control*, and *The Future of Air Traffic Control*
- Conducted a human/system performance assessment of the Departure Sequencing Engineering Development Model
- Completed a human factors audit of the Converging Runway Display Aid (CRDA) installed at St. Louis Airport. CRDA is a decision support tool that helps terminal radar controllers efficiently space aircraft arriving on separate, converging runways
- Completed measurement of task-load and document work processes of personnel at maintenance control centers
- Developed guidelines to reduce in-flight sudden/subtle incapacitation
- Evaluated autopsy data from fatal aviation accidents to recommend protective equipment and design practices
- Assessed flight attendant reproductive health hazards
- Reported on the suitability of component tests for showing regulatory compliance with crashworthiness standards for aircraft
- Completed definitive evacuation escape slide angle and strength studies to minimize escape injuries and escape failures
- Developed fit and comfort standards for aviation oxygen mask systems
- Assessed operational hazards of in-flight laser exposure

Research and Development (R&D) Partnerships

The Human Factors program is linked to NASA and DOD under the auspices of the *National Plan for Civil Aviation Human Factors: An Initiative for Research and Application.* Specific areas of coordinated program execution with NASA include cockpit automation, fatigue, crew resource management, team decisionmaking, air-ground communication, and the Automated Performance Measurement System. DOD joint efforts involve fatigue, team performance, and decisionmaking research. Additionally, the Human Factors Office maintains a membership in the DOD Human Factors Engineering Technical Advisory Group that provides a forum for the coordination of research across a variety of technical areas.

The Human Factors Office participates with the Netherlands National Research Laboratory in flight deck automation research, and with the Office of Aviation Medicine. The Office maintains an active membership on all Society of Automotive Engineering G-10 Human Factors subcommittees related to ongoing and future research areas to ensure transition of the results to standards and guidelines. Members from the National Transportation Safety Board work with the Human Factors Office in the areas of fatigue, flight deck automation, and error mitigation.

The Human Factors Office places grants with universities supporting research on air carrier training, flight deck automation, human performance integrity, and aviation maintenance technician training. Coordinated Free Flight research efforts are conducted with NASA's Ames Research Center. An Interagency Agreement with the U.S. Navy Air Warfare Center focuses on developing training and performance measurement strategies to enhance teamwork in both flight deck crews and air traffic control teams. Receiving special attention are training enhancements that develop aviation teamwork skills and the utility of advanced technologies for delivering team training. Additionally, elements of the controller perfor-

mance research project are conducted in concert with the U.S. Air Force's Armstrong Laboratory. Finally, collaborative research in shift work and fatigue is conducted with the U.S. Coast Guard Reserve and Development Center.

The Office of Aviation Medicine collaborates with NIOSH on a study addressing the cabin environment and flight attendant and passenger symptomatology and diseases. In addition, the office coordinates with the American Society of Heating, Refrigeration, and Air Conditioning Engineers Committee on addressing aircraft cabin air quality status and research.

The Office of Aviation Medicine maintains direct cooperative research processes with the manufacturers of safety products (seats, restraint systems, oxygen masks, evacuation slides, etc.). The Office is also represented on appropriate subgroups of organizations such as the Aerospace Medical Association, the Society of Automotive Engineers (SAE), the Civil Aviation Medical Association, and the Professional Aeromedical Transport Association. It maintains appropriate liaison with the military, either through direct project collaboration (e.g., crashworthiness, eye injury from lasers) or through participation in the Tri-Services Aeromedical Research Panel and the North Atlantic Treaty Organization (NATO) aerospace medical advisory group.

Long-Range View

The FAA is responsible for initiating and maintaining research and development programs that support modernization, regulation, certification, and NAS issues. The FAA is also responsible for initiating proactive research for identifying emerging safety trends. The Human Factors investment strategy will directly support these research efforts to identify and reduce targeted safety issues.

Baseline data will be established to show direct causal relationships between research outputs and accidents and incidents. Research programs will focus on targets that will have the greatest impact on aviation safety. The programs will be multiyear efforts and will require stabilized resources to plan, execute, and complete. Successful implementation of research outputs will require full partnerships and close cooperation within FAA organizations and the aviation community.

Research strategies will focus on technology, partnerships, and measurements. Methods will be developed to identify interventions to address human performance issues in flight maintenance and air traffic operations. Also, methods will be developed to reduce operational hazards. Regarding partnership strategies, a 5-year, integrated safety research plan will be developed with NASA, addressing long-range, high-payoff priorities. Measurement strategies will be developed to accurately monitor trends and identify opportunities for risk mitigation research.

There is strong public and Congressional interest in maintaining a healthy and comfortable environment for each civil aviation category. A 5-year interagency agreement between FAA and NIOSH began in FY 1997, addressing infectious disease and other health considerations in the aircraft cabin environment.

FAA goals related to minimizing injury, associated pain, necessary rehabilitation, and death as a consequence of aviation accidents make the work of the Aviation Medicine program a critical component of coordinated steps that will increase survivability, which is one of the accepted corporate strategies for decreasing fatal accidents. The Aviation Medicine program will emphasize reducing the severity of injuries encountered in aviation accidents and in such precautionary events as evacuation of passengers from an aircraft after the flight crew recognizes a safety concern. This approach will cut rehabilitation time, decrease medical costs, and improve the quality of life for people who suffer injuries.

In concert with the targets expressed in Challenge 2000 and with FAA's broad commitments to harmonize safety regulations on a global scale, the Aviation Medicine program—collaborating with domestic and international laboratories—will generate research data for use in developing internationally harmonized aviation standards and regulations. Aeromedical Research will be increasingly required to interpret data derived from around the world, and to determine if the data should be accepted or re-collected before being integrated into regulatory considerations and outputs.

A08a Flight-Deck/Maintenance/System Integration Human Factors

GOALS:

Intended Outcomes: The FAA intends to improve air transportation safety by:

- Developing more effective methods for aircrew, inspector, and maintenance technician training
- Developing more human-centered flight controls and displays
- Increasing human factors considerations in certification of new aircraft and equipment design and modification
- Improving aircrew, inspector, and maintenance technician task performance

Agency Outputs: The FAA seeks to ensure the safety and efficiency of operator performance through guidelines, handbooks, advisory circulars, rules, and regulations. It provides industry with human performance information and guidance critical to designing, operating, regulating, and certifying equipment, training, and procedures. The Human Factors program conducts and manages the research that provides the technical information necessary to generate these products and services.

Customer/Stakeholder Involvement: The Human Factors program directly supports a number of aviation community initiatives:

- *1998 FAA Strategic Plan Mission Goal for Safety.* By 2007, reduce U.S. aviation fatal accident rates by 80 percent from 1996 levels; ARA FY 1999 Performance Plan:
  - Goal 1 Contribute to the FAA goal to reduce the fatal aviation accident by 80 percent by 2007 as compared to 1994–1995 baseline data
  - Goal 2 Ensure human factors issues are addressed in the acquisition and integration of 100% of FAA aviation systems and applications by 2005, including Free Flight Phase 1
- The *National Plan for Civil Aviation Human Factors: An Initiative for Research and Application* was published in March 1995, with FAA, NASA, and DOD as signatories. This document, which had extensive aviation community participation in its development, outlines a coherent national agenda for human factors research and application leading to significant improvements in NAS safety and efficiency.
- The *Aviation Safety Plan*, through research supporting priority issues associated with four of the six workshops: crew training, safety data collection and use, application of emerging technologies, and aircraft maintenance procedures and inspection.
- Implementation of the FAA report, *The Interfaces Between Flight Crews and Modern Flight Deck Systems.*

The Human Factors program is also responsive to Public Law 100-591, which establishes requirements for human factors research and its application.

Accomplishments: The program output of data packages, models, and regulatory documents include:

- Developed, and currently field-testing with several airlines, a prototype APMS that allows gathering and analysis of data from aircraft flight data recorders. This information and analysis capability provides the backbone for the Flight Operations Quality Assurance program, a joint FAA and airlines venture to enhance aviation safety.
- Developed an advisory circular and handbook on crew resource management for aircrew members
- Developed a model AQP to support regional air carrier participation. AQP is a proficiency based approach to pilot training that is considered to be highly effective and efficient for aircrew training
- Published the *Aviation Maintenance Human Factors Guide*
- Provided educational outreach to the aviation community through the NASA/FAA fatigue countermeasures training module
- Developed pilot performance data, through flight simulation, for use in establishing certi-

fication standards for general aviation autonavigation and control systems

- Developed an aircraft certification human factors and operations checklist for standalone Global Positioning System receivers

R&D Partnerships: The program is linked to NASA and DOD under the auspices of the *National Plan for Civil Aviation Human Factors: An Initiative for Research and Application.* Specific areas of coordinated program execution with NASA include cockpit automation, fatigue, crew resource management, team decisionmaking, air-ground communication, and automated performance measurement system. DOD joint efforts involve fatigue, team performance, and decisionmaking. Additionally, the FAA is represented on the DOD Human Factors Engineering Technical Advisory Group, a forum for coordinating research across a variety of technical areas. The FAA participates with the Netherlands National Research Laboratory in flight-deck automation as well as on all of the Society of Automotive Engineers G-10 human factors subcommittees related to our research areas to ensure transition of the results to standards, guidelines, etc. Members from the National Transportation Safety Board have worked with the program in the areas of fatigue, flight deck automation, and error mitigation. The FAA also has extended grants to 10 universities supporting research on air carrier training, flight deck automation, and aviation maintenance technician and inspector training.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

Selection and training

- Provided "proceduralized" crew resource management guidelines for regional airlines
- Validated human performance transfer functions for level B full flight simulator
- Researched and developed input for maintenance resource management handbook
- Completed guidelines for maintenance technician situation awareness training
- Developed the AQP database, incorporating user comments on the task analysis and task listing components, and incorporated a performance database that links tasks to performance indicators
- Provided air carrier training data analysis and tools tailored to scenario-based evaluation

Human performance assessment

- Completed advanced APMS prototype
- Completed user needs studies at air carriers participating in APMS development
- Developed and implemented phase I APMS at partner air carriers
- Developed mapping of flight data parameters onto AQP qualification standards

Human-centered automation

- Completed limited functionality certification job aid
- Completed assessment of current air carrier and manufacturer automation training programs
- Completed human factors guidelines for assessing advanced general aviation transportation experiments (AGATE) cockpit controls/displays
- Initiated/coordinated comprehensive research program addressing cockpit automation

Information management and display

- Completed software tools for enhanced maintenance documentation

KEY FY 2000 PRODUCTS AND MILESTONES:

Selection and training

- Provide industry and FAA guidance addressing training crewmember use of advanced automated systems
- Provide methods to integrate quantitative indices of operational performance data with pilot training data to evaluate the effectiveness of flight training programs, specifically AQP
- Provide methods of using scenario-based evaluation and analysis techniques to identify troublesome trends before accidents occur, and provide appropriate training technologies to remedy identified weaknesses

Human performance assessment

- Define general aviation pilot decisionmaking skills required for training module development
- Complete research and develop maintenance resource management handbook
- Provide expanded APMS methodologies and analysis capabilities so that air carriers can collect and analyze increasing amounts of flight and simulator data

Human-centered automation

- Complete fully functional certification job aid
- Provide industry and FAA guidance addressing training for automated cockpits; these guidelines will encompass the performance difficulties associated with increased coupling, complexity, and autonomy of modern cockpit technology
- Provide human factors evaluation for AGATE flight systems configurations
- Develop certification guidelines for integrated technology in general aviation cockpits

Information management and display

- Develop guidelines for the use of simplified English in aircraft maintenance technician instructions and documentation
- Develop and implement guidelines for maintenance error investigating and reporting systems
- Develop flight data recording and analysis capability for flight simulators

FY 2000 PROGRAM REQUEST:

The program will continue to focus on providing technical information and consultation to improve aircrew, inspector, maintenance technician, and aviation system performance. It will emphasize developing guidelines, tools, and training to enhance error-capturing and mitigation capabilities in the flight deck and maintenance environments, as well as developing human factors tools to ensure that human performance considerations are adequately addressed in the design and certification of flight decks and equipment

A08a - Flight Deck/Maintenance/System Integration Human Factors Product and Activities	Program Schedule					
	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY2004
081-110 Flightdeck/Maintenance/System Integration Human Factors						
Selection and Training						
Develop Maintenance Resource Management Handbook	◆	◇	◇			
Develop AQP Database Incorporating User Comments	◆	◇	◇	◇		
Provide Air Carrier Training Data Analysis and Tools Tailored to Scenario-Based Evaluation		◇	◇	◇	◇	◇
Provide Industry and FAA Guidance Addressing Training Crewmember Use of Advanced Automated Systems	◆	◇	◇	◇	◇	◇
Develop the Advanced AQP Database with User Comments		◇	◇			
Implement Advanced GA Training Techniques	◆	◇	◇	◇	◇	◇
Completed Guidelines for Maintenance Technician Situation Awareness Training	◆					
Human Performance Assessment						
Complete Advanced Prototype APMS	◆	◇	◇			
Develop and Implement Phase I APMS at Partner Air Carriers	◆	◇	◇	◇		
Develop APMS data filtering, Automated Flight Analysis Modules	◆	◇	◇	◇		
Define GA Decision Making Skills Required for Training Module Development	◆	◇				
Complete Research on Identification and Classification of Aviation Maintenance Error Reporting Systems	◆	◇				
Human Centered Automation						
Initiate/Coordinate Comprehensive Research Program Addressing Cockpit Automation	◆	◇	◇	◇		
Provide Preliminary Recommendations for Improved Training for Automated Flight Management Systems	◆	◇	◇	◇	◇	
Develop a Tool Kit of Job Performance Aids to Help Certification Personnel and Designers Assess Automated Flight Decks	◆	◇				
Provide Industry and FAA Guidance Addressing Training for Automated Cockpits	◆	◇	◇	◇	◇	◇
Provide Industry and FAA Guidance to Effectively Address Cultural Influence on Crewmember Use of Automated Systems	◆	◇	◇			
Develop Usability Evaluation Tool for Electronic Flight Bag	◆	◇	◇			
Develop Certification Guidelines for Head-up Displays	◆	◇	◇			
Validate Pilot/Controller Integration Performance Requirements for Free Flight	◆	◇	◇	◇	◇	
Provide Human Factors Evaluation for AGATE Flight Systems	◆	◇				
Information Management and Display						
Complete Software for Enhanced Maintenance Documentation		◇				
Develop and Implement Guidelines for Maintenance Error	◆	◇	◇	◇		

Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	7,857	8,430	10,365	8,497	7,289
Personnel Costs	2,760	2,048	1,814	1,940	2,367
Other Costs	565	420	371	563	486
Total	**11,182**	**10,898**	**12,550**	**11,000**	**10,142**

A08b Air Traffic Control/Airway Facilities Human Factors

GOALS:

Intended Outcomes: The FAA intends to:

- Contribute to future concepts of NAS operation by building an integrated infrastructure that enhances human/system efficiency
- Increase understanding of the human factors of emerging technologies, changing human roles and responsibilities, and evolving procedures to help optimize human performance
- Promote integration of human factors products into advanced operational concepts and the NAS architecture
- Develop enhanced measures of human performance and increase understanding of factors that can lead to performance decrement

Agency Outputs: The products of this program will include: reference data and criteria; methods, tools, and measures; facility and equipment design recommendations and specifications; operational task load and performance baselines; expert human factors guidance; test and evaluation checklists, procedures, and determinations; and evaluative findings focused on human factors in present and future operational environments. These products—shared with the international aviation community—will provide essential assistance to FAA's Air Traffic Services for implementing and enhancing advanced operational concepts, including the systems, subsystems, and procedures integral to these concepts.

Human factors research and development products will include:

- Models of performance and efficiency based on system variables.
- Development of workload performance measures and models for existing systems and new technologies
- Human/system productivity enhancement technology
- Advanced methods and technology for training operational personnel
- Tests and criteria for selecting operational personnel
- Human factors recommendations for designing operational facilities and control rooms

Customer/Stakeholder Involvement: The Air Traffic Services (ATS) Human Factors Research program is directly mapped to and supports:

CONOPS 2005

- In 2005, the NAS will take a human-centered approach to maximize efficient delivery of air traffic services to users. Thus, system processes and workstations are designed to expedite information exchange among NAS information systems, service providers, and users. Human factors analyses and human-in-the-loop simulations have determined the appropriate allocation of tasks between service providers, users, and automation systems. Moreover, issues such as situation awareness, workload, and computer-human-interface (CHI) design have been resolved by incorporating human factors. This approach ensures that the human capabilities and limitations of users and service providers remain a primary consideration in systems development. NAS evolution uses a clear transition strategy for each operational capability and employs a human-centered approach for implementing new operational concepts and supporting technologies.

National Airspace System Architecture Version 4.0

- The NAS architecture specifies a broad range of research activities regarding the implications of human factors. These activities will acquire and then apply the information necessary to understanding human capabilities and limitations in each functional area. Human factors engineering will then be applied to identify and resolve risks and to assess costs, benefits, and tradeoffs.

Air Traffic Management (ATM) Research, Engineering, and Development Advisory Committee (REDAC) Recommendations

- The FY 2000 ATS Human Factors R&D program is a direct result of collaboration with representatives of Air Traffic Services and other FAA stakeholders in the ATM Research

and Development Agenda Team (ARDAT) to specifically address the recommendations of the Congressionally mandated REDAC. The NAS ATM R&D Committee has reported that "The culture within the FAA has not supported the development of a rigorous technical community focused on NAS related areas such as large-scale systems engineering; operations research; communication, navigation and surveillance (CNS); or operational human factors." Human factors considerations need to be incorporated as a key part of the preliminary concept of operation and system design efforts.

Recommendation: Increase emphasis on understanding the implications of various Free Flight architectural alternatives on pilot and controller performance, and incorporate this understanding early in the NAS architecture evolution process.

Some of the human performance issues[1] that appear to be important to "Free Flight" include:

- Balance of air-ground responsibility.
- Use of structure by controllers to organize traffic.
- Ability of controllers to deal with flexible airspace (e.g., dynamic resectorization).
- Monitoring and out-of-loop issues for pilots and controllers.
- Trust in automation
- Conflict resolution strategies
- Collaborative decisionmaking behavior
- Gaming behavior of pilots, airlines, and controllers
- Shared situational awareness
- Intervention strategies
- Communication requirements

ARA Performance Goals[2]

Goal 1. Safety: Contribute to the FAA goal to reduce the fatal aviation accident rate by 80 percent by 2007 as compared to 1994-1996 baseline data."

Goal 2. Human Factors: Ensure human factors issues are addressed in the acquisition and integration of 100 percent of new and modified FAA aviation systems by 2005, including Free Flight Phase 1.

The FAA Strategic Plan states that "human factors is one of the most important areas for improving safety."

- The *National Plan for Civil Aviation Human Factors: An Initiative for Research and Application.* This document, published in March 1995, with FAA, NASA, and DOD as signatories, had extensive aviation community participation in its development, and outlines a coherent national agenda for human factors research and application leading to significant improvements in NAS safety and efficiency.

Accomplishments: The program has performed or sponsored the following research and resulting products:

- Developed an enhanced visual scanning methodology for application in display design
- Conducted a study of the impact of shared separation on controller performance
- Completed an auditory alarm database
- Conducted a comprehensive assessment of the STARS operational radar display, and maintenance control workstations; identified a significant number of human factors issues deemed to have a negative impact on human/system performance; convened and facilitated a multidisciplinary work group consisting of representatives from Human Factors, ATS, the Standard Terminal Automation Replacement System (STARS) program office, National Air Traffic Controllers Association (NATCA), LMR, MITRE Corporation, and other stakeholders to resolve these problems; a notable product of the work group was a de-

1 Source: Subcommittee Report of the NAS ATM R&D to R,E&D Advisory Committee, March 25, 1997.

2 Source: Performance Agreement Between The Secretary of Transportation and The Federal Aviation Administration, Fiscal Year 1998; 1998 FAA Strategic Plan.

finitive process to address and resolve human factors issues inherent in other NAS systems.

- Developed performance baselines for STARS, the display system replacement (DSR), and PVD for use in measuring the impact of future system enhancements
- Developed a new selection instrument for Airway Facilities technicians
- Collaborated with ATS to develop a new selection instrument for air traffic controllers (ATSAT)
- Sponsored the National Research Council's assessment of human factors issues in the air traffic control system. Under this grant, the NRC has conducted informative briefings for FAA and Congress and published two books, *Flight to the Future—Human Factors in Air Traffic Control* and *The Future of Air Traffic Control*. These volumes, authored by aviation human factors experts, contain a wealth of information, conclusions, and recommendations on the present and future ATC system.
- Published an extensive book of information and advice on human factors issues in the design and evaluation of ATC systems and subsystems (750 pages). To date, the book and its associated electronic checklist have been widely distributed within the FAA to ATS and Integrated Product Team (IPT) customers for internal use.
- Validated the current air traffic controller pretraining screen-selection instrument to ensure that it was both effective and free of any race, gender, or cultural bias
- Completed development of en route Systematic Air Traffic Operations Research Initiative (SATORI), a research tool that uses routinely recorded ATC computer and voice data to recreate and display air traffic control operational incidents in the same way that they appeared on the controller's radar screen. SATORI has been transitioned to ATS which procured it for installation in all air route traffic control centers to study operational errors
- Conducted detailed human factors assessment of the Air Traffic Control System Command Center operational environment. Air Traffic Management used results as the basis for extensive redesign
- For the Airway Facilities Operations Management Team, measured task load and documented work processes of personnel at present maintenance control centers

R&D Partnerships

NASA, DOD, and FAA are cooperative partners in developing and implementing the *National Plan for Aviation Human Factors: An Initiative for Research and Application*. This document lays out a coherent national agenda for human factors research and provides the conceptual framework for the Air Traffic Services (ATS) human factors program. Coordinated research efforts are conducted with NASA's Ames Research Center in the areas of Free Flight and shift work induced fatigue and associated countermeasures. Additionally, elements of the controller performance research project are conducted in concert with the U.S. Air Force's Armstrong Laboratory. Internationally, research results on development and validation of controller applicant selection methods are shared between project leaders in this program and their functional equivalents in Sweden and Denmark.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

- Provide initial results of fatigue countermeasures study
- Validate strategies for human error prevention/mitigation in Airway Facilities (AF) maintenance control
- Develop strategies for human error prevention/mitigation in AF Maintenance Control Centers
- Provide guidelines for color-coding information on ATC displays
- Complete study of ATC complexity factors and provide guidance for their display
- Revise and update human factors handbook and electronic checklist
- Revise and update human factors design guide
- Conduct assessment of DSR implementation training

- Complete baseline of taskload and performance and selected air route traffic control centers (ARTCC)

KEY FY 2000 PRODUCTS AND MILESTONES:

Research to be conducted will affect a variety of ATS programs. These efforts are grouped into the following broad categories:

ATC Information Display and Interface Design

- A baseline of human performance levels associated with current information technologies/displays and input methodologies
- Guidelines for information display and interface design
- Guidelines to support common interface design across the NAS

Decision Support System (DSS) and Collaborative Decisionmaking

- Baselines of human performance levels associated with current decision processes proposed for support by DSS's
- Human-centered design guidelines for DSS capabilities
- Guidelines relative to DSS accuracy, sensitivity, and false alarm rates
- Guidelines to support collaborative decisionmaking across NAS users

Airspace Design and Procedures Human Factors

- A baseline of human performance levels associated with current sector operations (e.g., System Command Center, traffic management units (TMU), ATC)
- Human factors guidelines for airspace design and airspace display integration
- Human factors guidelines for procedures associated with alternative airspace design concepts (e.g., communications, coordination, etc.)
- Documentation of human factors requirements associated with system integration of new airspace design concepts (e.g., inter/intra-facility, area, sector, and position human factors requirements under current airspace concepts)

NAS Maintainability

- Human performance metrics to support evaluation of NAS maintainability
- Guidelines for the design of operational facilities that support the role of the human in maintenance operations
- Evaluation of the potential impact of incorporating new technologies into the NAS maintenance work environment

General Human Factors Research

- Human performance metrics for NAS system operators
- Selection methodologies, guidelines, and criteria for NAS personnel
- Training methodologies and guidelines for NAS personnel
- Guidelines for training interventions directed at team performance of NAS personnel
- Human performance guidelines for implementing alternative work schedules (e.g., rotating shift work)
- Human performance guidelines to mitigate/counteract fatigue
- Guidelines, strategies, and specific recommendations to facilitate workforce transition to new concepts of operation

FY 2000 PROGRAM REQUEST:

The FY 2000 research program reflects a heightened emphasis on working with ATS to meet the pressing challenge of successfully fielding new technologies and procedures over the next several years. Research projects focus on providing timely information to answer critical human factors questions associated with these new systems and procedures (such as Free Flight) and thus help to optimize human performance in the evolving and increasingly complex NAS.

A08b - Air Traffic Control/Airway Facilities Human Factors Product and Activities	Program Schedule					
	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY2004
082-110 Air Traffic Control/Airway Facilities Human Factors						
Information Display & Interface Design						
Guidelines for Information Display & Interface Design	◆	◇	◇	◇	◇	◇
Guidelines for Common Information Display & Interface Design across the NAS			◇	◇	◇	◇
STARS EDC, ISC & Tower Display Usability Assessments	◆					
Visual Scanning Assessments of Display Design	◆	◇	◇	◇	◇	◇
Measures of ATC's Situation Awareness (SA). Guidelines to Enhance SA	◆	◇	◇	◇	◇	
Decision Support & CDM						
Human-centered Guidelines for DSS Capabilities	◆	◇	◇	◇	◇	◇
Guidelines to Support Collaborative Decision-making	◆	◇	◇	◇	◇	◇
Guidelines Relative to DSS Accuracy, Sensitivity and False Alarm Rates	◆	◇	◇	◇	◇	
Operational Impact of Shared Separation Responsibility, Collaborative Decision-making	◆	◇	◇	◇	◇	◇
Airspace Design & Procedures						
Human Factors Guidelines for Airspace Design and Procedures	◆	◇	◇	◇	◇	◇
Roles & Responsibilities of ATCS in FF	◆	◇	◇	◇	◇	◇
Define Human Factors Issues for Transition from Unconstrained to Constrained Airspace in Free Flight	◆	◇	◇	◇	◇	
NAS Support						
Human Performance Metrics to Support Evaluation of NAS Maintainability		◇	◇	◇	◇	◇
Guidelines for the Design of Operational Maintenance Facilities	◆	◇	◇			
Human Error Prevention/Mitigation in AF MCC's	◆	◇	◇	◇		
Evaluation of Impact of New Technologies on AF Environment	◆	◇	◇	◇	◇	◇
General Human Factors						
Human Performance Metrics for NAS System Operators	◆	◇	◇			
Selection Methodologies for Next-Generation Air Traffic Controllers & NAS Technicians	◆	◇	◇	◇	◇	
New Training Methodologies	◆	◇	◇	◇	◇	◇
Guidelines for Enhancing Team Performance	◆	◇	◇	◇	◇	
Human Performance Guidelines to Mitigate/Counteract Fatigue	◆	◇	◇	◇		
Baselines of Human/System Performance	◆	◇	◇	◇	◇	◇
Recommendations for Workforce Transition to New CONOPS	◆	◇	◇			

Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	4,836	4,356	5,454	5,711	4,897
Personnel Costs	4,286	3,528	3,773	3,117	5,034
Other Costs	878	722	773	1,172	1,305
Total	**10,000**	**8,606**	**10,000**	**10,000**	**11,236**

A08c Aeromedical Research

GOALS:

The FAA safety mission dictates that:

- Existing injury and death patterns in civilian flight misadventures be meticulously reviewed
- Recommendations for protective equipment and procedures be developed
- Options be evaluated on behalf of FAA regulatory and medical certification staff charged with proposing safety regulations addressing all aircraft cabin occupants

A concurrent mission is to identify pilot, flight attendant, and passenger medical conditions that are incompatible with in-flight clinical and physiological demands on the occupant, both in the absence and presence of flight emergency conditions.

Intended Outcomes: The Aeromedical Research program addresses improved health, safety, and survivability of aircraft passengers and aircrews. It identifies human failure modes (physiological, psychological, clinical) both in uneventful flight and during civil aircraft incidents and accidents. Formal recommendations for counteracting measures are derived from in-house research.

The FAA is able to develop bioaeronautical guidelines, standards, and models for aircraft cabin equipment, procedures, and environments as a base for regulatory action to enhance appropriate human performance. Pilot medical and flight histories and information from accidents and incidents are reviewed to develop new medical criteria, standards, and assessment/certification procedures to ensure full performance capability. Assessments of flight attendant and passenger work, behavioral, and disease issues are used to propose guidelines for actions to improve the health and safety of cabin occupants.

Agency Outputs: The program has developed the following criteria for use in regulatory and certification processes:

- Quantitative bioengineering criteria to support aircraft seat and restraint system certification
- Quantitative biomedical criteria to support protective breathing equipment and operational procedures certification
- Quantitative biochemical and toxicological criteria supporting the use or certification of aircraft interior fire, smoke, and toxicity limits
- Quantitative biomedical criteria to support flotation and onboard rescue equipment certification
- Identification of medical/toxicological factors and human factors in aviation incidents and accidents
- Recommendations for aircrew medical criteria, standards, and assessment/certification procedures
- Quantitative data about the occupational health status of flight attendants to support regulatory oversight
- Quantitative data about passenger behavior and health to support regulatory oversight

Customer/Stakeholder Involvement: The Aeromedical Research program contributes to meeting the 1998 FAA Strategic Plan Mission Goal for Safety and ARA FY 1999 Performance Plan Goals for Safety and Human Factors. The program provides the primary bioaeronautical research (note: defined as the bioengineering, biomedicine, and biochemistry issues associated with safety and performance) called for in the *National Plan for Civil Aviation Human Factors of 1995*. (This plan committed to major deliverables referenced in the system safety goals of the FAA Strategic Plan of the following year.)

The program contributes significantly to the application of emerging technologies, as highlighted in the February 1996 FAA Aviation Safety Plan. The program is an integral participant and research provider under the FAA, Joint Aviation Authorities (JAA), and Transport Canada Aviation (TCA) Aircraft Cabin Safety Research Plan. The plan was developed in 1995 as a coordinated, living plan to maximize the cost-benefit of aircraft cabin safety research internationally.

The program develops International Civil Aviation Organization (ICAO) initiatives addressing the health of the aircraft occupant (crew and passenger) before final FAA recommendations are provided to ICAO. This program is the only FAA research component that can legally access confidential medical data about pilots for epidemiological research studies approved by FAA's institutional review board for use of human test subjects. Multiyear collaborative studies performed by the FAA and NIOSH into flight attendant and passenger symptomatology and diseases are funded by this budget item to satisfy the mandate placed by Congress upon the agencies in the FY 1994 Appropriation Act.

Accomplishments: Based on aeromedical research at the Civil Aeromedical Institute, the FAA issued an advanced notice of proposed rulemaking concerning usage and design of child restraints on aircraft. The output of this program's research is permitting the FAA and National Highway Traffic Safety Administration to revise the testing requirements in Federal Motor Vehicle Safety Standard 213, which covers the design of child restraints for use in aircraft. Quantitative data were provided on various prototypes of aircraft-specific child restraints being developed as commercial products targeted for airlines. Specialized quantitative crashworthiness assessments for aircraft continued, including side-facing aircraft seats and the use of state-of-the-art anthropomorphic test dummies with enhanced injury assessment capabilities.

Data are continuously provided to the research sponsor on the role of toxicological and clinical factors associated with each aircraft accident and significant incident. Current findings indicate that about one in six pilots fatally injured in a civilian aircraft accident shows evidence of prescription drug use; one in four had taken an over-the-counter drug, one in 25 had ingested significant positive alcohol, and 1 in 20 had used a significant amount of a controlled dangerous substance. Long-term aviation forensic and epidemiological research has helped the FAA to identify human factor roles in accident/incident causation. Specialized clinical evaluations were applied to cases associated with aircraft decompression. Probable seizures and other factors indicative of the pilot's inability to perform were evaluated.

R&D Partnership: Several of these partnerships (e.g., FAA/JAA/TCA; FAA/NIOSH) have been cross-referenced in the "Customer/Stakeholder Involvement and Accomplishments" sections above.

In addition, in each program area output category, the FAA maintains direct cooperative research processes with all the manufacturers responsible for the safety products listed (seats, restraint systems, oxygen masks, evacuation slides, etc.). FAA investigators also maintain memberships on every Society of Automotive Engineers committee addressing safety research conducted under this program. The agency maintains a liaison with the American Society of Heating, Refrigeration, and Air Conditioning Engineers committee, which addresses aircraft cabin air quality status and research. Besides active involvement in the FAA/JAA/TCA process of oversight for safety research, participants in this program serve on appropriate subgroups of organizations such as the Aerospace Medical Association, the Civil Aviation Medical Association, and the Professional Aeromedical Transport Association. Appropriate liaison with the military is maintained either through direct project collaboration (e.g., crashworthiness, eye injury from lasers) or through the more global participation in the TriServices Aeromedical Research Panel or NATO aerospace medical advisory groups.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS

The following program results have been completed or are expected to be achieved in FY 1999:

- Performed epidemiological assessment of toxicology factors from fatal civilian aviation accidents
- Developed guidelines to reduce in-flight sudden/subtle incapacitation
- Evaluated autopsy data from fatal aviation accidents to determine protective equipment and design practices
- Assessed flight attendant reproductive health hazards (Congressionally requested FAA-NIOSH study)
- Developed improved fit and comfort standards for oxygen mask systems

- Assessed operational hazards of in-flight laser exposure

KEY FY 2000 PRODUCTS and MILESTONES

The following program activities are scheduled for FY 2000:

- Conduct epidemiological assessment of toxicology factors from fatal civilian aviation accidents
- Compare toxicology findings at time of flight physical to post-accident data
- Develop guidelines to reduce in-flight sudden/subtle incapacitation
- Evaluate autopsy data from fatal aviation accidents to determine protective equipment and design practices
- Report on guidelines for aircraft cabin occupant health maintenance
- Develop a model of disease transmission via aerosols in an aircraft cabin environment
- Evaluate the suitability of using analytical modeling as a substitute for evacuation tests in certifying new passenger aircraft
- Develop improved fit and comfort standards for oxygen mask systems
- Report the frequency and nature of in-flight medical emergencies and use of defibrillators on commercial aviation flights

FY 2000 PROGRAM REQUEST:

The Office of Aviation Medicine encounters complex medical decisions during initial and followup medical assessments of airmen who request special medical issuances (e.g., cardiac conditions, neurological deficits, etc.) to permit them to continue flying. The prospective epidemiological assessment of special issuance methodology and medical outcomes in the airman population is required to ensure that medical issuances do not result in unexpected or increased aircraft accident or incident rates.

Ongoing research projects will:

- Develop safer aircraft cabin evacuation approval guidelines and safer field applications under operational conditions
- Reduce head, neck, and extremity injuries in aircraft crash environments
- Evaluate trends in toxicology and clinical findings from all major civil aviation aircraft crashes
- Develop guidelines for aircraft cabin crew and passenger environmental management

A08c - Aeromedical Research Product and Activities	Program Schedule					
	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY2004
086-110 Aeromedical Research						
Cabin Health and Environmental Guidelines						
Assessment of Flight Attendant Reproductive Health Hazards	◆	◇	◇	◇		
Report on Guidelines for Aircraft Cabin Occupant Health Maintenance	◆	◇	◇	◇	◇	
Development of a Model of Disease Transmission Via Aerosols in an Aircraft Cabin Environment		◇				
Human Protection/Survival in Civil Aviation						
Analyze the Suitability for Component Tests as an Alternative for Showing Regulatory Compliance with Crashworthiness Standard for Aircraft	◆	◇	◇	◇		
Assess Impact Protection Performance of Aircraft Seating Systems, Including Child Restraints	◆	◇	◇	◇	◇	◇
Develop Performance-Based Narrow and Wide Bodied Aircraft Cabin Evacuation Approval Guidelines	◆	◇	◇	◇	◇	◇
Report on Suitability of Aircraft Cabin Evacuation Modeling as a Partial Replacement for Evacuation Tests with Human Subjects	◆	◇	◇	◇		
Implement Dual Aisle Evacuation Model					◇	
Development of Improved Oxygen Mask Fit and Comfort Standards	◆	◇				
Analyzed the Influence of Cabin Crew Duty Stations on Evacuation Performance of Passenger Aircraft in Panic Situations	◆					
Survey Parents Flying With Small Children on Their Likelihood to Divert to Other Modalities if Child Restraints are Required		◇				
Survey of In-flight Medical Emergencies and Defibrillator Usage on Commercial Airline Flights		◇				
Medical/Toxicology Factors of Accident Investigations						
Perform Epidemiological Assessment of Toxicology Factors from Fatal Civilian Aviation Accidents	◆	◇	◇	◇	◇	◇
Develop Guidelines to Reduce In-flight Sudden/Subtle Incapacitation	◆	◇	◇	◇	◇	◇
Compared Toxicology Findings at Time of Flight Physical to Post-Accident Data	◆					
Evaluate Autopsy Data from Fatal Aviation Accidents to Determine Protective Equipment and Design Practices	◆	◇	◇	◇	◇	◇
Reported on the Impact of the Drug Abatement Program on Aviation Accidents/Incidents	◆					
Develop Toxicological Test to Distinguish Between Ingested and Post-Mortem Alcohol					◇	

Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	0	0	0	313	394
Personnel Costs	2,075	3,320	3,320	3,155	3,858
Other Costs	425	680	680	597	577
Total	**2,500**	**4,000**	**4,000**	**4,065**	**4,829**

2.6 Environment and Energy

Mission

Environmental opposition is the greatest single threat to continued growth and prosperity of the aviation system. The FAA must provide strong international leadership in mitigating aviation's adverse impact on the public while maintaining an effective aviation system. The FAA has adopted the following strategies:

- Balance noise reduction with adequate airport capacity through a cooperative development effort
- Minimize adverse environmental consequences and comply with all Federal statutes
- Reduce noise, emissions, and energy consumption by the aviation sector by stimulating private industry and Government sponsored research
- Harmonize international aircraft noise and engine emissions certification standards

Intended Outcomes

Using its regulatory authority, FAA must serve as an advocate for both the environment and industry. Through an optimal mix of aircraft and engine certification standards, operational procedures, compatible land use, and abatement technology, FAA intends to:

- Reduce the impact of aircraft noise by 80 percent (based upon population) by 2000 and prevent any increase after 2000
- Minimize the global, regional, and local impact of aircraft exhaust emissions

Program Area Outcomes

The findings of aviation environmental research become:

- Noise and emissions standards for certification of new and modified airframe and engine type designs
- Technical guidance on certification procedures and practices for manufacturers and modifiers in the form of technical reports, handbooks, advisory circulars, training courses, and rules
- Computer models and impact criteria for civil aviation authorities to use in environmental assessment of proposed actions

Program Area Structure

The aviation environmental research program is composed of the following major disciplines:

- Aircraft Noise Reduction and Control
- Engine Emissions Reduction and Control
- Aviation Environmental Analysis

These disciplines form a cohesive system of research projects that focus on noise and engine exhaust emissions to support Federal actions that will identify, control, and mitigate the environmental consequences of aviation activity.

Customer/Stakeholder Involvement

Working closely with other Federal agencies, industry, and foreign governments, the FAA uses a unified regulatory research and development (R&D) approach, which:

- Assesses environmental concerns
- Plans research and development efforts
- Shapes technical requirements
- Identifies feasible abatement technologies or other mitigation actions
- Implements aircraft and engine certification regulations to mitigate the potential impacts

FAA collaboration on aviation environmental issues includes these committees:

- *Aviation Regulatory Advisory Committee (ARAC).* ARAC is a formal standing committee established by the FAA and composed of representatives from aviation associations and industry. ARAC provides industry input in the form of recommendations, advice, and information to be considered in the full range of FAA rulemaking activities. Harmonization working groups under ARAC ensure that certification regulations affecting both domestic and foreign parties do not impose different standards in different countries.

- *International Civil Aviation Organization's (ICAO) Committee on Aviation Environmental Protection (CAEP).* FAA participates—as the U.S. member—on the CAEP, along with representatives of other civil aviation authorities and observers from aviation industry. CAEP assesses the adequacy of the international aviation environmental standards, especially in the areas of aircraft noise and engine exhaust emissions standards.
- *Federal Interagency Committee on Aviation Noise (FICAN).* FICAN, established by the FAA and other interested Federal agencies, provides forums for debate over needs for future aviation noise research and encourages new development efforts in this area. FICAN conducts annual public forums in different geographic regions, soliciting general input on aviation noise impacts with the intent to better align research with the public's concerns.

Accomplishments

Since 1993, the program has produced:

- Simplified noise certification procedure for light helicopters, as promulgated by FAA and ICAO. The new procedure should save manufacturers and modifiers at least $24 million over 15 years.
- Four reports to Congress on the annual progress of the FAA/NASA subsonic jet noise research program and one report to Congress on quiet aircraft technology for light propeller-driven airplanes and helicopters. The finding of the latter report led to a joint FAA/NASA research project on general aviation noise.
- Handbook on small airplane noise certification and publication of advisory circulars on the aircraft noise certification database that will improve the efficiencies of both the manufacturers' measurement tests and the FAA's review and approval.
- Training course on 14 CFR, part 34, "Fuel Venting and Exhaust Emissions Requirements for Turbine Engine Powered Airplanes," for FAA engine certification personnel and applicants. This training will improve the efficiencies of both the manufacturers' measurement tests and the FAA's review and approval.
- Advances in the computer models used for airport and heliport noise analysis. Over 1,000 copies have been sold worldwide. In the United States, these models have been used in over 150 airport studies involving more than $1.3 billion in airport noise compatibility grants.
- Four public forums on aviation noise research in Atlanta, San Diego, Seattle, and Washington, D.C.; four FICAN annual reports; one report on Federal aviation noise research projects; a report to Congress on the effects of aircraft noise; and a Federal finding on the relationship between aircraft noise and sleep awakenings. Public participation led to new Federal research projects on commuter airplane noise impacts and the influence of ambient noise on community annoyance.
- Enhancements to the computer model used for airport air quality analysis and formal acceptance by the Environmental Protection Agency (EPA) as a preferred guideline model which is EPA's highest-ranking; development of a handbook on the procedures for airport air quality analysis for use by civilian and military aviation authorities. Standardizing the civilian and military analytical procedures will improve the quality of environmental assessments that are reviewed by the Federal Government.
- The Global Aircraft Noise Impact Assessment Model, accepted by CAEP for future use in assessing the benefits of advances in noise reduction technologies.
- Achieved the mid-term goals of the joint FAA/NASA subsonic jet noise reduction research program.
- Aircraft noise exposure prediction model for overflights of Grand Canyon National Park.

R&D Partnerships

FAA participates with others in the aviation community in joint R&D efforts:

- Through a series of memorandums of understanding, FAA works NASA and U.S. industry under the NASA Advanced Subsonic Technology (AST) and the High Speed Civil

Transport (HSCT) research programs to identify source abatement technologies.

- FAA also participates in the Aviation Effects on the Atmosphere Project (AEAP) with NASA, industry, and academia to assess the possible global impact of aircraft engine exhaust emissions.
- The Volpe National Transportation Systems Center (VNTSC) continues to provide substantial technical assistance in aircraft noise measurement and assessment.

FICAN is also a forum for partnership. All Federal agencies concerned with aviation noise are represented on the committee, including the military services (Air Force, Army, Navy) the Department of Interior, Department of Transportation, EPA, National Aeronautics and Space Administration (NASA), and the Department of Housing and Urban Development.

FICAN has led to expanded coordinated and cooperative research efforts among the individual agencies, resulting in more efficient use of Federal funds. Participating agencies have signed a letter of understanding defining the purpose, scope, membership, process, and products of FICAN and formally documenting the commitment of the participating agencies.

Long-Range View

Planning for environmental research needs beyond 2000 requires a look at key indicators. These indicators are generally described as driving forces for change, targets of opportunities, or future (environmental) threats. The key indicators that may relate to aviation environmental research include:

- Air transportation growth
- New aircraft designs
- New aviation technologies
- Scientific findings on environmental impact
- Increased globalization of aviation
- Reduced Federal resources

FAA predicts slow and steady growth of the demand for aviation services into the first decade of the next millennium. The growth in aircraft operations to meet this demand will produce increased environmental impacts and create barriers to further growth.

The key to successful environmental planning is to identify operational mitigation options for those sectors of the growing aviation markets that are most likely to reach environmental critical mass. FAA will need to continue to assess the situation to determine whether research to support mitigation should be directed toward tour operations over national parks, urban vertiports, resurgent general aviation activity, the old standby large jet transport operations, or a new threat.

Several major NASA aeronautics research programs will come to an end in the first few years of the next decade most notably, the AST program. Several new source technologies will come out of the NASA research programs that U.S. industry will turn into the next generations of aircraft in 10-15 years. With the end of the AST program, FAA will close its companion research program on subsonic noise reduction. The agency will use its research findings to identify new environmental certification standards and procedures for the next generation of transport aircraft. FAA will shift future environmental research in the field of new aircraft technology toward other research programs on rotorcraft and general aviation.

The solution to controlling the environmental consequences of new aircraft technologies is through a unified regulatory R&D approach involving the FAA with other Federal agencies, such as NASA, from the early stages of the technology research program.

Technologies, such as the Global Positioning System (GPS), are already beginning to have a profound effect on the aviation system. As these technologies are introduced to improve system efficiency and flexibility, a new FAA paradigm is emerging under the general term, “Free Flight.” As the FAA builds more user flexibility into the NAS, what are the environmental consequences (impacts and improvements)? FAA must commit funds to expand on the current suite of environmental analysis tools to address the consequences as the agency moves towards free flight in all domains.

While human (animal) behavioral research is not the duty or responsibility of the FAA, the agency

must devote some research resources to translate any pertinent scientific findings on environmental impacts into Federal guidance and policy. For example, NASA's AEAP will conclude in 2003. One potential outcome is a finding on the effects of supersonic and subsonic aircraft cruise operations on global climate change and the ozone layer. FAA must be prepared to produce appropriate aviation environmental policy, guidance, and interpretation for these and other scientific findings.

As stated in FAA's 1996 Strategic Plan, "The globalization of aerospace is another factor driving FAA to change." What is the potential effect of expanding international and multinational manufacturing centers on the harmonization of international aircraft noise and engine emissions certification procedures and recommended practices? FAA must plan for research efforts to support continued maintenance of international harmonization and standardization of the aviation environmental certification standards and procedures.

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A09a Environment and Energy

GOALS:

Intended Outcomes: The FAA intends to reduce the impact of aircraft noise by 80 percent (based on population) by 2000 and prevent any increase thereafter through an optimal mix of new aircraft certification standards, operational procedures, compatible land use, and abatement technology; define and minimize the impact of aircraft emissions through an optimal mix of new aircraft certification standards, operational procedures, and abatement technology; and mitigate the environmental consequences of aviation operations.

Agency Outputs: The aviation environmental research findings have resulted in the publication of significant standards, rules, and technical guidance, including:

- Standards for certifying new and modified designs for reducing aircraft noise and engine exhaust emissions
- Technical reports, handbooks, advisory circulars, training courses, and procedures for manufacturers and modifiers
- Computer models and impact criteria for civil aviation authorities when making environmental assessment of proposed actions

Customer/Stakeholder Involvement: The FAA uses a unified regulatory R&D approach, working closely with other Federal agencies, industry, and foreign governments to guide R&D efforts into the area of aviation impact on the environment. Lessons learned from this research identify and shape technologies, regulations, and certification criteria with real potential to improve our present and future global environment.

The ARAC is a formal standing committee of representatives from aviation associations and industry. Established by the FAA, ARAC provides industry input in the form of recommendations, advice, and information to be considered in the full range of FAA rulemaking activities. ARAC's harmonization working groups will ensure that the aircraft noise certification regulations that impact both domestic and foreign parties do not impose different standards in different countries.

The FAA represents the United States on the ICAO CAEP, along with representatives of other civil aviation authorities and observers from the aviation industry. CAEP assesses the adequacy of international aviation environmental standards, especially in the areas of aircraft noise and engine exhaust emissions standards.

FAA and other interested Federal agencies established FICAN to provide forums for debate over needs for future aviation noise research and to encourage new efforts in this area. FICAN conducts annual public forums in different geographic regions to solicit general input on aviation noise impacts to better match research to public concerns.

The Aviation Environmental Research Program directly supports the General Aviation Action Plan in demonstrating noise abatement technologies for light propeller-driven airplanes.

Accomplishments: Through this program, FAA has produced a simplified noise certification procedure for light helicopters and promulgated it with ICAO. The new procedure should save manufacturers and modifiers at least $24 million over 15 years. FAA has also produced a handbook on small airplane noise certification and published advisory circulars on the aircraft noise certification database.

These publications improve the efficiencies of industry's measurements of engine exhaust emissions as well as FAA review and approval in this area. A training course is available for FAA engine certification personnel and applicants that will improve the efficiencies of both the manufacturers' engine exhaust emissions measurement tests and the FAA's review and approval.

The FAA's advances in computer models used for airport and heliport noise analysis have resulted in the worldwide sale of over 600 copies of the model. In the United States, these models have been used in over 150 airport studies involving more than $1 billion in airport noise compatibility grants. The FAA has conducted four public forums on aviation noise research in Atlanta, San Diego, Seattle, and Washington, D.C.; four FICAN annual reports; one report on Federal aviation noise research projects; and one report to Congress on the effects of aircraft noise. Public participation has led to new Federal research projects on commuter airplane noise impacts and

the influence of ambient noise on community annoyance.

R&D Partnerships: Through a series of memorandums of understanding, the FAA works closely with NASA and U.S. industry on NASA's AST and the high speed civil transport (HSCT) research programs to identify source abatement technologies. FAA also participates in AEAP with NASA, industry, and academia to assess the possible global impact of aircraft engine exhaust emissions. The Volpe National Transportation Systems Center (VNTSC) continues to provide substantial technical assistance in the areas of aircraft noise measurement and assessment. FICAN is also a forum for partnership, as all Federal agencies concerned with aviation noise are represented on the Committee. FICAN has led to expanded coordinated and cooperative research efforts among the individual agencies, which resulted in more efficient use of Federal funds.

MAJOR ACTIVITIES AND ANTICIPATED FY 1999 ACCOMPLISHMENTS:

Aircraft noise reduction and control

- Harmonized FAA subsonic jet airplane noise certification regulations with those of the European Joint Aviation Authorities that govern the procedures used by airframe manufacturers
- Published revised Advisory Circular 36-4D, *Noise Certification Handbook*, which will provide technical guidance to FAA field personnel, airframe manufacturers, designated engineering representatives, and aircraft modifiers

Engine emissions reduction and control

- With the assistance of NASA and U.S. industry, continued comprehensive scientific assessment of the atmospheric effects of aviation

Aviation environmental analysis

- Published a new airport air quality assessment handbook that will provide technical guidance to airport authorities, FAA field offices, and other Federal reviewers of environmental assessments
- In cooperation with ICAO CAEP and the Society of Automotive Engineers (SAE), initiated validation of methodologies and databases used in airport noise modeling

KEY FY 2000 PRODUCTS AND MILESTONES:

Aircraft noise reduction and control

- Continue the three cooperative FAA/NASA noise reduction research programs to identify feasible technologies for U.S. manufacturers to develop quieter subsonic jet transport airplanes, helicopters, and light propeller-driven airplanes, respectively

Engine emissions reduction and control

- Develop a simplified engine exhaust emissions measurement procedure to reduce manufacturers' test costs

Aviation environmental analysis

- Continue to examine and validate the methodologies used to assess aircraft noise exposure and impact

FY 2000 PROGRAM REQUEST:

Although several major NASA aeronautics research programs (most notably, the AST) will end in the first few years of the next decade, several new source technologies will have emerged from NASA's research. This will be the basis in 10 to 15 years for the next generation of U.S. industry aircraft. With the end of the AST program, FAA will close its companion research program on subsonic noise reduction and will use its research findings to identify new environmental certification standards and procedures for the next generation of transport aircraft. FAA will shift future environmental research in the field of new aircraft technology toward other research programs for rotorcraft and general aviation.

A09a - Environment and Energy Product and Activities	Program Schedule					
	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY2004
091-110 Aircraft Noise Reduction & Control						
Airplane and Rotorcraft Noise Reduction Technologies, Noise Certification Standards & Procedures						
Harmonized FAA Noise Certification Regulations with European Joint Aviation Authorities	◆					
Final Assessment of FAA/NASA Subsonic Jet Noise		◇				
Final Assessment of FAA/NASA Light Propeller-Driven Airplane Noise Reduction Technology Research			◇			
Publish Advisory Circular 36-4d			◇			◇
Developed Simplified Noise Certification Procedures or Requirements for Helicopters	◆					
Develop New Basis for Certification Standards and Procedures for High Speed Civil Transports			◇			
Initiate Development of Supersonic Noise Certification Standards and Procedures				◇		
091-111 Engine Emissions Reduction & Control						
Engine Exhaust Emissions Reduction Technologies, Standards and Procedures, and Impact Assessments						
Develop Simplified Engine Exhaust Emissions Certification Procedures	◆					
Harmonize FAA Engine Exhaust Emissions Certification Regulations with European Joint Aviation Authorities		◇				
091-113 Aviation Environmental Analysis						
Develop Noise & Air Quality Assessment Methodologies						
Initiated the Validation of the Methodologies and Databases Used in Airport Noise Modeling	◆					
Initiate Noise Modeling Validation	◆				◇	

Budget Authority ($ in Thousands)	FY 1996 Enacted	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Request
Contracts	3,800	3,600	2,891	2,239	2,856
Personnel Costs	0	0	0	607	589
Other Costs	0	0	0	45	36
Total	**3,800**	**3,600**	**2,891**	**2,891**	**3,481**

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APPENDIX A
RESEARCH, ENGINEERING AND DEVELOPMENT ADVISORY COMMITTEE

The FAA values the ongoing involvement of the R,E&D Advisory Committee in reviewing its current and planned R,E&D programs. A formal process has been established whereby the agency replies to the Committee's reports. This document summarizes recent Committee recommendations and FAA responses.

During 1998, the FAA responded to four Committee reports. Two of the responses were updates to previously provided FAA responses. One of these was an updated response to the *Human Factors Subcommittee Report,* dated August 1996, to which the FAA originally responded on January 28, 1997. The second was the FAA's final response to the *NAS ATM R&D Panel Report,* dated March 25, 1997, for which the FAA provided an initial response on September 9, 1997. The Committee submitted three reports in 1998. The FAA responded to the *Report and Minutes of the Subcommittee on Air Traffic Services*. The other two reports submitted in 1998, were the *Committee's Recommendations on FY 2000 R,E&D Investment,* dated April 1998, to which the FAA plans to respond between January and April 1999, and the *Report of the Subcommittee on Runway Incursion*.

In total, this section provides recommendations from four Committee reports (listed below) and FAA responses to the first three reports on the list.

- *Human Factors Subcommittee Report* (dated August 1996—updated response)
- *NAS ATM R&D Panel Report* (dated March 25, 1997—updated response)
- *Report and Minutes of the Subcommittee on Air Traffic Services* (dated November 6, 1997)
- *Committee's Recommendations on FY 2000 R,E&D Investments* (dated April 23, 1998—response pending)

In 1999, the FAA expects to receive the Committee's recommendations on planned FAA research and development investments for fiscal year 2001, which will include detailed recommendations from the standing subcommittees.

Updated Response to the *Human Factors Subcommittee Report* (Report dated August 1996)

In September 1994, the Advisory Committee chartered a Human Factors Subcommittee under the Chairmanship of Dr. Earl L. Wiener. The purpose of the Subcommittee was to investigate, assess, and report on the status and organization of the human factors program in the FAA, and make recommendations for improvements.

Dr. Maureen Pettitt, FAA Chief Scientific and Technical Advisor for Human Factors, addressed the following recommendations from the Subcommittee's August 1996 report during the Committee meeting on January 29–30, 1998.

The responses below are an update to the responses the Committee received at the January 28, 1997 meeting, which were published in the 1998 FAA Plan for Research, Engineering and Development.

Recommendation: Centralize responsibility for Human Factors in the FAA.

***Response*:** A human factors group was convened as a result of human factors issues surrounding the STARS system. This process group also agreed that there should be a centralized responsibility for FAA human factors, adequately resourced and that

AAR-100 should be designated as the lead in this effort. An implementation plan is under development.

Recommendation: Assign resources and people to this central responsible structure, define the agency's expectation, and hold [those assigned] accountable.

***Response*:** A human factors group was convened as a result of human factors issues surrounding the STARS system. This process group agreed that there should be a centralized responsibility for FAA human factors, adequately resourced, and that AAR-100 should be designated as the lead in this effort. An implementation plan is under development.

Recommendation: Provide an agency lead organization for Human Factors.

***Response*:** A human factors group was convened as a result of human factors issues surrounding the STARS system. This process group agreed that there should be a centralized responsibility for FAA human factors, adequately resourced, and that AAR-100 should be designated as the lead in this effort. An implementation plan is under development.

Updated Response to the *NAS ATM R&D Panel Report* (Report dated March 25, 1997)

The National Airspace Systems (NAS) Research and Development (R&D) Panel was an ad hoc subcommittee chartered to review the content and management of FAA's current R&D program against the proposed NAS Architecture. The purpose of the review was to identify issues that require resolution in order to complete the architecture and to explore opportunities for increasing the programs' effectiveness in enhancing the NAS.

The Subcommittee's report dated March 25, 1997, was approved by the Committee on April 9, 1997 and provided by letter to the Administrator on April 17. The report provided recommendations in six areas: management, advanced ATM, software engineering, aviation weather, system capacity, and leveraging.

The following response is considered the final response and is an update to FAA's initial response, which was provided on September 9, 1997 and published in the 1998 FAA Plan for Research, Engineering and Development. The final response was provided to the Committee by letter dated July 9, 1998.

Management Issues

Recommendation: Create a new Deputy Administrator position for the National Airspace System (NAS), with responsibility for research, development, acquisition, operation, and maintenance of the NAS.

Recommendation: Elevate the Federal Aviation Administration (FAA) system engineering function to a very high level (administrator or deputy administrator level) to promote/allow aviation-wide solutions, decisions and development to occur quickly.

***Response*:** The National Civil Aviation Review Commission (NCARC) report was published last December. The report recommends a performance-based Air Traffic Services (ATS) organization, which would encompass air traffic services and engineering functions. The NCARC recommendations will be resolved within the Administration and with Congress over the March-to-October time frame. It is expected that the subject matter of these recommendations will be addressed in the process.

Recommendation: Reverse the losses of technically competent and highly experienced and skilled FAA personnel crucial to effectively manage technology changes and to provide the necessary leadership to manage contractor efforts.

***Response*:** The Associate Administrator for Research and Acquisitions (ARA) is developing an Intellectual Capital Investment Plan to foster more effective recruitment, development, and retention of its work force.

Recommendation: Develop the ability to plan and fund the continuous insertion of evolving technology into the NAS.

***Response*:** The NAS Architecture provides for continuous technology insertion over the life cycle of systems.

Advanced ATM

Recommendation: A "strawman" vision, with broad agency support, of the evolution of the NAS including functionality, concepts of operation, architecture, transition mechanisms, and environmental and safety considerations, is required to provide a basis for the research and development (R&D) investment process.

***Response*:** The FAA agrees. During the course of the past year, the FAA has developed a concept of operations for the NAS in the year 2005. It was developed by ATS, with support from the Associate Administrator for Certification and Regulation (AVR), and ARA. This broad support within the agency reflects continued migration of the NAS from a ground-based infrastructure to one that encompasses both ground- and space-based systems. The participation of these organizations also demonstrates recognition of the need to engage the operational components of the FAA early in the concept formulation process.

The current concept of operations for the NAS presents a high-level description of air traffic operations in 2005. The concept does not describe an end-state system architecture. Instead, the concept defines an initial change in the air traffic environment and lays the groundwork for transitional phases subsequent to 2005.

Over the past several months, the Administrator has convened two meetings of a NAS Modernization Task Force to identify a near-term plan for system modernization that best applies available resources to the needs of the agency's customer community. The work of the task force has been based on the operational concept for 2005 and NAS Architecture Version 3.0. The FAA will continue to develop and refine a community-supported concept of operations for the future and to maintain a NAS architecture consistent with that operational concept and consistent with the FAA budget.

Recommendation: Increase emphasis on understanding the implications of various Free Flight architectural alternatives on pilot and controller performance and incorporate this understanding early in the NAS architecture evolution process. Continue the collaborative efforts between FAA and the National Aeronautics and Space Administration (NASA) in this area.

***Response*:** The FAA agrees with this recommendation and believes that several ongoing and new initiatives will provide the emphasis necessary to achieve the appropriate level of understanding of Free Flight human factors and related human performance alternatives. The FAA recognizes the critical role of human performance in NAS architecture development and has taken steps to address the issues. These steps include: (1) conducting human factors research studies, (2) preparing human factors research and application inputs to the NAS Architecture Version 3.0, (3) establishing a working group to identify future human performance research requirements, (4) establishing a human factors working group to support the Flight 2000 demonstration and to provide connectivity to Free Flight human factors requirements, and (5) working with NASA to develop a coordinated research program that addresses Free Flight human performance issues.

Recommendation: Safety considerations need to be explicitly included in NAS concept evaluation. R&D is required to support the development of methods to evaluate safety and environmental impacts.

***Response*:** The FAA agrees. During the course of the past year, the FAA and NASA have conducted collaborative modeling and analysis activities through the Interagency Integrated Product Team (IPT) directed at evaluating safety implications associated with potential future air traffic scenarios. These scenarios incorporate systematic reductions in restrictions associated with the current system concept of operations. These analyses will provide information regarding conflict geometry, closing velocities, aircraft densities, and other measures that will assist in the evaluation of safety associated with potential future operational concepts. Scenarios that reflect future demand are being prepared and will be analyzed during the upcoming year. These scenarios and analyses will be used also to support future environmental impact evaluation activities.

The processes for end-to-end safety assessments for air and ground systems are being developed jointly by RTCA Special Committee 189 and EUROCAE Working Group 53. Concurrently, FAA Safety Assessments Working Group is developing procedures and tolls for safety assessments within the Acquisition Management System specifically targeted at NAS modernization. A new agency policy order is in final coordination and will require safety risk assessments.

Recommendation: Efforts should be continued to improve the analytical basis on which to support NAS evolution decisions. These efforts should include improving the understanding of the current air traffic control (ATC) system, the theoretical basis of ATC, and the development and use of fast time models.

***Response*:** FAA continues to strengthen the analytical basis of evolution decisions. This is done by applying fast time models such as SIMMOD[1], NASPAC[2], and RAMS[3] to evaluate alternative

1. A trademark name for the FAA's Airport and Airspace Simulation Model
2. National Airspace System Performance Analysis Capability
3. Reorganized Mathematical Air Traffic Control Simulator

NAS concepts and to guide investment decision-making in the NAS. While some models to support this work exist, the lack of sufficient funding hampers further development and widespread use.

Recommendation: Continue collaboration between FAA and NASA. Work to maintain a relationship which will promote the most effective joint R&D program supporting domestic and international air traffic management (ATM) evolution.

***Response*:** The FAA agrees with this recommendation, and is continuing to work with NASA to ensure that the joint ATM R&D activities are responsive to user needs.

The ATM R&D program within the United States is being coordinated with the European Organization for the Safety of Air Navigation (Eurocontrol) and the European national administrations through a memorandum of cooperation between the FAA and Eurocontrol. This is intended to ensure that international ATM evolution is coordinated and convergent upon a worldwide seamless operational environment, and allows further opportunities for collaborative R&D and leveraging of R&D resources within the international ATM community.

Recommendation: Continue the coordination with international organizations working on NAS issues and build a combined stakeholder/technical consensus on NAS evolution.

***Response*:** The FAA strongly agrees with this recommendation and is actively supporting this recommendation through multiple international initiatives. The FAA has established bilateral R&D agreements with a number of international civil aviation organizations. Through these agreements, the FAA is able to build a combined stakeholder/technical consensus on NAS evolution, and to ensure a consistent progression toward a global, seamless communications, navigation, and surveillance/air traffic management (CNS/ATM) system for the 21st century.

The FAA and Eurocontrol have defined several R&D cooperative tasks, assigned FAA and Eurocontrol points of contact to lead each task, and established a FAA/Eurocontrol R&D Committee to provide the management oversight and guidance necessary for progressing the R&D cooperative tasks. One of these tasks provides a framework by which the FAA coordinates the development and gains support for its NAS architecture within the European community.

In addition to the ongoing initiatives with Europe, the FAA is actively engaged in R&D initiatives with countries within the Asia-Pacific region. The FAA has established a cooperative working relationship with Japan and Australia regarding the Global Positioning System (GPS) and the Wide Area Augmentation System (WAAS) in support of the evolution of a Global Navigation Satellite System (GNSS).

The FAA also works very closely with numerous other countries within the International Civil Aviation Organization (ICAO) regional planning groups, task forces, and panels. In this way, issues are being addressed and coordinated at both the management and technical levels.

Software Engineering

Research and Development

Recommendation #1: The FAA should elevate the position of Chief Scientist for Software Engineering so that it directly reports to the Associate Administrator for Research and Acquisitions. The responsibilities associated with this position should include oversight for software engineering policy, procedures, techniques, and technology used throughout the FAA and by its suppliers. This position should be staffed by a nationally recognized software expert to interface with Government, industry, and academic organizations doing research in software to improve FAA insight and leverage.

***Response*:** FAA agrees with the spirit of this recommendation and believes that developments in the FAA since 1990, when the Office of Information Technology was created, are in keeping with an orderly program intended to elevate the importance of software engineering throughout the FAA. Currently, the Chief Scientist for Software Engineering, a position that was created a little over 2 years ago, reports to the Director of the Office of Information Technology. This director also serves as the Chief Information Officer for the FAA and reports to the Associate Administrator for Research and Acquisitions. We believe that this represents an optimum solution at this time,

since it makes available the resources of the Office of Information Technology to the Chief Scientist for Software Engineering, as needed, and allows software engineering policy, procedures, techniques, and technology used throughout the FAA and by its suppliers to be coordinated with all of the other software activity occurring throughout the FAA.

The first Chief Scientist for Software Engineering, Dr. Floyd Hollister, was an internationally recognized software scientist recruited from the Software Engineering Institute of Carnegie-Mellon University. The incumbent, Dr. Art Pyster, was recruited into the FAA from the Software Productivity Consortium, a well known, nonprofit software research institute. Dr. Pyster is an internationally recognized software scientist. His duties include oversight of software engineering policy, procedures, techniques, and technology used throughout the FAA and by its suppliers, and he interfaces with Government, industry, and academic organizations doing research in software to improve FAA insight and leverage.

Recommendation #2: The FAA should establish a software engineering laboratory under the direction of the Chief Scientist for Software Engineering that performs as a center of excellence to provide in-house capability in state-of-the-art software engineering technology and processes. The laboratory should be staffed by a small, high-competency team of recognized software engineering experts who would leverage their skills across the FAA organization. The Software Engineering Lab (SEL) mission would include:

- Education: Develop and present software engineering and relevant technology courses that are tailored to the needs of the FAA.
- Consultation: Have a cadre of software engineers available to provide technical and managerial expertise to FAA projects and research initiatives.
- Guidance: Provide software engineering guidance to FAA organizations on all aspects of system acquisition to include evaluation of vendor proposals and evaluation of work in progress.

***Response*:** The FAA agrees. Budget item A02j, titled, “Software Engineering R&D,” has been entered into the FY 1999 R,E&D budget submission to Congress. This item addresses two proposed software R&D efforts, the second of which is for a center for software engineering to provide a ‘virtual’ facility using resources at the FAA William J. Hughes Technical Center and with nodes located at university, Government agency, and other research facilities contributing to the activities of the center. The purpose of the center is to organize research critical to improving the safe use of software within the FAA and the aviation community generally.

Recommendation #3: The FAA should investigate the Department of Defense's (DOD) initiative in domain-specific software architectures (DSSA) to determine how the concept can be used to improve software reuse (and hence productivity) and software reliability. The FAA should consult with experts like Dr. Barry Boehm, who was instrumental in initiating DSSA concepts within the DOD, to guide development and implementation of DSSA concepts within the FAA.

***Response*:** The FAA agrees. The FAA has become an Affiliate of the University of Southern California Center for Software Engineering, which will make available the services of Dr. Barry Boehm and other Center staff, as necessary. The FAA recognizes that any approach to reengineering the NAS, and the broader FAA information complex of which the NAS is a part, will require substantial innovation in the area of software architectures.

The center for software engineering (Recommendation #2) will provide a facility where various architectures and architectural innovations can be tested.

Recommendation #4: The FAA should increase the scope and elevate the importance of security engineering. In the environment of increasing automation, reliance on communications, and the sophistication of automated techniques used by malicious persons to penetrate systems, it is no longer adequate for the FAA security focus to be limited to the physical aspects of the NAS. Research must be applied to address the information warfare aspects associated with flight critical systems.

***Response*:** The FAA agrees and has established a security architecture team within the System Architecture Office, ASD-110, led by Dr. Feisal Keblawi. This team has launched several major initiatives, including an inventory of the various NAS information security activities ongoing or planned. To organize and coordinate these activities better and to increase their combined effectiveness, the NAS Information Security (NIS) Group has been formed with Dr. Keblawi as chair and Dennis Hupp, ACO-3, as co-chair. The group, which includes a cross section of FAA operational and technical offices, was approved by the FAA Joint Resource Council (JRC) as an FAA Standing Committee on May 1, 1997.

This group has developed an action plan for implementing information security (INFOSEC). The plan is now in coordination, and the NIS Group has commenced working on a number of activities described in the plan. These include working with IPT's in supporting vulnerability assessments; holding INFOSEC workshops; performing a general INFOSEC program review; supporting development of updated INFOSEC policy; and developing a security engineering process. The group will serve as the overseer of all aspects of FAA INFOSEC (policy, procedures, management, training, assessment, analysis, security engineering, and security technology insertion).

Although the NIS Group has an aggressive plan for implementing INFOSEC, the availability of funding will have an impact on the timely implementation of their efforts, especially with regard to NIS research.

Recommendation #5: The FAA should increase the emphasis on enhancing standard processes and continuous process improvement.

***Response*:** The FAA agrees and believes that our current process improvement strategy, plans, and activities are fully in concert with this recommendation. The associate administrators in three lines of business have committed to support FAA-wide process improvement based on capability maturity models. In particular, ARA has committed to increasing to FAA capability maturity model (CMM) Level 2 (or equivalent) by December 1999, and to Level 3 by December 2001, the process maturity of 75 percent of selected major software-intensive programs.

In addition, FAA has developed an integrated CMM (iCMM) reference model, which merges the three CMM's for systems engineering, software acquisition, and software development following the latest CMM integration guidelines from the Software Engineering Institute. The agency is using the iCMM to guide its process improvement efforts. FAA expects this model to help develop and improve integrated cross-disciplinary processes more effectively and efficiently for the full acquisition life cycle.

The FAA has set aggressive improvement goals and will continue to improve the processes that it uses to manage, acquire, and engineer software-intensive systems.

Recommendation #6: Establish a program for standardizing data element definitions for all FAA software-intensive systems, and mandate that all integrated product teams (IPT) utilize these definitions in all systems developments, whether in-house or by contract. Make conformance with the standard data elements an important consideration in the selection of commercial off-the-shelf (COTS) systems.

***Response*:** The FAA agrees with the recommendation and believes that the data standardization processes being established are needed to accomplish the ultimate goal of Free Flight through seamless NAS interoperability and collaborative decisionmaking. The information architecture will be more integrated with the rest of the NAS data/service users and data/service providers in NAS architecture. An FAA-wide NAS Information Architecture Committee (NIAC) has been established and currently has three subcommittees working: (1) the Traffic Flow Management (TFM) Common Data Working Group; (2) the Host Information Architecture Group, and (3) the MITRE Information Architecture Support Group. Through the auspices of the NIAC, a "user-friendly" process is being instituted by which NAS stakeholders can collaborate in establishing standards for common NAS data elements and populating a NAS information directory or metadata repository. The goal is to integrate the agreed-to standard data formats and definitions into FAA's acquisition tools so vendors can start to build toward FAA-wide interface standards.

Recommendation #7: A research program should be established to address:

(1) ground system as well as airborne system certification, (2) improvements in the certification process to accommodate the ever-increasing pace of software change due to technology insertion or defect correction, and (3) certification of safety-critical systems that contain COTS software components. The FAA should determine whether it is feasible to characterize COTS suitability for inclusion in safety-critical systems and to quantify this suitability.

***Response*:** The FAA agrees. The FAA COTS/ Non-developmental item (NDI) program was launched in May 1997, with the express goal of providing guidance on the acquisition of CNS/ ATM ground and ground-air systems incorporating COTS/NDI. The program is co-sponsored by Dr. Art Pyster, Chief Scientist for Software Engineering, and Dr. Herman Rediess, Chief Scientist for Test and Evaluation. The guidance produced will address the testability, certification, safety, and reliability of COTS software components in safety-critical systems.

Recommendation #8: The FAA should begin a research study, in collaboration with the Advanced Research Project Agency's (ARPA) Evolutionary Design of Complex Software (EDCS) project, to characterize and measure system complexity and its relationship to system architecture with the objective of reducing complexity in FAA safety-critical systems.

***Response*:** The FAA agrees, and steps are being taken to implement this recommendation. Preliminary work has determined that real-time systems can be characterized by the number of attainable discrete states, including defined legal states (such as normal and exceptional operations), defined illegal states (such as hazardous or undesirable operations), and undefined states. The number of states can be calculated as the product of the total number of values, which are possible for each of the variables used to define the system. Complexity can then be measured as a function (e.g., the logarithm) of the number of states. Using a discrete state approach allows complexity to be directly related to system architecture. In particular, it allows a distinction between controlled and uncontrolled complexity, permitting the use of very complex architectures which, nevertheless, can be shown to be consistent and correct. This is most easily accomplished by using a formal architectural language to characterize the architecture.

Recommendation #9: The FAA should establish a research program to develop explicit safety metrics, objectives, measures, etc. At a minimum, the metrics would be used to determine, via prototyping, if system A is safer than system B.

***Response*:** The FAA agrees and currently is a partner with DOD, NASA, and the

United States Coast Guard (USCG) in the joint development of a software system safety handbook. This is a first step in evolving from a total reliance on quality assurance and good software engineering practices to the implementation of a software safety engineering discipline. A safety engineering discipline will employ metrics, measures, and hazard analysis practices to identify and define the safety critical elements of software specifications, requirements, and end product.

The Radio Technical Commission for Aeronautics (RTCA) document DO-178b is accepted within the aviation software community as a means for assuring the safety of software in avionics systems. The document currently is under review by RTCA Special Committee 190, which brings together experts from around the globe. The modifications to DO-178b will need to be carried out in concert with the development of ground-based software safety practices to ensure that ground, air-ground, and airborne software use common standards and provide a uniform level of confidence in overall system safety.

Aviation Weather

Recommendation #1: The FAA should facilitate the dissemination of consistent, common, and timely aviation weather information, in graphical format, to all users of the aviation system, both ground and airborne, as soon as possible. The FAA should take advantage of existing data links for this purpose. This could include licensing commercial vendors to have access to some fraction of existing links, such as Mode S, to provide weather graphics on a fee-for-service basis.

***Response*:** The FAA strongly supports this recommendation and has long advocated the need for

parity in access to and dissemination of weather and flight information service (FIS) products among all NAS users. This position and policy are reflected in the NAS Architecture Version 3.0 (draft) and in the "Airborne Flight Services Policy Statement" signed by the Administrator May 1, 1998. Also, the weather and FIS planning for Flight 2000 is based on the same principle of common access and parity.

Recommendation #2: FAA policy statements and strategic plans should consider hazardous weather information as an aviation safety issue, as well as a capacity one.

***Response*:** The FAA Administrator has signed an aviation weather policy statement that recognizes the role of aviation weather in the safe operation of the NAS. The statement, as well as agency strategic plan documents, addresses hazardous weather as a safety issue. These documents also reflect users' priorities to reduce delays and increase system efficiency. The Aviation Weather Directorate (ARW) has taken the lead for developing a National Aviation Weather Strategic Plan, published in April 1997, which directs the FAA and other agencies to pursue strategies and new systems for aviation weather that will enhance safety as well as system capacity. The plan also details the case for aviation weather initiatives by citing safety data such as accident and incident statistics.

Recommendation #3: The Associate Administrator for Research and Acquisitions, ARA-1, should establish a separate weather IPT within the AND organization, to focus the leadership and responsibility for all research, engineering, development, and implementation of weather projects.

***Response*:** Weather research is vested in a single IPT in FAA's Office of Air Traffic Systems Development (AUA). Wake vortex research is performed in AND.

Recommendation #4: The FAA should support a weather architecture which includes the appropriate elements and interfaces needed to disseminate critical weather information to <u>all</u> aviation users, supported by adequate funding and priorities.

***Response*:** The FAA agrees with this recommendation. The FAA will provide an integrated weather architecture that includes not only the sensor systems required to collect critical weather information, but also weather processing systems [i.e., Weather and Radar Processor (WARP) and Integrated Terminal Weather System (ITWS)] to support product dissemination. The WARP and ITWS will disseminate user-friendly products to *all* aviation users within the en route and terminal environments. Consequently, when controllers, specialists, pilots and dispatchers receive the same weather information from these weather 'servers', a 'common situational awareness' will be achieved, thereby improving safety and enhancing the efficiency of the NAS.

Recommendation #5: The FAA should continue to fund longer term (greater than 1 hour) convective weather prediction, and longer term (greater than 20 minutes) storm growth and decay forecasting R&D. These efforts are intended to develop improved techniques for sensor data analysis, assimilating sensor data into predictive models, and converting these model outputs into products that benefit air traffic and aircraft operators decision-making in convective weather.

***Response*:** The FAA has a plan to conduct research to meet this goal.

Recommendation #6: The FAA should continue the research programs directed at improved 1 to 2 hour forecasting of ceiling and visibility at airports. This effort could be extended to allow improved ceiling and visibility (C&V) forecasts up to 6 hours.

***Response*:** The FAA has a plan to conduct research to meet this goal. However, this effort is not funded in fiscal year 1998.

Recommendation #7: The FAA should fund a research program that builds on the National Center for Atmospheric Research (NCAR) research to develop a model whose output is an hourly gridded forecast of hazardous in-flight icing.

***Response*:** The FAA has an ongoing program to conduct research to meet this goal.

Recommendation #8: The FAA should fund a research program, in conjunction with NASA, to exploit ITWS products to produce reliable short-term forecasts of key variables which most affect wake vortices.

***Response*:** The FAA will continue coordination with the NASA program on research associated with providing wake vortex prediction capabilities, including initiatives that exploit ITWS capabilities.

Achieving New Aviation

System Capacity

Recommendation #1: Introduction of automation aids for controllers into en route and terminal operations to:

- Achieve optimal arrival sequencing.
- Provide guidance for staggered and converging arrivals.
- Achieve minimum required wake vortex spacing for operations to or from single, parallel and intersecting runways.
- Reduce inter-arrival variability by 50 percent or more.
- Reduce the need for pilot-to-controller voice communication.

***Response*:** IPT's are pursuing the above initiatives to provide better utilization of airspace and runway capacities while operating in a safe environment with regard to wake vortices. Much of this work is being carried out in collaboration with NASA. An example of currently planned research activities includes development of arrival/departure decision support systems for increased efficiencies in arrival and departure, and development of an integrated decision support toolset for the en route environment.

Recommendation #2: Improvement in required separation standards and minimums:

- Reduction of required spacing for independent and dependent arrivals to parallel runways.
- Reduction of minimums for independent arrival operation to converging runways.
- Establishment of procedures for instrument flight rule (IFR) operations to closely spaced parallel, triple and quadruple runways.

***Response*:** The Research, Engineering and Development (R,E&D) program has carried out a number of initiatives in the past that have resulted in reductions in the separation standards addressed in the recommendation. There are no initiatives underway in this area at this time and none planned.

The R,E&D program is undertaking a comprehensive analysis of opportunities to improve system capacity and will examine the need for new efforts in this area.

Recommendation #3: Renewed effort to reduce operational impact of wake vortices.

***Response*:** Further research is necessary into the effects of wake vortices upon capacity. Research during 1997 addressed wake vortex issues on an individual airport basis concerning the separation of takeoffs and landings. Research into a laser-based wake vortex detection capability is underway in 1998 with proof-of-concept demonstrations planned. At present, inclusion of a wake vortex project into the 2000 budget recommendation is underway.

Recommendation #4: Development of requirements and procedures for use of cockpit traffic displays to provide better information to pilots on the traffic situation and to permit pilot participation in approaching visual flight rules (VFR) capacity in IFR conditions.

***Response*:** The R,E&D program developed the Traffic Alert and Collision Avoidance System (TCAS) and supported its worldwide implementation. TCAS provides a traffic situation display for the purpose of reducing the risk of midair collisions.

Currently, there is no significant work underway or planned in FAA or in NASA on more general applications of cockpit displays providing traffic information to flightcrews, e.g., applications focused on providing VFR system capacities in IFR conditions. It is expected that such research will be initiated in the future as higher priority tasks are completed. Research into this area is being examined as part of safety initiatives being worked with NASA.

Recommendation #5: Flow management and evolution to more cooperative ATC.

***Response*:** Substantial research investments are now being made by FAA in the area of traffic flow management and collaborative decisionmaking with airspace users. The approach is based on spiral development of incremental improvements

with the stakeholders heavily involved in prioritizing the research and guiding the implementation of system enhancements.

Recommendation #6: Examination of the basis for current separation standards and criteria.

***Response*:** FAA is in the process of implementing reduced vertical separation standards in oceanic airspace and developing CNS/ATM improvements to support reduced lateral and longitudinal separation standards over the ocean. Whereas most of the effort thus far has been expended in the reduction of oceanic separation standards, initiatives pertinent to other domains are underway. An Integrated Requirements Team (IRT) has been formed as part of the mission and analysis process where reduced separation standards for the en route and terminal domains are being explored. Additionally, a joint effort with Eurocontrol is underway where domestic separation standards are being addressed.

The FAA R,E&D program will continue to explore opportunities to enhance ATM system performance through reduced separation standards.

Recommendation #7: Weather information, both near terminals and aloft, needs to improve dramatically. Safety-related aspects -- wind shear, wake vortices, downburst protection, etc. -- have priority, but effective terminal and en route automation and sensible flow management require the best possible weather and wind gradient data. FAA should continue to work in partnership with other agencies, especially DOD and NOAA.

***Response*:** A major thrust of the National Aviation Weather Strategic Plan is an emphasis to improve the quality of aviation weather information available to pilots, controllers and dispatchers to support improved, collaborative operational decisionmaking. The underlying theme of our aviation weather research is a focus on solving near-term operational problems related to safety and system capacity. R,E&D programs, which are heavily leveraged with other research both within and outside the Government, include the development of new and improved algorithms to model and predict weather events that affect aviation. There is also a limited basic research effort aimed at increasing the scientific understanding of the atmospheric processes associated with hazardous weather impacting aviation safety and capacity. These hazards include in-flight icing, turbulence, convective weather, and reduced ceiling and visibility.

Recommendation #8: Demonstration of capabilities and development of procedures to exploit the capabilities of satellite navigation.

***Response*:** The FAA is continuing the acquisition and certification of satellite navigation services ranging from oceanic positioning through precision approach capabilities. Extensive R,E&D into the capabilities of GPS and satellite-based augmentation, WAAS and LAAS, is well underway and continuing.

Recommendation #9: Expedited development of procedures for beneficial application of GNSS/ Flight Management System (FMS) or equivalent systems to achieve precision arrival and departure paths, and more precise missed approaches.

***Response*:** The FAA has developed and certified a number of FMS-guided terminal procedures for approaches, departures, and missed approaches in collaboration with the user community. This work is continuing in the Flight Standards Service and is funded in the Operations appropriation.

Recommendation #10: Improved safety of on-airport air traffic movement and control:

- By development of an automated, airspace-system-compatible, airport surface surveillance, guidance, and control system, which supports improved runway incursion control.
- By improving and standardizing airport lighting, signage, and marking to provide safe airport operation during runway entry, turnoff, departure and crossing, and reduced runway occupancy time.

***Response*:** The FAA has a number of research efforts underway to reduce the risk of runway incursions, including the development of low-cost airport surface detection equipment intended to provide lower-activity towers with real-time radar surveillance of the airport surface. The FAA also is reviewing and addressing the recommendations of the R,E&D Advisory Committee document titled, “Report of the Subcommittee on Runway Incursions,” dated January 29, 1998.

The FAA and NASA have developed a surface movement advisor capability that is intended to improve the efficiency of surface movements by providing tower controllers, airlines, and airport operators a comprehensive, consistent understanding of the surface traffic situation.

R,E&D in the airports technology area includes prototyping and test of an Advanced Taxiway Guidance System (ATGS) for visual guidance along airport taxiways. There is no significant research underway at FAA or NASA to develop an airport surface guidance and control capability. It is expected that such research may be initiated as higher priority activities are completed.

Recommendation A1: Optimize the present airport system including:

- Physical airfield and terminal improvements and expansion.
- Ground access enhancement.
- Procedural/operational changes and flow management.
- Use of new capacity technology.

***Response*:** Airport sponsored R,E&D projects are actively supporting improved flow management and new technologies, which will be incorporated into the operating environment as they are developed. These projects include Airport Planning and Design, which will conduct research to support development of advisory circulars to provide updated guidance on terminal building planning and design. This replacement advisory circular will provide a modern computer-aided design process to improve airport design. The project will also support research on improving ground access including demonstration of high-occupancy vehicles (busses and vans) for airport access.

Recommendation A2: Add new airports in cities with the most serious congestion.

***Response*:** It is expensive and difficult to add major new airports to metropolitan systems. In most instances, air carriers prefer to add capacity to existing airports gradually and to make better use of existing capacity by the use of larger aircraft and higher load factors. When new airports are added, they are typically reliever airports, allowing general aviation an alternative to the use of the congested air carrier airports. Sites are very difficult to obtain for major new airports in metropolitan areas. The conversion of surplus military airports to civil use is more easily achieved. FAA is currently working with more than 30 communities to help convert military airports to civil use.

Recommendation A3: Add a new type of airport, the "remote transfer airport."

***Response*:** The concept of the remote transfer hub has been explored over the years. There is an FAA/industry consensus that there is no need to construct, or even designate, a class of airports in remote areas for relocating transfer functions from congested hubs. The airlines have indicated that the preferred locations for transfer hubs are existing airports which have good facilities and are located in major cities which can generate a large number of higher fare origin/destination traffic to supplement the lower fares paid by the transfer passenger. There is, at this time, no compelling reason or industry support to seek "remote" locations for transferring passengers.

Recommendation A4: Use new vehicle technology like the New Large Aircraft (NLA), VSTOL's or even improved surface transportation to optimize the airport system.

***Response*:** Larger aircraft are already an important factor in providing capacity at airports, which cannot be easily expanded. Forecasted growth rates of aircraft operations at congested airports are often only half the growth rate of passenger enplanements reflecting the greater seating per operation. FAA has made design standards for the NLA available to airports to assist in planning future development and is working with industry to identify and remove any barriers that stand in the way of a smooth introduction of these aircraft.

VSTOL's are recognized as having a potential role in the high-density, short-haul market and FAA has issued appropriate design guidance to airport engineers and planners. When remaining economic and marketing obstacles to their wider use are resolved, they may be able to contribute to metropolitan airport system capacity in a more meaningful way.

Improvements in surface transportation and communications technologies outside the aviation sphere already have effects, though difficult to

isolate, on aviation growth. An example is the sensitivity of Northeast Corridor airport traffic to AMTRAK service and fares. FAA is working in cooperation with other Department of Transportation (DOT) agencies to optimize ground access to airports and to encourage the development of an efficient national intermodal system.

Leveraging

Recommendation #1: FAA leadership recognize the critical necessity to leverage its own R&D resources and appreciate that the unique role of the FAA in providing ATM services for actual and potential FAA suppliers of ATM hardware and software to undertake R&D beyond the levels of the past.

Recommendation #2: FAA's recognition of this relationship be explicit and widely publicized.

***Response to Recommendations #1 and #2*:** FAA is placing a greater R&D burden on industry through a number of program-specific initiatives:

- Acquisition Management Systems
- Coordinating specifications with industry
- Performance specifications and standards
- NAS architecture
- Cooperative R&D agreements

Recommendation #3: For both hardware and software that FAA requires, only performance specifications should be published (rather than design specifications); such performance specifications should be published broadly and reflect the FAA's vision for ATM in the future; they should also be updated with appropriate frequency to reflect changing technology.

Recommendation #4: Standards should be established well in advance of the deployment of hardware and software incorporating them and should be reviewed with the appropriate periodicity to ensure that requisite R&D is being done to enable suppliers to meet (or even exceed) such standards.

Recommendation #8: For FAA-acquired and operating systems, make decisions as to their attributes and performance requirements as far ahead of deployment as possible to enable potential suppliers and cooperators to commit maximal resources to supporting R&D.

***Response to Recommendations #3, #4, & #8*:** We agree with the spirit of the recommendations. The FAA intends to use the NAS Architecture and its supporting standards and documents as a basis for informing industry of the intended further development of the NAS infrastructure. In addition, the agency will continue to work with industry through public forums and other mechanisms to foster its internal investments in the development of the systems the FAA requires. It is recognized that design specifications can stifle innovation in industry and, therefore, can be counterproductive. Where possible, the FAA intends to exploit equipment and capabilities that are commercially available in meeting NAS infrastructure needs.

Recommendation #5: It is recommended that the FAA make better use of the National Resource Specialist (NRS) concept in order to anticipate possible and practical technological changes.

***Response*:** The FAA agrees with the recommendation. AVR uses NRS's extensively in the review of opportunities to exploit technology to improve the performance of the NAS. They also work closely with AVR policy offices and through them participate in the definition of R,E&D requirements with respect to airborne equipment design, production, and operational certification. With the recent expansion of the Aircraft Certification Service NRS program, it is anticipated that NRS participation in the management of technological changes will increase.

Recommendation #6: Announce and implement a policy to accommodate technological changes of merit with minimum delay.

***Response*:** The recent activities of the NAS Modernization Task Force have focused specifically on near-term implementation of technological improvements to the NAS. In addition, the community-wide consensus to adopt a spiral-development approach to NAS modernization responds directly to the recommendation.

Recommendation #7: Exploit the concept of cooperation with industry to the extent it does not produce long-term, anti-competitive effects in the marketplace.

***Response*:** The FAA agrees and is dedicated to the principle that NAS modernization can be ac-

complished only through community-wide collaboration of all stakeholders, including industry.

Response to the *Report and Minutes of the Subcommittee on Air Traffic Services* (Report dated November 6-7, 1997)

The Air Traffic Services Subcommittee in one of the six standing subcommittees established in January 1997 to provide recommendations to the FAA on its proposed R,E&D investment portfolio and to conduct annual reviews of FAA's research and development program.

The purpose of the Subcommittee's November 1997 meeting was to review and comment on the Flight 2000 initial program plan, the Operation Concept for 2005, and their integration with NAS Architecture Version 3.0 and the overall R,E&D program plan. The Subcommittee Report was approved by the Committee on January 29, 1998 and provided by letter to the Administrator on February 12, 1998. The following response was presented to the Committee by letter dated June 29, 1998.

Recommendation #1: In its program for ATM modernization, the FAA should give highest priority to increasing capacity, reducing delay, and improving safety. Allocation of resources should be in accord with this high priority.

***Response*:** We concur with the Subcommittee's recommendation to give the highest priority to increasing capacity, reducing delays, and improving safety. The Air Traffic Services (ATS) Target Area Team (TAT) proposed to the R,E&D Advisory Committee, Tier One fiscal year (FY) 2000 funding allocations for the Aviation System Capacity Research Project Description (RPD), Aviation Weather RPD, and Tower/Surface Automation RPD. These research programs are expected to increase the capacity of the U.S. aviation system to meet customer demand for aviation services, allow more flexibility in the use of resources for National Airspace System (NAS) users, and reduce weather-related accidents and incidents. In addition, the Runway Incursion Reduction, Separation Standards, and Aeronautical Data Link RPD's have been proposed for Tier One funding for FY 2000 by the ATS TAT.

Recommendation #2: The FAA should refocus Flight 2000 on the highest priority issues—safety, capacity, and delay in capacity-constrained airspace—with emphasis on total system integration.

***Response*:** The concept for a program like Flight 2000 has evolved over several years, based on a realization that the challenge of the NAS modernization is in achieving new flight capabilities, not just installing new ground-based automation equipment. Flight 2000 will accomplish a manageable cross-section of total system integration, and validate the resulting flight capabilities in a real-world operational environment. The program is being refocused with greater emphasis on reducing the technical, operational, and institutional risks of NAS modernization. Communication, navigation, and surveillance (CNS) systems must be integrated, aircraft compatibly equipped, and operational procedures developed, for controllers and pilots to assess the benefits of advanced technology and thereby reduce the risks associated with modernizing the NAS.

Applying the CNS flight capabilities of Flight 2000 at higher density contiguous United States (CONUS) sites was originally conceived as an activity to transition the results of Flight 2000 to NAS-wide modernization. Based on a recent recommendation by the Air Traffic Services Subcommittee, Flight 2000 intends to add a CONUS site as an integral part of the program. We are currently analyzing candidate sites, based upon traffic density, prevalence of air carrier operations, numbers of aircraft equipped with Flight 2000 avionics, necessary CNS and air traffic management (ATM) ground equipment, and suitability of airspace. Once this work is complete, a set of criteria will be forwarded to the RTCA Free Flight Steering Committee for industry review and concurrence on a final site. The Select Committee has committed to providing its recommendations to the FAA by August.

The flight capabilities resulting from Flight 2000 development also will offer vastly improved pilot and controller situational awareness and the potential for collaborative decisions between pilots and controllers. Eventually, and under carefully managed situations, controllers may authorize pilots to maintain self-separation in instrument conditions similar to the visual separation instructions controllers routinely issue to pilots today. In

such an environment, controllers will be able to devote greater attention to managing the overall traffic situation to accommodate user-preferred trajectories. The results will be more efficient traffic flow without compromising safety.

For pilots to maintain instrument separation comparable to today's visual separation, both controllers and pilots will need a reliable, accurate, and consistent depiction of traffic, as well as an ability to identify positively specific aircraft. By integrating advanced CNS capabilities in a real-world environment, Flight 2000 will demonstrate and validate the feasibility and potential benefits of collaborative decision-making and pilot instrument separation responsibility. These new flight procedures will then permit controllers to employ fully the sophisticated ATM tools that promise substantial NAS capacity improvements for the future.

Recommendation #3: To enhance safety, the FAA should increase the priority for deploying the ground systems which transmit weather information to the cockpit, and should continue to support the development of affordable avionics for the display of weather and hazardous terrain.

***Response*:** The FAA is committed to providing Flight Information Services (FIS) to pilots and has issued a policy statement which includes delivery of weather products to the cockpit. This policy statement was developed in conjunction with the general aviation user communities and industry. The policy enables the FAA and industry to partner in providing the services thus expediting the implementation of FIS. R,E&D activities necessary to develop standards and guidance materials for the implementation of FIS are contained within the Aeronautical Data Link R,E&D program and Flight 2000. Flight 2000 is a limited, real-world demonstration and validation of advanced operational capabilities. It is an R,E&D program focused on integrating technologies, developing procedures, and mitigating risks prior to a full-scale NAS deployment. As such, Flight 2000 is a key near-term learning effort in applying new CNS technology to the operational NAS. Critical decisions regarding subsequent Facilities & Equipment (F&E) programs to implement these technologies throughout the NAS will be heavily dependent on the validation results of Flight 2000. Until these results are known, there is no basis for an investment decision to deploy the CNS systems Flight 2000 addresses.

Recommendation #4: The FAA should develop a plan for ATM modernization expressed in terms of quantitatively-defined goals for evolving operational capabilities and user benefits. The concept of operations and the architecture should be tied to this ATM Modernization Plan, and the R&D plans should in turn be tied to the concept of operations and the architecture (i.e., what R&D must be done, and when, to support these plans?).

***Response*:** The FAA plans to expand both the concept of operations and the architecture to develop this plan for modernization. The architecture will be expanded to include identification and milestone planning for procedures and certification. We hope that by including these details, the architecture and its appendices will become the planning document for modernization.

The current architecture is logical based on the high-level concept of operations. The process for deriving a technical architecture is based on a feedback loop with the concept of operations. As the detail is added to the concept, it will increase the specificity by which the initial requirements for a capability can be defined. Where the concept is not clear or sufficiently detailed for deriving requirements, the push will be from the technical architecture to the concept developers to provide a basis for requirement definition.

The FY 2000 R,E&D plan used the architecture and the concept to validate current activities and identify needed R,E&D shortfalls. Many of the needs expressed in the RPD's beyond the current FY 1998 core were first identified in the process of rationalizing concept and architecture with R,E&D. The proposals and initial assignment to the funding tiers were based on the proposed architectural schedule for fielding capabilities. As the concept is developed and the architecture refined, the R,E&D requirements will also be refined and more closely tied to the modernization schedule.

It is clear that all capabilities and proposed paths to meeting the capabilities' shortfalls are not equal. Clear definition of the operational improvement sought and an understanding of the

current baseline performance are required to decide which capabilities to pursue and which solutions are tenable. In a concurrent and related activity, operational analysis will be conducted and performance measures will be developed to determine which steps are achievable and affordable. The activities pioneered by the System Capacity organization to define operational performance and value will be expanded as part of the continuing efforts of System Capacity, and performance definition and measurement is a key step in concept validation.

The clear articulation of the operational changes to be made and the method by which they will be measured will allow the FAA to develop clear performance baselines for capabilities as opposed to constituent systems. The baseline will allow tracking of all aspects to the delivery of new capabilities, such as systems, procedures, training, and airspace adaptation. The ARA performance plan goal 6 is the initial step in tracking capabilities in this fashion.

Recommendation #5: The Administrator should make sure that she is aware of the recommendations of the R,E&D Advisory Committee and other existing advisory committees, possibly by direct representation of these committees on the NAS Modernization Task Force.

***Response*:** The FAA established the NAS Modernization Task Force to advise the Administrator on the next steps necessary to NAS Modernization. The task force began its work in November 1997 and held its last meeting in January of this year, having completed its requested task. It recommended that the FAA concentrate its modernization efforts on a subset of the proposed NAS Architecture and delay work on other parts until this first subset was accomplished. The recommended subset, labeled Free Flight Phase 1 (FFP1), consists of the following systems and controller tools: Passive Final Approach Spacing Tool; Traffic Management Advisory Single Center; Controller Pilot Data Link; User Request Evaluation Tool; Collaborative Decision-making with Airline Operations Centers; and Surface Movement Advisor.

Subsequently, the FAA has requested the RTCA Free Flight Steering Committee and its Free Flight Select Committee to provide oversight of the FAA's efforts in accomplishing the FFP1 tasks. Some members of the R,E&D Advisory Committee and its subcommittees are also members of the RTCA Free Flight Steering Committee and Select Committee. This dual membership should provide the recommended R,E&D Advisory Committee representation on committees that advise the Administrator on NAS Modernization.

Committee Recommendations on FY 2000 R,E&D Investments (Letter dated May 24, 1998)

At the April 23–24, 1998, Committee meeting, the Committee reviewed FAA's planned FY 2000-2004 R,E&D Investment portfolio with special emphasis on FY 2000. The Committee provided feedback to FAA in a May 24 letter from the Committee Chairman Mr. Ralph Eschenbach to Administrator Jane Garvey. The FAA will consider these recommendations as it finalizes its R,E&D budget and respond to the Committee on these recommendations between January and April 1999.

Recommendation #1: FAA should bring together, in a single organization within FAA, all aspects of the National Airspace System (NAS)—R,E&D, acquisition, operation and maintenance (but not certification)—headed by a person reporting directly to the Administrator. A small system team responsible for planning the evolution of the NAS should directly support this person. The system team should be made up of the best and brightest from both the operational and developmental parts of FAA. Other organizations and agencies can support this activity, but the responsibility and leadership must remain within FAA. The Committee emphasizes that strong, credible FAA leadership is mandatory for success. Such leadership must include the willingness to make decisions *when consensus cannot be achieved*. There continues to be a need to strengthen the number and competence of FAA's internal staff. Only with a strong internal capability can FAA make good use of outside support contracts.

Recommendation #2: Free Flight Phase 1 should be only the first step in a multi-step process. The rapid movement toward the full implementation of the operational concept and the new architecture is essential for the evolution of the NAS and

the continued leadership of the United States in the emerging global transportation system. Continued R&D effort will be required to achieve reduced separation standards in all domains and increased terminal and airport capacity to meet the growth projections of the next decade. The FAA weather program has developed a number of weather products, which can provide significant benefits to aircraft operations. The FAA should move aggressively to effect an operational deployment of these products, with emphasis on making them available to aircraft in flight.

Recommendation #3: FAA needs to address the certification process issue energetically, as it is a pacing item in NAS evolution. Certification must be end-to-end (ground and air) across the NAS.

Recommendation #4: Given the Administration's requested budget level, the Air Traffic Services' (ATS) budget of $50.1 million has the right program balance. However, the following R&D areas are not adequately funded in the $50.1 million ATS program. In fact, the ADS-B project, a cornerstone of the NAS modernization has been zeroed! We feel it is *crucial* that these projects be restored.

Area Additional Funding Required:

ADS-B	$2.5 million
Aviation Weather	$2.8 million
Flight System Technology	$0.8 million
En route Automation	$9.0 million
NAS Management	$3.0 million
Total	**$18.1 million**

Recommendation #5: For many R&D areas, there is significant R&D work being done in other nations, usually with public support. FAA must systematically identify such R&D efforts and gather the outcomes, as they become available. This will minimize duplication of effort and facilitate subsequent harmonization in appropriate matters.

Recommendation #6: FAA needs to rebuild and strengthen its leadership role in international aviation. A mismatch in ATM approaches regionally around the world will require international aircraft to have multiple systems on board their aircraft. We cannot allow this to happen.

Recommendation #7: FAA needs to pursue R&D partners, who benefit from the R&D that FAA conducts and can partially or fully fund the R&D effort. The FAA should systematically and regularly review each of its present and prospective research project descriptions to determine the major private and public agency beneficiaries of the R&D work either underway or proposed. This will identify likely R&D "partners." The value of the benefits for each such party should be estimated competently, and a proposal for joint funding of each R&D effort should, then, be developed. In the course of estimating the value of the benefits available to a prospective partner (an appropriateness analysis), FAA will find some instances in which such benefits exceed the cost required to achieve the R&D results -- often by a substantial amount. Such cases are candidates for the transfer of perhaps all the costs of such R&D to the other parties, thus enabling FAA to use its own resources to pursue R&D which, otherwise, would not be undertaken.

APPENDIX B
NAS AVIATION RESEARCH PLAN PERFORMANCE DATA SECTION

The following tables are based on data extracted from the FAA performance plan and represents Government Performance and Results Act (GPRA) data specific to the R,E&D program.

Table B-1 shows how the FY 2000 R,E&D budget request will be allocated toward accomplishing the performance goals.

Table B-2 identifies FY 2000 initiatives and projects that support FAA focus areas. The focus areas are specific problem areas the FAA will address regarding the three performance goals designated by the FAA.

Table B-3 links R,E&D program chapters to specific performance indicators, which are derived from the performance plan prepared for the FAA.

Table B-1. FY 2000 R,E&D Budget Request Allocation

		STRATEGIC PLAN GOAL	System Safety: By 2007, reduce U.S. aviation fatal accident rates by 80 percent from 1996 levels	Security: Eliminate security incidents in the aviation system	System Efficiency: Provide an aerospace transportation system that meets the needs of users and is efficient in applying FAA and aerospace resources
Program Area/Program		Budget Request			
A1.	System Development and Infrastructure	18,043	2,902	411	14,601
A2.	Capacity and Air Traffic Management Technology	85,421	36,290	0	48,900
A3.	Communications, Navigation, and Surveillance	16,939	4,196	0	12,624
A4.	Weather	15,722	8,145	0	7,567
A5.	Airport Technology	7,516	2,761	0	4,719
A6.	Aircraft Safety Technology	36,127	35,968	0	0
A7.	System Security Technology	51,235	0	51,235	0
A8.	Human Factors (HF) and Aviation Medicine	24,089	23,026	0	900
A9.	Environment and Energy	3,641	*see the note below		
A10.	Strategic Partnerships	3,267	1,296	1,296	647
	Total	262,000	115,459	52,942	89,958

* Environment and Energy funding supports the FAA, enabling environmental goals of understanding aerospace environmental impacts and reducing them.

Table B-2. Safety Focus Areas and Related R,E&D Projects

FOCUS AREA	R,E&D PROJECTS
Safety Information Sharing and Analysis. To reduce the aviation fatal accident rate by 80 percent, the FAA must become more than a regulator and enforcer. The agency must also be a partner with an aviation community that itself seeks to identify and address the root causes of aviation accidents. The Administrator's Safety Agenda discusses the attributes of this root-cause analysis. Voluntary sharing of safety information is fundamental to it. Protecting information and its sources is needed to gain voluntary disclosure. Thus, FAA must balance its enforcement activities with the need to share information in order to achieve maximum safety improvements. Traditional methods of reacting to each accident with new regulations to prevent its re-occurrence are no longer enough. The data now available from flight recorders, maintenance reports, and other sources can be used to analyze operations and develop procedures or regulations to prevent accidents before they occur.	• Aviation Safety Risk Analysis • Flight Deck/Maintenance/Systems Integration • Human Factors
Surveillance/Inspection. While partnership, information sharing, and addressing human factors are keys to improving safety, FAA must also get the maximum benefit possible from its surveillance and inspection programs. This means working with others on inspection and surveillance and targeting FAA resources where they will do the most good. The Administrator's Safety Agenda seeks to build on several recent initiatives in which feedback is a unifying element, including the Air Transportation Oversight System (ATOS), the Air Carrier Certification Standardization and Evaluation Team, and the Aircraft Certification Safety Evaluation Program (ACSEP).	• Aviation Safety Risk Analysis • Flight Deck/Maintenance/Systems Integration • Human Factors
Accident Prevention. Based on detailed root-cause analysis, FAA seeks to work with the aviation community to prevent accidents through appropriate targeted, systematic interventions. The Administrator's Safety Agenda highlights three broad initiatives, each addressing several issues that will change over time. The Airline Initiative addresses uncontained engine failures, runway incursions, controlled flight into terrain (CFIT), loss of control, weather, and flight deck human factors. The General Aviation Initiative addresses CFIT, weather, runway incursions, loss of control, and decisionmaking. Finally, the Cabin Safety Initiative addresses passenger seatbelt use, carry-on baggage, child restraints, and passenger interference.	• Runway Incursion Reduction • Cockpit Technology (TCAS) • Aviation Weather Research • Juneau, AK (windshear detection and forecast) • Communications (Data Link Communications/ Flight Information Services) • Aviation Human Factors • General Aviation and Vertical Flight Technology Program • Safe Flight 21 • Surveillance (Automatic Dependent Surveillance-Broadcast and Cockpit Display of Traffic Information • Aircraft Safety Technology Research Program • Airport Technology Research Program (airport movement area markings, signs, and lighting and wildlife hazard mitigation research)

Table B-3. Security Focus Areas and Related R,E&D Projects

FOCUS AREA	R,E&D PROJECTS
New Security Baseline. FAA's approach to aviation security has long been to establish a solid baseline level of security at airports throughout the Nation, then to address key vulnerabilities that remain. The White House Commission stressed the need to continue to improve the baseline security system for civil aviation.	• Explosives and Weapon Detection • Aircraft Hardening
Performance and Procedures. Maximize human factors—the performance capability of people working in the aviation system is critical to raising the aviation security baseline. This is done by constantly testing all parts of the aviation security system, improving the quality of its components, and assessing vulnerabilities that the system may not fully protect.	• Aviation Security Human Factors
Information Security Architecture. A security architecture is presently being defined for implementation as part of the National Airspace System (NAS) modernization. The information security architecture will specify the framework, policies, concepts of operation, and security engineering methodologies to minimize the vulnerability of NAS information to loss, misuse, or unauthorized access. Security vulnerability and risk assessments of the major systems will be completed to assist each NAS element to identify all significant potential security threats.	

Table B-4. System Efficiency Focus Areas and Related R,E&D Projects

Focus Areas	R,E&D PROJECTS
Systems Integration. Department of Transportation organizations, including FAA, along with Federal, state, local, and private organizations, all help improve transportation system efficiency. Only close communication and integration of efforts will lead to efficient transportation. Thus, when FAA's Research and Acquisition organization oversees development of a new technology, the Air Traffic Services organization must recognize the need for it and train and prepare its personnel to use it. When a new airport runway is built, lighting, approaches, and radar coverage must be provided so that the runway can be used. Airports must be well linked to local surface transportation and local transportation planning. Information technology architectures, including system security, telecommunications, and others, must be integrated under the NAS Architecture. More recently, there are opportunities to integrate commercial space transportation and aviation by having aircraft land at spaceports, using the Global Positioning System (GPS) to locate the position of space vehicles, and even, in the future, having space vehicles land and take off from commercial airports. This will require close coordination among FAA's Research and Acquisition, Air Traffic Services, and Commercial Space Transportation offices to support developing an integrated air and space traffic management system.	• Safe Flight 21 • Operational Concept Validation • Center for Advanced Aviation System Development • System Capacity, Planning and Improvements • Airport Technology Research Program (airport planning and design) • AT/AF Human Factors
Free Flight. Free Flight is a safe and efficient flight operating capability under instrument flight rules in which the operators have the freedom to select their paths and speeds in real time. air traffic restrictions are only imposed to ensure separation, to preclude exceeding airport capacity, to prevent unauthorized flight through special use airspace, and to ensure safety of flight. Restrictions are limited in extent and duration to correct the identified problem. Any activity that removes restrictions represents a move toward Free Flight.	• Traffic Flow Management • System Capacity, Planning and Improvements • Safe Flight 21 • Operations Concept Validation • Communications (Data Link) • Navigation (GPS, WAAS, and LAAS) • Surveillance (ADS-B) • Center for Advanced Aviation System Development • General Aviation and Vertical Flight Technology Program
NAS Modernization. The existing air traffic system must be updated, and problems such as Year-2000 compliance must be addressed. Opportunities such as those presented by information technology must be realized. Developing an efficient aerospace system requires describing the system to be built and how it meets aerospace needs. The NAS Architecture continually updates the system description.	• Center for Advanced Aviation System Development • System Capacity, Planning and Improvement • Operations Concept Validation • Navigation (GPS, WAAS, and LAAS) • Software Engineering R&D

Table B-5. Performance Goals Linked to Program and Financing Schedules

***Performance Area*:** Safety

***Strategic Plan Goal*:** By 2007, reduce U.S. aviation fatal accident rates by 80 percent from 1996 levels

PERFORMANCE GOALS	By 2007, reduce the U.S. aviation fatal accident rate per aircraft departure, as measured by a 3-year moving average, by 80 percent from the 3-year average for 1994–96. Interim Goal: By 2000, reduce aviation fatal accident rate by 15 percent of baseline levels.	By 2007, reduce the aviation fatal accident rate by 80 percent of baseline levels primarily attributed to human error.	By 2007, reduce the aviation fatal accident rate by 80 percent of baseline levels primarily attributed to elements in production systems, certification.	By FY 2000, enhance the AVR surveillance program to utilize risk management models and tools to forecast, identify, and target areas.	By FY 2002, increase the participation of industry in AVR partnership programs by 20 percent over the 1996 level.	By 2007, reduce by (x percent) the rate of airport accidents/incidents (i.e., accidents/incidents in which an aircraft leaves the pavement or in which Aircraft Rescue and Fire Fighting responds) from baseline levels that result in injury to persons or damage to aircraft.	By FY 2000, reduce the rates of operational errors and operational deviations by 10 percent from the 1994 baselines.	By 2005, ensure human factors issues are addressed in the acquisition and integration of 100 percent new and modified FAA aviation systems, including Free Flight Phase 1.	In FY 2000, reduce the total number of runway incursions by 15 percent from the CY 1997 baseline.
Appropriation and Budget Request									
Research, Engineering, and Development $TBD									
System Development and Infrastructure							●		●
Capacity and Air Traffic Management Technology	●						●		●
Communications, Navigation, and Surveillance									●
Weather	●								
Airport Technology	●					●			●
Aircraft Safety Technology	●		●	●	●				
System Security Technology									
Human Factors and Aviation Medicine	●	●					●	●	●
Environment and Energy									
R,E&D Partnerships									●

Table B-6. Performance Goals Linked to Program and Financing Schedules

***Performance Area*:** Security

***Strategic Plan Goal*:** Eliminate security incidents in the aviation system

PERFORMANCE GOALS	X percent improvement from the 1998 baseline by 2000 in detection of improvised explosive devices and weapons in carry-on baggage with no significant increase in operational impact.	X percent improvement from the 1998 baseline by 2000 in detection of improvised explosive devices and weapons carried on the person with no significant increase in operational impact.	Increase the percentage of selected passengers' checked bags screened with explosives detection systems from the 1999 baseline by 2001 while maintaining x percent detection of improvised explosive devices.	X percent increase from the 1999 baseline by 2001 in the system's ability to sustain compliance with security requirements.	Convene aviation security consortia at 134 airports and provide tools and assistance to airports that voluntarily maintain consortia.	By 2001, increase by 20 percent from the 1999 baseline the number of FAA facilities accredited as fully meeting security standards.	Improve cargo security by x percent from the 1997 baseline in detecting improvised explosive devices in small packages accepted by air carriers from unknown shippers for air transportation.
Appropriation and Budget Request							
Research, Engineering, and Development $TBD							
System Development and Infrastructure							
Capacity and Air Traffic Management Technology							
Communications, Navigation, and Surveillance							
Weather							
Airport Technology							
Aircraft Safety Technology							
System Security Technology	●	●	●	●	●	●	●
Human Factors and Aviation Medicine							
Environment and Energy							
R,E&D Partnerships							

Table B-7. Performance Goals Linked to Program and Financing Schedules

***Performance Area*:** System Efficiency

***Strategic Plan Goal*:** Provide an aerospace transportation system that meets the needs of users and is efficient in the application of FAA and aerospace resources

PERFORMANCE GOALS	Decrease system delays.	By FY 2000, reduce the rates of volume- and equipment-related delays by 20 percent from the 1994 baseline.	Demonstrate the capability of new systems to decrease the rate of delays due to weather by 10 percent by, 2002 relative to a historically significant delay rate baseline.	Increase system capacity attributable to airport infrastructure at the 50 busiest airports by 0.5 percent annually by 2000 from the 1998 baseline.	Maintain 93 percent of runway pavement in good or fair condition at all NPIAS airports by year 2002 from the 1998 baseline.	Increase system flexibility.	By FY 2000, reduce the amount of extra flight-plan miles associated with ATC-preferred routes by 10 percent from the 1994 baseline.	By FY 2000, increase the percentage of flight segments flown off of ATC-preferred routes to over 80 percent from the 1996 baseline.
Appropriation and Budget Request								
Research, Engineering, and Development $TBD								
System Development and Infrastructure		●				●	●	●
Capacity and Air Traffic Management Technology	●	●		●		●	●	●
Communications, Navigation, and Surveillance	●	●				●	●	●
Weather	●	●	●			●	●	●
Airport Technology	●	●			●			
Aircraft Safety Technology								
System Security Technology								
Human Factors and Aviation Medicine								
Environment and Energy								
R,E&D Partnerships								

APPENDIX C
ALPHABETICAL LISTING OF NAS AVIATION RESEARCH PLAN BUDGET LINE ITEMS

APPENDIX D
NUMERICAL LISTING OF NAS AVIATION RESEARCH PLAN PROJECTS

Project Number	Project Title	Budget Item
011-130	System Planning and Resource Management	A01a
011-140	William J. Hughes Technical Center Laboratory Facility	A01b
011-160	Center for Advanced Aviation System Development (CAASD)	A01c
021-110	Traffic Flow Management	A02a
021-200/250	Runway Incursion Reduction	A02b
024-110	System Capacity, Planning and Improvements	A02c
022-110	Cockpit Technology	A02d
022-142	General Aviation and Vertical Flight Technology Program	A02e
025-150	Safe Flight 21 (formerly 'Flight 2000')	A02f
028-110	Operations Concept Validation	A02g
028-130	Software Engineering R&D	A02h
031-110/111	Communications	A03a
032-110	Navigation	A03b
033-140	Surveillance	A03c
041-110	Weather Program	A04a
051-110/120/ 121/130	Airport Technology	A05a
061-110	Fire Research and Safety	A06a
062-110/111	Advanced Materials/Structural Safety	A06b
063-110	Propulsion and Fuel Systems	A06c
064-110/111	Flight Safety/Atmospheric Hazards Research	A06d
065-110	Aging Aircraft	A06e
066-110	Aircraft Catastrophic Failure Prevention Research	A06f
060-110	Aviation Safety Risk Analysis	A06g
071-110	Explosives and Weapons Detection	A07a
073-110	Airport Security Technology Integration	A07b
076-110	Aviation Security Human Factors	A07c
075-110	Aircraft Hardening	A07d
081-110	Flight-Deck/Maintenance/System Integration Human Factors	A08a
082-110	Air Traffic Control/Airway Facilities Human Factors	A08b
086-110	Aeromedical Research	A08c
091-110/111/113	Environment and Energy	A09a
101-210	Strategic Partnerships	A10a

APPENDIX E
ACRONYMS AND ABBREVIATIONS

A

AA-COE	Airworthiness Center of Excellence
AANC	Aging Aircraft Nondestructive Inspection Validation Center
AC	Advisory Circular
ACAS	Airborne Collision Avoidance System
ACD	Automatic Conflict Detection
ACI-NA	Airports Council International-North America
ACR	Avionics Computer Resource
ACSEP	Aircraft Certification Systems Evaluation Program
ADF	Airline Dispatchers Federation
ADL	Aeronautical Data Link
ADS	Automatic Dependent Surveillance
ADS-B	Airport Surveillance Radar Broadcast
AEAP	Aviation Effects on the Atmosphere Project
AF	Airway Facilities
AFSS	Automated Flight Service Station
AGATE	Advanced General Aviation Transport Experiment
AGFS	Aviation Gridded Forecast System
AIA	Aerospace Industries Association
AIAA	American Institute of Aeronautics and Astronautics
AIDC	Air Traffic Data Communications
AIP	Airport Improvement Program
ALPA	Airline Pilots Association
AMASS	Airport Movement Area Safety System
AOAS	Advanced Oceanic Automation System
AOC	Airline Operations Center
AOPA	Aircraft Owners and Pilots Association
APANPIRG	Asia Pacific Air Navigation Planning and Implementation Regional Group
APEC	Asia Pacific Economic Cooperation
APMS	Automated Performance Measurement System
AQP	Advanced Qualification Program
ARAC	Aviation Regulatory Advisory Committee
ARDAT	Air Traffic Management Research and Development Agenda Team
ARTCC	Air Route Traffic Control Center
ARTS	Automated Radar Terminal System
ASAC	Aviation Security Advisory Council
ASDE	Airport Surface Detection Equipment

ASDI	Aircraft Situational Display for Industry
ASR	Airport surveillance radar
ASRA	Aviation Safety Risk Analysis
AST	Advanced Subsonic Technology
ASTI	Airport Security Technology Integration
ASTI	Airport Security Technology Integration
ASTM	American Society on Testing and Materials
ATA	Air Transport Association
ATC	Air Traffic Control
ATCA	Air Traffic Controllers Association
ATCBI	Air Traffic Control Beacon Interrogator
ATCS	Air Traffic Control Specialist
ATCSCC	Air Traffic Control System Command Center
ATM	Air Traffic Management
ATN	Aeronautical Telecommunications Network
ATNSI	ATN Systems, Inc.
ATOS	Air Transportation Oversight System
ATS	Air Traffic Services
ATSP	Air Traffic Service Plan
AVGAS	aviation gasoline
AWC	Aviation Weather Center
AWIN	Aviation Weather Information
AWT	Area Work Team

C

C3I	Command, Control, Communications, And Information
CAA	Cargo Airlines Association
CAASD	Center for Advanced Aviation System Development
CAEP	Committee on Aviation Environmental Protection
CAMI	Civil Aeromedical Institute
CAPS	Computer-assisted Passenger Screening
CASR	Center for Aviation Systems Reliability
CBT	Computer-Based Training
CDM	Collaborative Decision Making
CDTI	Cockpit Display of Traffic Information
CFC	chlorofluorocarbon
CFIT	Controlled Flight Into Terrain
CIA	Central Intelligence Agency
CIP	Capital Investment Plan
CIS	Cockpit Information System
CMAS	Center for Computational Modeling of Aircraft Structures
CNS	Communication, Navigation, and Surveillance

COE	Center of Excellence
COE-AWA	Center of Excellence in Airworthiness Assurance
CONOPS	operational concept
COTS	Commercial-Off-the-Shelf
CPDLC	Controller-pilot Data Link Communications
CRC	Coordinating Research Council
CRCT	Collaborative Routing Coordination Tool
CRDA	Cooperative Research and Development Agreement
CTAS	Center TRACON Automation System

D

D-ATIS	Digital Air Traffic Information Service
DARPA	Defense Advanced Research Project Agency
DME	Distance Measuring Equipment
DOD	Department of Defense
DOE	Department of Energy
DSR	Display System Replacement
DSS	Decision Support System
DSSS	Decision Support System Services
DT&E	Developmental Test and Evaluation

E

EAA	Experimental Aircraft Association
EARTS	Enroute Automated Radar Tracking System
EDD	Explosives Detection Device
EDM	Expert Decisionmaking
EDS	Explosives Detection System
EEHWG	Electromagnetic Effect Harmonization Working Group
EMS	Emergency Medical Service
EPA	Environmental Protection Agency
ETA	Estimated Time Of Arrival
ETC	Engine Titanium Consortium
EUROCAE	European Organization for Civil Aviation Equipment
EUROCONTROL	European Organization for Safety of Air Navigation

F

F&E	Facilities and Equipment
FAA	Federal Aviation Administration
FANG	FMS-ATM Next Generation
FANS	Future Air Navigation System
FAR	Federal Aviation Regulation
FAST	Final Approach Spacing Tool

FEM	Finite Element Model
FFP1	Free Flight Phase 1
FFSC	Free Flight Steering Committee
FICAN	Federal Interagency Committee on Aviation Noise
FIS	Flight Information Service
FIT	Florida Institute of Technology
FMCW	Frequency Modulated Continuous Wave
FMS	Flight Management System
FOC	Full Operating Capability
FRED	FAA Research and Development Electromagnetic Data Base
FSD	Full Scale Development
FSM	Flight Schedule Monitor
FSS	Flight Service Station
FTE	Full Time Equivalent
FTHWG	Flight Test Harmonization Working Group
FVS	Functional Verification System
FY	Fiscal Year

G

GA	General Aviation
GA&VF	General Aviation and Vertical Flight
GAMA	General Aviation Manufacturers Association
GAO	General Accounting Office
GDP	Ground Delay Program
GICB	Ground Initiated Communications-B
GIP	Government and Industry Partnership
GNSS	Global Navigation Satellite System
GPRA	Government Performance and Results Act
GPS	Global Positioning System
GWS	Graphic Weather Service

H

HAI	Helicopter Association International
HIC	Head Injury Criteria
HIRF	High-intensity Radiated Fields
HOCSR	Host Oceanic Computer System Replacement
HSCT	High-speed Civil Transport
HSI	Human Systems Integration
HSI	Human Systems Integration
HUMS	Health/Usage Monitoring System

I

IACSE	Interagency Advisory Committee on Security Equipment
IAIMT	Inter-Agency Integrated Management Team
IAIPT	Inter-Agency Air Traffic Management Integrated Product Team
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ICP	Initial Conflict Probe
IDACS	Intelligent Damage Adaptive Control System
IDM	Integrated Design And Manufacturing
IEEE	Institute of Electrical and Electronics Engineers
IFR	Instrument Flight Rules
IGEB	Interagency GPS Executive board
ILS	Instrument Landing System
IMD	Integrated Mechanical Diagnostic
IOC	Initial Operating Capability
IOT&E	Independent Operational Test and Evaluation
IPHWG	Ice Protection Harmonization Working Group
IPT	Integrated Product Team
IRS	Internal Revenue Service
ITWS	Integrated Terminal Weather System

J

JAA	Joint Aviation Authorities
JRC	Joint Resources Council

L

LAAS	Local Area Augmentation System
LVLASO	Low Visibility Landing and Surface Operations

M

MANPADS	Man Portable Air Defense Systems
MASPS	Minimum Aviation System Performance Standards
MCDC	Modified Condition/decision Coverage
MMR	Maintenance Malfunction Reporting
MOA	Memorandum of Agreement
MOPS	Minimum Operational Performance Standards
MOU	Memorandum of Understanding
MSODL	Multi-sector Oceanic Data Link

N

NARP	National Aviation Research Plan
NAS	National Airspace System

NASA	National Aeronautics And Space Administration
NASAO	National Association of State Aviation Officials
NATA	National Air Transportation Association
NATCA	National Air Traffic Controllers Association
NATO	North Atlantic Treaty Organization
NAWCAD	Naval Air Warfare Center Aircraft Division
NBAA	National Business Aircraft Association
NCARC	National Civil Aviation Review Commission
NDB	Non-Directional Beacon
NDI	Non-Developmental Items
NEXRAD	Next Generation Weather Radar
NHTSA	National Highway Traffic Safety Association
NIMS	NAS Infrastructure Management System
NIOSH	National Institute of Occupational Safety and Health
NIST	National Institute of Standards and Technology
nmi	nautical miles
NOAA	National Oceanic and Atmospheric Administration
NOTAM	Notice to Airmen
NPRM	Notice of Proposed Rulemaking
NRP	National Route Program
NRS	National Resource Specialist
NSTB	National Satellite Test Bed
NSTC	National Science and Technology Council
NTSB	National Transportation Safety Board
NWS	National Weather Service

O

O&M	Operations and Maintenance
OAP	Oceanic Automation Program
OAS	Oceanic Automation System
OMB	Office of Management and Budget

P

P^3I	Pre-Planned Product Improvement
PAST	Program Analysis/Section Tool
PBO	Performance-based Organization
PCCIP	President’s Commission on Critical Infrastructure Protection
PDC	Predeparture Clearance
pFAST	passive Final Approach Spacing Tool
PIP	Program Implementation Plan
PIREP	Pilot Report
POET	Post Operations Evaluation Tool

PPBM	Positive Passenger Baggage Matching
PPIHWG	Powerplant Installation and Harmonization Working Group

R

R&D	Research and Development
R,E&D	Research, Engineering and Development
RAA	Regional Airline Association
REDAC	R,E&D Advisory Committee
RF	Radio Frequency
RIAT	Runway Incursion Action Team
RIRP	Runway Incursion Reduction Program
RMM	Remote Maintenance Monitoring
RVR	Runway Visual Range
RVSM	Reduced Vertical Separation Minima

S

SAE	Society of Automotive Engineers
SAIC	Science Applications International Corporation
SAMA	Small Aircraft Manufacturers Association
SARP	Standards and Recommended Practices
SATORI	Systematic Air Traffic Operations Research Initiative
SBIR	Small Business Innovative Research
SC	Special Committee
SDTF	Surface Development and Testing Facility
SEIPT	Security Equipment Integrated Product Team
SERC	Software Engineering Resource Center
SFP	Surveillance Fusion Platform
SIC	Standard Industrial Code
SICAS	Secondary Improvements and Collision Avoidance System
SID	Supplemental Inspection Document
SIR	Screening Information Request
SITA	Société Internacionale de Télécommunications Aéronautique
SLD	Supercooled Large Droplets
SMA	Surface Movement Advisor
SMPC	Specialty Metals Processing Consortium
SNI	Simultaneous Non-interfering
SOIT	Satellite Operational Implementation Team
SPAS	Safety Performance Analysis System
SPEARS	Screener Proficiency Evaluation and Reporting System
SPIE	International Society for Optical Engineers
SSTP	System Security Technology Program
STARS	Standard Terminal Automation Replacement System

STDMA	Self-organizing Time Division Multiple Access
SUA	Special Use Airspace

T

TAP	terminal area productivity
TCA	Transport Canada Aviation
TCAS	Traffic Alert and Collision Avoidance System
TDLS	Tower Data Link System
TERPS	Terminal Instrument Procedures
TFM	Traffic Flow Management
TIS	Traffic Information Service
TMA	Traffic Management Advisor
TMS	Traffic Management System
TMU	Traffic Management Unit
TOGAA	Technical Oversight Group On Aging Aircraft
TRACON	Terminal Radar Approach Control
TWIP	Terminal Weather Information for Pilots

U

U.K.	United Kingdom
U.S.	United States
U.S.C.	United States Code
UHF	ultra high frequency
UPS	United Parcel Service
URET	User Request Evaluation Tool
USAF	United States Air Force
USN	United States Navy

V

VHF	very high frequency
VNTSC	Volpe National Transportation Systems Center
VOR	very high frequency omnidirectional range

W

WAAS	Wide Area Augmentation System
WARP	Weather and Radar Processor
WFD	Widespread Fatigue Damage
WJHTC	William J. Hughes Technical Center
WSDDM	Weather Support to Deicing Decision Making
WVSS	Water Vapor Sensing System

Y

Y2K	Year 2000

FAA ORGANIZATIONS

AAR	Aviation Research
ABA	Financial Services
ACR	Civil Rights
ACS	Civil Aviation Security
AFS	Flight Standards
AGI	Government and Industry Affairs
AHR	Human Resource Management
AIR	Aircraft Certification
AND	Communications, Navigation, and Surveillance Systems
AOZ	Free Flight Phase One
APA	Public Affairs
API	Policy, Planning and International Aviation
ARA	Research and Acquisition
ARC	Region/Center Operations
ARP	Airports
ASC	System Capacity
AST	Commercial Space Transportation
ASY	System Safety
ATS	Air Traffic Services
AVR	Regulation and Certification