1.0 OVERVIEW

1.1 The FAA Mission and R&D

The American public and their elected officials rely upon the Federal Aviation Administration to provide a safe, secure, efficient, and environmentally responsible National Airspace System (NAS). The FAA has committed to reducing the U.S. rate of fatal aviation accidents by 80 percent, based on 1996 levels, by the year 2007. In an increasingly mobile and complex world, innovative solutions are vital to meeting these expectations. The importance of the FAA's research and development (R&D) will grow with the expanding demands placed upon it.

FAA R&D develops technologies, systems, and procedures to fulfill the agency's principal operational and regulatory responsibilities: air traffic services, certification of aircraft and aviation personnel, operation and certification of airports, civil aviation security, and environmental standards for civil aviation.

1.2 Increased Demands on FAA R&D

The job of safely managing air traffic in the United States is becoming increasingly complex. In May 2000, the FAA's Technical Center reported: "Our air transportation system has over 17,000 landing facilities, 226,000 registered aircraft, 700,000 pilots, 8000 tower controllers, a multitude of terminal buildings and access roads, and 500 million passenger enplanements each year." FAA forecasts predict major growth in demands upon the system.

- *Between 2000 and 2010:*
  - Domestic passenger enplanements will increase at an average annual growth rate of 3.4 percent.
  - Regional/commuter passenger enplanements will increase at a yearly growth rate of 5.4 percent.
  - The commercial air carrier jet fleet will increase at an annual rate of 4.0 percent or 260 aircraft per year.
  - The active general aviation fleet will come to total 220,800.
  - Total civil aircraft activity at towered and non-towered airports will reach 129.4 million operations.
- *By 2015:*
  - The numbers of passengers carried on our commercial aircraft will reach one billion.
- *By 2025:*
  - Domestic passenger enplanements will slow somewhat to an average annual rate of 2.9 percent.
  - Regional/commuter passenger enplanements will slow to a yearly rate of 3.6 percent.
  - The regional/commuter fleet (60 seats or fewer) will grow from 2,039 aircraft (1998) to 3,800.
  - The active general aviation fleet will expand to 248,800.
  - Total civil aircraft activity at towered and non-towered airports will reach 142.8 million.
  - The total pilot population will grow to 849,200.

1.3 Civil Aviation and the Nation

The technologies and procedures resulting from FAA R&D contribute heavily to our domestic economy and fuel the nation's largest export sector. Estimates recently updated by Wilbur Smith Associates (see Figure 1) indicate that nearly one dollar in every twenty in the U.S. Gross Domestic Product is generated by aviation and related industries. A wide range of economic activities including the airlines, travel industries, food services, construction, and communications provide nearly 11 million American jobs, create $278 billion in annual earnings, and pump $976 billion into the domestic economy.

Increased foreign competition is threatening to erode our preeminent international position in aviation. Although U.S. aircraft manufacturers expect to deliver over 14,000 transport aircraft valued at $1 trillion world-wide in the next 20 years, aviation research and development is accelerating in other nations and improving their commercial aviation products. Effective R&D is a major factor in protecting our leadership and market share in the vibrant and crucial aviation industry.

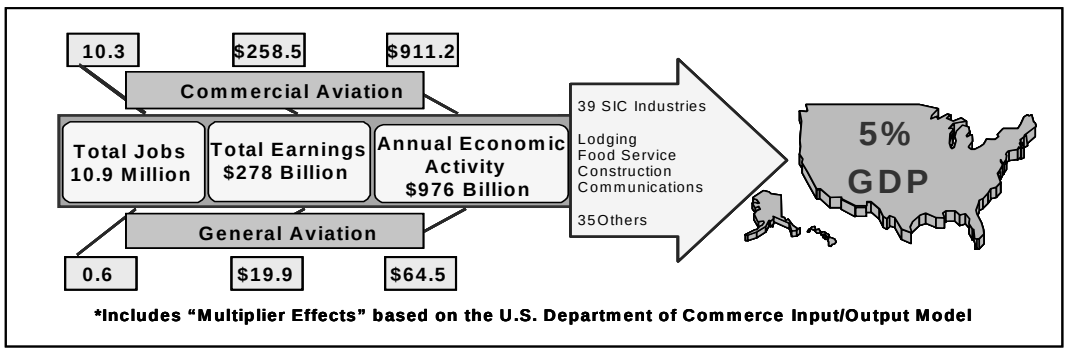


Figure 1. Aviation Impact on the Economy

1.4 FAA R&D Program

Most of the research described in the "Program Information" portion of this plan is funded through the agency's Research, Engineering and Development (R,E&D) appropriation. Except for the Weather Program (A04a), all Air Traffic Services research is funded through the Facilities and Equipment (F&E) appropriation.

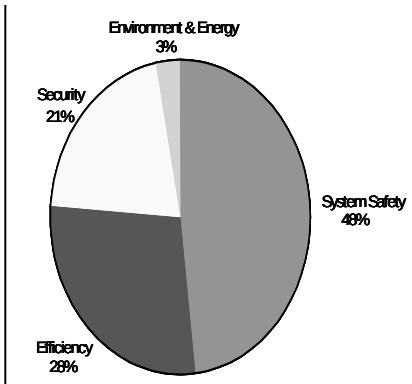
Figure 2 shows the relative percentages of FY 02 R&D funding to be directed toward meeting the following major FAA goals:

System Safety: By 2007, reduce U.S. aviation fatal accident rates by 80% from 1996 levels.

Security: Prevent security incidents in the aviation system.

Efficiency: Provide an aerospace transportation system that meets the needs of users and is efficient in the application of FAA and aerospace resources.

Environment & Energy: Prevent, minimize, and mitigate environmental impacts.



Applicable Goal	FY 02 Level	Appropriation(s)
System Safety	$123,249	R,E&D, F&E, AIP
Efficiency	$ 71,885	R,E&D, F&E, AIP
Security	$ 53,392	R,E&D
Environment & Energy	$ 7,602	R,E&D
Total:	$256,128	

Figure 2. FY 02 R&D Funding Percentages by Goals

The FAA R&D program is functionally divided into the eight areas described below:

- *Air Traffic Services*—R&D focuses on increasing system safety and capacity and enhancing the flexibility and efficiency of air traffic management operations. Improved decision support tools are key to enabling FAA air traffic specialists to collaborate with the user community in managing traffic flows as efficiently as possible.
- The R&D program is also working to reduce occurrences of runway incursions, midair collisions, and aircraft encounters related to the effects of wake vortices and hazardous weather. Research is helping to develop new technologies that will improve navigational accuracy and 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 is introducing new technologies to support a Free Flight system, in which aircraft operators can vary their speed and flight path to increase efficiency, while air traffic controllers can still ensure safe operations.
- *Airport Technology*—R&D develops and evaluates technologies and materials designed to ensure safe and efficient airport operations. Research focuses on development 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&D focuses on ensuring the safe design, manufacture, and maintenance of aircraft. It addresses the hazards to 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 and nonstructural problems associated with degradation, damage, 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. This work includes studies in structural integrity of airframes and engines, maintenance and repair of composites, atmospheric hazards, crashworthiness, fire safety, and forensics capabilities to support accident investigations.
- *Aviation Security*—R&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 aspects of threat 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&D programs described in this Overview directly support the needs of the FAA's lines of business and NAS users, as identified in the National Plan for Civil Aviation Human Factors. These Civil Aeromedical Institute (CAMI) initiatives address major human factors areas affecting the flight deck, Air Traffic Control, flight deck/ATC system integration, airway facilities, aircraft maintenance, as well as aeromedical issues related to the safe operation and forensic investigation of aircraft cabin environments.
- *Environment and Energy*—R&D develops technical information, standards, and procedures to mitigate the environmental impact of aircraft operations, particularly upon noise and air pollution emissions. The program seeks to identify and balance technology, operations, and land-use measures with special emphasis on developing assessment methodologies that give insight into the system-wide consequences of alternative courses of action.
- *Commercial Space Transportation*—The overall mission of Commercial Space Transportation (AST) is to protect public health and safety, protect the safety of property, and protect U.S. foreign policy and national security interests; to encourage, facilitate, and promote U.S. commercial space launches; to enhance the international competitiveness of the U.S. commercial space transportation industry; to ensure compliance with international obligations of the U.S., and to facilitate new or improved U.S. space transportation infrastructure.
- *National Aviation Research Plan Program Management*—includes the management, planning, control, and support activities associated with formulating the FAA R&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.

The cross-cutting emphases just described ensure outside assessment of the FAA R&D investments. NARP Program Management also facilitates research partnerships with industry, universities, and other government agencies that enable the FAA to leverage its research dollars.

1.5 The Need for Modernization

In the course of the 1990s, the FAA often has been called on to do business differently. Sometimes these calls have come from outside the DOT/FAA ranks, and sometimes from within. The advocates of change about to be described have contributed to a growing spirit of modernization both in systems and in the operating "culture" of the agency.

1.5.1 External Motivators

Government Performance and Results Act of 1993

The FAA emphasizes GPRA concepts throughout the National Aviation Research Plan. Figure 3 relates the workings of agency's research programs within a GPRA framework. The most forceful **suppliers** of the requirements that shape FAA research are direct mandates from Congress and the Administration. In response to these directions, the FAA partners with interested **stakeholders**, public and private, to formulate specific research budgets and programs. The Research, Engineering and Development Advisory Committee (REDAC) is a permanent conduit, instituted by Congress, to bring the expertise and experience of industry, academia, and the full aviation community into the planning and implementation of FAA research. Implementation of improved systems and regulations, the physical **outputs** of FAA aviation research, results in **outcomes** that increase aviation safety, efficiency, security, and environmental compatibility.

White House Commission on Aviation Safety and Security

The Commission on Aviation Safety and Security was established in August 1996. The group reviewed the current status of NAS modernization efforts and found that, in the interest of safety and efficiency, improvements to the program should be accelerated "to achieve full operational capability by 2005."

President's Commission on Critical Infrastructure Protection

The President's Commission on Critical Infrastructure Protection was established in July 1996 to find current and viable means to protect critical infrastructures, including aviation, from physical and cyber threats. An advisory committee of industry leaders supported the main body, and a steering committee of cabinet-level officials reviewed the final report, "Critical Foundations." The agency has accordingly heightened its emphasis on combating threats to the security of information deemed vital to the safe performance of the NAS.

National Science and Technology Council

The National Science and Technology Council (NSTC) was established on November 23, 1993. This Cabinet-level Council is the principal means to coordinate science, space, and technology among the diverse parts of the Federal research and development enterprise.

A key NSTC objective is to establish clear national goals for Federal science and technology investments that can strengthen and improve areas ranging from information technologies and health research to transportation systems and fundamental research. The NSTC Committee on Transportation Research and Development has developed the rationale and framework for guiding Federal initiatives that will make the transportation system safer, more productive, and more efficient.

In its report titled "National Research and Development Plan for Aviation Safety, Security, Efficiency, and Environmental Compatibility" (1999), the Council provides a description of the coordinated long-term research initiatives needed to bring about the advances in aviation for the opening decades of the next century.

The FAA is a highly visible member of the transportation community. Continuing investments in its research activities are critical to meeting the national goals and sustaining the prosperity of the national economy.

The FY 2002 FAA R&D budget supports the strategic goals for transportation outlined in the NSTC plan. These goals include:

- Providing a safer transportation system.
- Achieving a high level of transportation system security.
- Improving environmental quality and energy efficiency.
- Fostering economic growth and productivity through more effective and flexible global passenger and freight services.

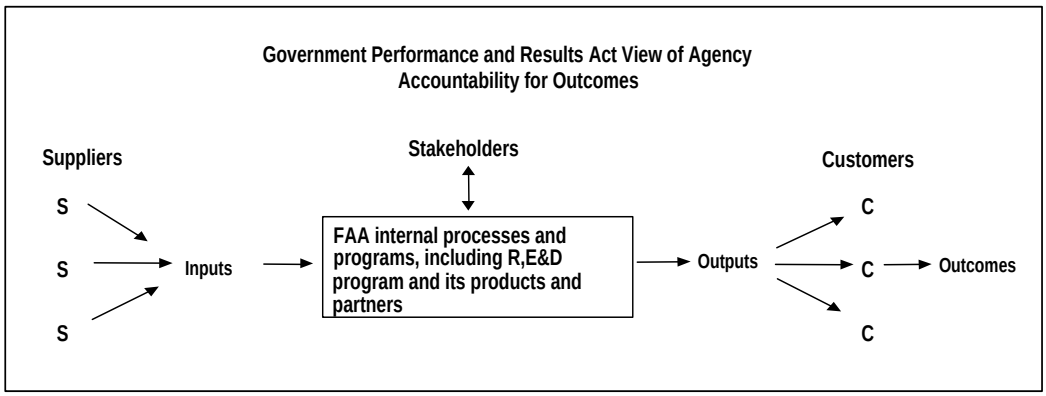


Figure 3. FAA R&D Program and GPRA Terminology

- Ensuring improved access to and increased mobility on the nation's transportation system.

The NSTC report is available on the internet at: http://www.volpe.dot.gov/resref/strtplns/nstc/aviatrd.

R,E&D Advisory Committee

Established by Congress in 1989, the FAA's R,E&D Advisory Committee (REDAC) reports to the Administrator on research and development issues and provides a liaison between the FAA R&D program and similar efforts of industry, academia, and other government agencies. The committee considers aviation research needs in air traffic services, airport technology, aircraft safety, aviation security, human factors, and the environment.

Up to thirty members may hold two-year terms on the committee. They represent corporations, universities, associations, consumers and other government agencies. The FAA's Director of Aviation Research, serves as the executive director of the committee. The REDAC meets two times during the year, typically in April and in September.

NASA's Aerospace Technology Advisory Committee and FAA's REDAC now conduct joint meetings to establish a framework allowing them to provide better support to inter-agency R&D modernization goals in the areas of safety, efficiency, and Environment and Energy.

Recent REDAC recommendations appear in Appendix A of this Plan.

1.5.2 DOT/FAA-Internal Motivators

DOT Flagship Initiatives

One hundred and eighty senior leaders from all components of the Department of Transportation met for two days in February of 1999 as the DOT's first-ever expanded Senior Leadership Team. Their charter was to identify ways to improve overall cooperation among the various departmental components and ensure consensus on crosscutting issues. DOT "Flagship Initiatives," a two-year "intermodal" strategic agenda with roots in the department's Strategic and Performance Plans, was the result.

Flagship Initiatives generally involve more than one major DOT component and cluster around five strategic goals: safety, mobility, economic growth and trade, human and natural environment, and national security. FAA programs included in previous "Flagships" have included: Safer Skies, Free Flight Phase 1, research relying upon GPS technologies, Aircraft Noise Standards, and a number of physical security efforts.

FAA Administrator

The FAA Administrator has firmly supported recent NAS modernization and related activities. The following remarks from Ms. Garvey's speeches and congressional testimony further illustrate this continuing commitment:

> "It cannot be business as usual. Let me rephrase that — it will not be business as usual. Our job is too important."
>
> — March 12, 1998
>
> "What drives us to work so hard and so well together is that we all know that Safer Skies is absolutely the right approach. This data-driven, prioritized, and measured approach is the best way to enhance aviation safety. Safer Skies is the right thing to do."
>
> — April 15, 1999
>
> "I believe that we have put into place a structure for information system security that is vigilant; and will continue to seek all ways and means to provide the greatest level of protection for our information systems."
>
> — September 27, 2000

R&D Executive Board

The nine-member R&D Executive Board (REB) was established during the past year to provide a high level of FAA-internal R&D management support to the Executive Director, Office of Aviation Research (AAR-1). The REB advises the Executive Director regarding three key program planning and implementation stages: 1) it guides the initial R&D portfolio planning and preparation phase, 2) it oversees the integration of budget requests from various projects and funding sources into one comprehensive R&D program, and 3) it helps to adjust program impacts during

the culminating phases of the annual budget deliberation process.

Membership on the REB includes senior representatives from the following organizations:

- ABU - Financial Services
- ACS - Civil Aviation Security
- API - Policy, Planning, International Aviation
- ARA - Research and Acquisition
- ARP - Airports
- ATS - Air Traffic Services
- AVR - Regulation and Certification
- AIO - Chief Information Officer
- AST - Commercial Space Transportation

The REB has taken an active role in the past year in a baseline appraisal of selected R&D management actions. This effort is part of an agency-wide initiative to document, evaluate and improve overall management processes through application of a unique integrated Capability Maturity Model (iCMM).

1.6 Ongoing Aviation Community Initiatives

All FAA initiatives described in this section relate directly to the agency's pragmatic approach to NAS Modernization. In their planning and execution, they are "benefits-driven," involve all facets of the user community, minimize implementation risk, and link to past, current, and future R&D efforts. In philosophy, they are consistent with the Free Flight operational concept: "…a safe and efficient flight operating capability, under instrument flight rules, in which the operators have the freedom to select their path and speed in real time."

All are based on the FAA's three essential goals of modernization:

- Sustain the integrity and reliability of the system.
- Improve on our Nation's excellent safety performance.
- Increase flight efficiency and flexibility.

1.6.1 NAS Architecture

The NAS Architecture responds to the requirements of the Government/Industry Operational Concept for the Evolution of Free Flight (CONOPS). The most recent version culminates an intensive effort of the FAA, DOD, industry representatives, and pilot and owners' organizations to define a comprehensive system architecture that can realistically meet the infrastructure needs of 21st-century air transportation. The NAS Architecture Version 4.0 document, approved by the FAA Joint Resources Council on September 14, 1998, was published in February 1999.

The Architecture incorporates the needs and requirements of NAS users through an incremental, benefits-driven approach to achieving the capabilities of Free Flight. It covers the transition from the current NAS through three distinct phases, respectively ending in: 2002; 2007; and the year when mature Free Flight is anticipated, 2015. The concept forms the basis for various FAA and user community plans calling for procedural, financial, and architectural decisions regarding capabilities needed for Free Flight.

Before the full Architecture was announced, a NAS Modernization model was used to validate all current and proposed R&D initiatives within the Air Traffic Services (ATS) area. New requirements were identified, and some ongoing research activities were restructured. Details of how ATS research activities map to NAS Modernization appear in the NAS Architecture Version 4.0. As system managers continue to prepare to meet future needs, they will continue to assess architecture options against the NAS Modernization model and existing capabilities.

1.6.2 Free Flight Initiatives

Free Flight enhances the aviation community's ability to collaboratively share data and to view and optimize all phases of flight - from planning and surface operations to en route flight paths. In collaboration with the aviation community, Free Flight is introducing new technologies and procedures. Free Flight is the industry-endorsed strategy that calls for the deployment of selected capabilities with potential to benefit users of the National Airspace System. Deployed systems are

integrated into the traffic management system with operational procedures and training to minimize risk and achieve greater user satisfaction.

Free Flight Program

The partnerships, systems, and regulations that will make Free Flight safe and efficient are being developed in phases through extraordinary consensus between the FAA and the full aviation community. Free Flight Phase 1 (FFP1) was begun in July of 1998 and will be completed at the end of calendar year 2002. FFP1 has deployed its "core capability" prototype systems to selected sites, in specific configurations, to demonstrate the potential of adapting known research vehicles to meet the steep capacity and efficiency demands of the Free Flight environment.

The deployed FFP1 capabilities are:

- *Traffic Management Advisor (TMA)* – A tool that aids the en route controller in making decisions regarding sequencing and spacing of en route arrival aircraft approaching selected airports.
- *passive Final Approach Spacing Tool (pFAST)* – A tool that aids the controller in making decisions regarding sequencing and runway assignment for terminal arrival aircraft.
- *User Request Evaluation Tool (URET)* – A tool that aids the controller in managing en route traffic, supporting user request decisions, and identifying potential conflicts.
- *Collaborative Decision Making (CDM)* – A collection of tools that allows the FAA and participating airlines to exchange NAS status information including weather, equipment and delays.
- *Surface Movement Advisor (SMA)* – A data distribution capability that provides aircraft arrival information to airline ramp towers and permits data exchange to support efficient surface movement.

Concerned that the momentum would be lost upon the scheduled completion of FFP1, RTCA formed the 2003-2005 capabilities working group to: define which FFP1 capabilities should be further implemented; nominate sufficiently mature capabilities for post-FFP1 implementation; identify flexible airspace and procedural initiatives that could alleviate en route congestion; and, select and prioritize a set of research projects for possible implementation within the 2003-2005 timeframe.

The FAA has selected RTCA-recommended capabilities for direct inclusion in the Free Flight Phase 2 (FFP2) program. Four of these continue and build upon FFP1 capabilities, specifically URET, TMA (used in conjunction with a single air traffic control center), pFAST, and CDM. An additional FFP2 capability, Collaborative Routing Coordination Tools (CRCT) has been added to provide improved system-wide problem prediction to controllers. The FAA also has included Controller Pilot Data Link Communications (CPDLC) Builds 1 and 1A as an FFP2 component.

The agency has opted to address FFP2 airspace and procedural recommendations through the Air Traffic Airspace Management (ATA) program and the Air Traffic Planning and Procedures (ATP) organization, respectively. These ongoing FAA management resources will develop and implement national plans to fulfill the RTCA recommendations and report their progress to the aviation community.

RTCA also recommended that certain research projects be prioritized for FFP2. These have been categorized into two groups according to the maturity level of the technologies involved:

These items are sufficiently mature to implement within the 2003-2005 timeframe:

- *Direct To (D2)* – Will aid the controller in establishing priorities by placing all aircraft eligible to fly directly to a destination airport in an ordered sequence.
- Surface Management System (SMS) – Will support the safe, prioritized movement of aircraft on the airport surface in order to increase the efficiency of arrivals and departures.
- Problem Analysis Resolution and Ranking (PARR) – Will improve upon the URET capability to provide planning and conflict detection information to controllers.
- Equitable Allocation of Limited Resources – CRCT does not currently provide this RTCA-recommended capability; therefore, the working group recommended the high priority

R&D development of automation to work toward this goal.

- Traffic Management Advisor-Multi Center (TMA-MC) – FFP1 TMA technology works best for airports located approximately 200 nautical miles from an air traffic control center boundary. The envisioned FFP2 capability will improve the efficiency of sequencing aircraft for descent through airspace controlled by more than a single center.

Development of these items will be accelerated as opportunities emerge within the 2003-2005 timeframe:

- active Final Approach Spacing Tool (aFAST) – Will improve upon the pFAST capability by adding the benefits of vector and speed data to improve the safe sequencing of aircraft on final approach.
- Advanced Vortex Spacing System (AVOSS) – A ground-based system that will dynamically provide safe spacing for aircraft in trail to a single runway.
- En Route Descent Advisor (EDA) – An en route decision support system that will aid the efficient control of en route and arrival traffic in transition airspace.
- Expedite Departure Path (EDP) – A decision support system that will assist controllers in managing unrestricted climbs into the en route system and safely merging other departure operations involving multiple aircraft.

Free Flight Phase 2 is currently working with the Joint Resources Council (JRC) to determine the appropriate funding profile for the program. Once that is established, more information will be available regarding the numbers and locations of sites to be implemented for each of the selected capabilities.

Safe Flight 21

Safe Flight 21 is a high-priority three-year activity designed to demonstrate and validate, in a real-world environment, the capabilities of advanced surveillance systems and air traffic procedures associated with free flight. The program uses Automatic Dependent Surveillance-Broadcast (ADS-B) and Traffic Information Services-Broadcast (TIS-B) as enabling technologies. With the collaboration of the aviation industry, the program has targeted nine communications, navigation, and surveillance operational enhancements of high potential to deploy in strategically selected locations. The results will provide a basis for future FAA policies and decisions regarding the selected technologies and procedures.

The FAA is working with air carriers in the Bethel, Alaska region through the "Capstone" initiative, to improve aviation safety while offering greater efficiencies to operators. The initiative will concentrate on the evaluation and implementation of operational enhancements in the region to improve the quality of weather and other information to pilots, provide affordable means to avoid the dangers of Controlled Flight Into Terrain (CFIT), and enhance pilots' ability to see and avoid adjacent traffic.

Another Safe Flight 21 initiative pools the resources of the FAA with the Cargo Airline Association (CAA) to conduct an operational evaluation of ADS-B capabilities in the Ohio Valley. The CAA began equipping its aircraft in late 1998 in preparation for in-flight evaluations of the air-air use of promising see-and-avoid technologies. Subsequent operational evaluations have resulted in the addition of operational enhancements to the original systems and capabilities.

1.6.3 Ongoing Safety and Security Initiatives

Safer Skies

In 1997 the President's Commission recommended the FAA launch a concentrated effort to reduce accidents dramatically over the next decade. The National Civil Aviation Review Commission (NCARC) concurred and further advised that the FAA work with industry on safety data analysis. Later that year, Administrator Garvey committed the agency to developing a plan to focus its resources on the accident prevention steps that hold the greatest potential. "Safer Skies" was the result. The essence of the initiative was to look at available accident and incident data and develop intervention strategies to mitigate the major causes of fatal accidents—a pointed, pragmatic research emphasis.

The new initiative, "Safer Skies—A Focused Agenda," was announced on April 14, 1998. Under this agenda, the FAA pledged to review available data on all major causes of aviation accidents

and, where necessary, refocus its safety priorities. Just a year and a day later, Administrator Garvey was able to report to a conference of industrial participants that 230 aircraft of 13 types were collecting Flight Operations Quality Assurance (FOQA) data and 350 additional aircraft were being equipped for FOQA.

Safer Skies continues to focus on commercial and general aviation accident prevention. Accomplishments to date include:

- Published 23 final rule Advisory Directives for the inspection of high- and priority low-pressure turbine engine components capable of preventing uncontained engine failures.
- Published a final rule to reduce Controlled Flight into Terrain (CFIT) accidents by requiring Terrain Awareness and Warning System (TAWS) equipment in all air carrier aircraft.
- Published the FOQA Notice of Proposed Rulemaking and prepared related Advisory Circulars and Handbook Bulletins.
- Instituted Air Carrier programs to train pilots in the use of comprehensive Standard Operating Procedures; incorporated a CFIT training aid as part of these training programs.
- Provided special CFIT training for air traffic controllers through publication of an Air Traffic Bulletin.
- Conducted checks to ensure that by-products associated with ground-based radar provide terrain avoidance protection.
- Developed plans, procedures, and techniques for flying stabilized approaches and producing the full range of precision instrument approaches.
- Issued policy for Required Navigation Performance (RNP) procedures and operational approvals.

Research is making a valuable, direct contribution in the form of developing low cost analytical tools for FOQA and Aviation Safety Program (ASAP) data, developing synthetic vision technology, and developing data link capabilities and systems. Additional interventions are being developed and will be implemented in the near future.

Aging Aircraft Systems

In 1997, the White House Commission on Aviation Safety and Security requested that the FAA institute regulatory and research programs to address aging nonstructural systems issues not at that time covered by the FAA's Aging Aircraft Program and Aging Aircraft Research Program. In response, the FAA released the Aging Transport Nonstructural Systems Plan (ATNSP) in October 1998. The initial intent of the ATNSP is to evaluate the effectiveness of current practices for design, maintenance, and repair in preventing or mitigating aircraft accidents precipitated by degradation or damage to aircraft nonstructural systems. Based on these evaluations, recommendations will be made for changes to the current processes under which systems are designed, maintained, and repaired.

The ATNSP calls for the FAA to add the following five specific tasks to the Aging Aircraft Research Program:

- To assess the degradation of airplane electric wiring and determine the point at which wiring degradation may present a hazard to safe flight.
- To establish the condition of aging aircraft wiring components and validate the adequacy of visual inspection.
- To develop nondestructive testing tools for inspection and testing of wiring systems.
- To develop an arc-fault circuit interrupter for transport aircraft.
- To perform destructive testing of flight control linkages.

Current research initiatives related to aging systems include: the development of an aging systems test and validation infrastructure; an assessment of the condition of aging wire components; an assessment of the adequacy of visual inspection; the development of wire inspection and testing technologies and techniques; and the development, test, and validation of aircraft arc-fault circuit breakers.

One of the program's first initiatives is the development of a systems test and validation capability at Sandia National Labs. This effort will draw upon the existing infrastructure of the FAA Aging Aircraft Nondestructive Inspection Validation

Center (AANC), including its three retired aircraft: a Boeing 737, a McDonnell Douglas DC-9, and a 1971 Boeing 747 with over 100,000 hours of service. The B-747, recently added to the FAA AANC, will be subjected to an intensive visual inspection of its electrical and mechanical systems. Selected electrical and mechanical systems on both the B-747 and DC-9 testbed aircraft will also be baselined using state-of-the-art test and inspection techniques. In addition to yielding valuable insight regarding the state of aged aircraft systems, this initiative will provide two testbed aircraft for the test and validation of current and emerging maintenance technologies and procedures.

The FAA and U.S. Air Force Office of Productivity, Reliability, Availability, and Maintainability (PRAM) jointly sponsored a short-term effort to enhance an automated wire test system. The state-of-the-art equipment will be used to help baseline AANC's test aircraft and test articles and to establish a benchmark for future testing equipment developed and tested in aging systems.

The FAA is working with the U.S. Navy's Office of Naval Research and the Naval Air System Command, Aircraft Division (NAVAIR) to develop aircraft arc-fault circuit breakers. An arc-fault is the undesired, momentary discharge of current (a spark) from a conductor. This type of short circuit is particularly destructive because the high temperature of the sparks it generates, and the absence of current excursions, might trip standard thermal circuit breakers typically used on aircraft. Arc-fault circuit interrupter technology has the potential to mitigate the consequence of wire failure without requiring the redesign of aircraft circuitry. The execution plan for this initiative calls for a device sensitive to arc faulting while still meeting all performance and design specification of existing circuit breakers.

Fielding of Security Equipment

Since the early 1990s, the FAA Aviation Security R&D Program has been highly responsive to congressional mandates to expedite the passage from research to the field of less costly, more reliable aviation security technologies. To date, the FAA Security Equipment Integrated Product Team has advanced the protection of the traveling public by deploying over 531 explosive trace detection devices to U.S. airports. The team already has completed 92 installations of one vendor's advanced Explosives Detection System (EDS) installations. Another competitor's EDS was certified in October 1998. The FAA will begin phasing in new a technology at Checkpoints called Threat Image Projection (TIP). The technology applied to X-ray systems inserts fictional threats such as gun, knives, and explosives devices into the images as they are presented to screeners. This strategy increases the awareness of the screeners and allows for the evaluation of their performance. The agency works closely with its industry partners to encourage constructive competition, to decrease the costs, and to increase the reliable capabilities of field-worthy systems.

Various types of systems are in, or are nearing, prototype stage to mitigate the security threats involving the full range of aviation facilities and situations. Examples include checked baggage screening technologies, checkpoint technologies, cargo screening technologies, and systems designed for small volume vs. large volume airports and other facilities. While automated solutions are preferred, standards and training programs are being developed to screen and train the airport and airline employee operators of systems.

1.7 Cooperative Research

1.7.1 FAA/NASA Collaborative Research

FAA/NASA Safety Program

Technology has always held the key to maintaining commercial aviation's impressive safety record, but in an increasingly complex world, the search for technologies requires increasing discipline. The wrong technologies, employed in the wrong ways, could introduce more problems than they solve.

In August 2000, NASA and FAA signed the "FAA-NASA Integrated Safety Research Plan." This plan is significant in that it builds on existing relationships between the two agencies to accomplish the following important objectives:

- Builds upon the national plan for research described in the *National Research and Development Plan for Aviation Safety, Security, Efficiency and Environmental Compatibility.*
- Introduces the ability to analyze the combined research portfolios in a simple, clear format, including making needed programmatic adjustments.
- Describes how NASA and FAA will achieve ongoing communication and coordination with respect to safety research in pursuit of common safety goals.
- Establishes a strategy for the FAA and NASA to make complementary, coordinated research investment decisions.

The foundation for this plan was established on October 9, 1998, when FAA Administrator Jane Garvey and NASA Administrator Daniel Goldin signed a formal agreement to articulate and achieve specific joint goals enabling the NAS to meet its future challenges. The agencies have worked together through Memoranda of Understanding on specific topics such as human factors, aging aircraft, aircraft icing, airworthiness of new classes of aircraft, crashworthiness, energy efficiency, and noise reduction. Since 1980, each of the agencies has provided members to a common R&D coordinating committee. With the 1998 agreement, that committee was restructured into a new "FAA/NASA Executive Committee" and charged with the coordination of all joint R&D efforts.

According to the 1998 agreement, the role of NASA in our national aviation R&D is to perform research, development, verification and transfer activities upon technologies with advanced potential for long and short-term NAS improvement. The FAA's complementary R&D role is to prepare these identified technologies for introduction into the NAS. The FAA sponsors research to develop and field regulations and procedures to control the operation of new systems, as well as research to refine the systems themselves. The results of FAA R&D have provided operational benefits in direct support of the agency's key goals in safety, security, efficiency, and environmental compatibility.

The NSTC National R&D Plan provides an "Aviation Safety Roadmap" of the inter-agency plan to achieve the national goal for safety. The initiative encompasses the following research issues:

- **Accident Precursor Identification and Safety Risk Management** — Accidents rarely have a single cause. The detection and mitigation of anomalous operating conditions can actually avoid many accidents. Jointly, the FAA and NASA are working to develop the Aviation Performance Measuring System (APMS) to help all segments of the aviation community draw safety improvement from normally collected data.
- **Accident prevention** — Together with DOD, the FAA and NASA are working to improve the effectiveness of their long-term commitment to the Aging Aircraft Program. FAA is working closely with industry in aviation safety areas including the improvement of propulsion and fuel systems, the prevention of aircraft catastrophic failure, the elimination or containment of in-flight fires, and the creation of safer airport materials and systems. NASA research is developing new technologies to afford better visibility to pilots and flight crews experiencing adverse conditions, to improve the overall health of pilots and crews, and to allow pilots to regain control of their aircraft when engines or systems fail in flight.
- **Accident Mitigation** — When aviation accidents do occur, their effects can be lessened through attention to factors such as aircraft crashworthiness, occupant protection, fire safety, evacuation equipment and procedures, and airport emergency services. The FAA is conducting detailed and innovative aeromedical research to improve the chances that more passengers and crew members will survive aviation accidents. The agency also works to improve airport systems to provide better materials, methods and equipment to increase survival rates. NASA partners with the FAA on research to improve the structural crashworthiness and the fire resistance of aircraft and fuels.

Integrated Plan for Air Traffic Management for Research and Technology Development

In 1995, the FAA and NASA formed the FAA/NASA Interagency Air Traffic Management

(ATM) Integrated Product Team (IAIPT) to coordinate research into air traffic control technologies and the development of procedures for their safe and efficient use. This relationship was broadened three years later through an agreement enlisting the cooperation of the Department of Defense.

The IAIPT is comprised of the major stakeholders in the planning, execution, and outcome of ATM R&D programs, throughout the FAA and NASA. The IAIPT is structured as follows to facilitate communications and the resolution of issues:

- Co-Leads, who formulate R&D policy and goals.
- The Interagency Integrated Management Team (IAIMT), which targets R&D outputs to the needs of customers and stakeholders.
- Area Work Teams (AWT), which execute research activities in these research areas:
  - System/Cross-Cutting — System-wide initiatives, including the initial definition of concepts and assessment methodologies and demonstrations of cross-domain system(s) integration (e.g., en route, terminal, and surface decision support systems).
  - *Traffic Flow Management* — Strategic resource allocation and flow management.
  - *Surface* — Operations on an airport's surface.
  - *Terminal* — Operations in airspace surrounding one or more closely spaced airports where a TRACON or a comparable military facility provides services.
  - *En Route* —Operations in airspace between airports where an ARTCC provides services, and transition airspace between the en route and terminal environments.
  - *Oceanic* — Operations in airspace over international waters where an oceanic ARTCC provides services.

IAIPT receives guidance from the FAA R,E&D Advisory Committee (REDAC), its Subcommittee on Air Traffic Services, the NASA Aeronautics and Space Transportation Technology Advisory Committee, and the NASA Air Traffic Management Research and Development Executive Steering Committee. The IAIPT also maintains collaborative partnerships with federally-funded research and development centers, industry, academia, Department of Defense, EUROCONTROL, the Center of Excellence in ATM and Operations Research, the National Weather Service, and research contractors.

The IAIPT periodically reports to the FAA Associate Administrator for Research and Acquisitions and the NASA Associate Administrator for Aerospace Technology through the FAA/NASA Coordinating Committee. Specific program direction and control comes through internal program management mechanisms in both agencies.

IAIPT research is accomplished at the following research facilities: FAA William J. Hughes Technical Center, NASA Ames Research Center, NASA Langley Research Center, MITRE CAASD, MIT Lincoln Laboratory, Volpe National Transportation Systems Center, and NASA North Texas Research Station. Joint ATM research is described in Joint Research Project Descriptions (JRPD), as shown in the IAIPT Integrated Plan, available on the Internet at: ftp://www.faa.gov/ara/iaipt.

All of FAA's Free Flight Phases 1 and 2 capabilities have been transitioned from former IAIPT products.

1.7.2 Technology Transfer

Technology Transfer addresses the need for Government-private sector cooperation by enabling companies, institutions of learning, and Federal laboratories to work together to develop innovative technologies and marketable products.

The FAA has tailored its Technology Transfer program to meet the objectives of the Stevenson-Wydler Technology Innovation Act of 1980, the Bayh-Dole Act of 1980, the Federal Technology Transfer Act of 1986, and Executive Orders 12591 and 12618: Facilitating Access to Science and Technology.

Current projects overseen by the Technology Transfer Program Office, at the FAA William J. Hughes Technical Center include:

- Effective use of meteorological measurement and sensing equipment at airports with terrain-induced turbulence and in regions prone to inflight icing.

- Development of a generic model for predicting the transport and validating the dispersal of glycols.
- Industrial validation of an acoustic emissions technology system prototype for use with onboard hazardous materials containers.
- Development and evaluation of internationally applicable alternative user interface display options and requirements for a next generation voice communication system.
- Test and evaluation of an unleaded high octane fuel formulation for general aviation piston engines.
- Measurement of the interaction/interference between a selected set of personal medical electronic devices and the magnetic fields emitted by walk-through metal detectors.

Cooperative Research and Development Agreements (CRDA) have proven highly effective in meeting congressionally mandated technology transfer requirements where little or no funding has specifically been available to meet those needs.

Marketing is a critical component of the FAA Technology Transfer Program. The agency maintains membership in a wide range of professional organizations and on high-visibility committees that include private industry as well as all levels of government participants.

The Technology Transfer Program Office is also responsible for the Small Business Innovation Research (SBIR) program. After eligible small business contractors complete the second phase of the SBIR cycle, the office encourages them to enter into CRDAs with the FAA to strengthen their ability to perform well in Phase III, as well as to attract and negotiate successfully with venture capitalists.

1.7.3 Centers of Excellence

Air Transportation Centers of Excellence (COE) are established through cooperative agreements among academic institutions, their affiliate partners, and the FAA. COEs 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 three to ten years. Thereafter, they are expected to be self-supporting.

Center of Excellence in Airworthiness Assurance

The Center in Airworthiness Assurance was established 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 1997, conducts research in the areas of:

- Maintenance, inspection, and repair
- Crashworthiness
- Propulsion and fuel systems performance
- Safety
- Advanced materials

Funded through contracts and grant awards, this center has a $100M contract cap over the next ten years and is making a $500K per year minimum 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 ten university affiliates and twenty industrial partners. The COE program uses a new funding vehicle blending grant and sole-source contracting authority to award a wide range of contracts. The center's areas of research involvement include traffic management and control, human factors, system performance and assessment measures, safety data analysis, scheduling, workload management and distribution, navigation, communications, data collection and distribution, and aviation economics.

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. The COE also supports the test design and analysis work at the FAA's Pavement Test Facility at the William J. Hughes Technical Center.

1.7.4 International 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 environmental compatibility 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 Naviion 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 decision makers in order to make significant contributions toward international coordination of air traffic services.

The FAA 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.

The FAA is also working with the Joint Aviation Authorities (JAA) and Transport Canada Civil Aviation (TCCA) to encourage international cooperation in identifying and developing technologies needed to support safety regulatory activity. The pilot program, begun in FY2000, is designed to encourage technical cooperation in limited areas through exchange of information. Continued airworthiness and regulatory concerns, exchange of information among the research communities on safety-related research, identifying areas for collaborative research will focus initially on cabin safety, flight deck human factors, and aircraft icing issues.

1.8 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 rulemaking action within five years, or in the initial installation of operational equipment within ten years after the date of the commencement of such project."

The FAA's R&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 $186,589M appropriated for R&D efforts in FY 2001, 26% of these funds are earmarked for long-term research, with the remainder devoted to developmental/near-term efforts. Similarly, the $187,781M FY 2002 congressional budget submission for R&D designates 23% of the total request for long-term research. These percentages are significantly in excess of the congressionally mandated 15% level.

1.9 Permanent FAA Research Facilities

The FAA maintains two permanent, world-renowned research centers, The Civil Aeromedical Institute, located in Oklahoma City, Oklahoma, and the William J. Hughes Technical Center, lo-

cated adjacent to the Atlantic City International Airport in New Jersey.

Civil Aeromedical Institute

The Civil Aeromedical Institute (CAMI) is a unique, internationally recognized aeromedical facility located at the Mike Monroney Aeronautical Center in Oklahoma City, Oklahoma. CAMI maintains a cadre of in-house scientific specialists whose safety research thrusts are all distinctively human-centered and include:

- *Advanced ATC Systems Research* — Using rapid prototyping techniques with advanced real-time ATC simulation capabilities, scientists analyze advanced ATC system designs and their effects on workload and performance, develop metrics of performance and workload, assess the applications of innovative control and design concepts, and identify and evaluate the applications of intelligent systems to enhance aviation safety.
- *Behavioral Stressors Research* — Human factors researchers investigate variables that could compromise safety by impairing both air traffic controller and pilot job performance levels (e.g., shift management, age, fatigue, drug and alcohol-induced impairment, color perception) and assess the effectiveness of policies, procedures, individual coping strategies, and countermeasures to reduce performance decrements and enhance individual performance.
- *Organizational Effectiveness Research* — Through field research, analytic information is developed to measure progress toward achieving agency change goals and for agency guidance on the relative merits of various innovations intended to enhance safety, efficiency, effectiveness, workforce health and satisfaction, and system performance. Relationships between psychological characteristics (e.g., work attitudes, organizational perceptions) and the work environment (e.g., business practices, organizational climate) are explored.
- *Flight Crew Performance Assessment* — General Aviation research emphasizes design of flight deck controls and displays related to emerging technology, development and validation of performance-based criteria for use in certification and regulation, and the successful integration of training devices into existing instructional systems to enhance flight crew performance and reduce accidents and incidents.
- *Selection, Validation, Research, and Team Performance* — Researchers use laboratory and field studies to develop scientific evidence of the job validity of criteria within aviation selection and training systems. Cognitive strategies and processes underlying aviation skill acquisition through training are identified and assessment measures of individual and team performance developed to determine effects of advancing technologies on individual and workteam safety, efficiency, and effectiveness.
- *Aircraft Accident Research* — CAMI scientists maintain comprehensive databases and conduct extensive analyses involving the human factors, medical, physiological, and pathological aspects of aviation mishaps. Preventive measures and proactive interventions that will enhance aviation safety in the next millennium are rigorously investigated.
- *Forensic Toxicology Research* — Impeccable procedural integrity and robust toxicological and biochemical analyses of human samples from fatal aircraft accidents are required in support of the National Transportation Safety Board to ensure continuous safety of the NAS. Scientists evaluate the underlying human basis for mishaps to prevent future tragedies in our transportation systems. State-of-the-art analytical and molecular biological techniques, including DNA analyses, are developed to assist in identifying human causes or influences associated with aviation fatalities.
- *Biodynamics Research* — When failures do arise in aviation, occupant survival may depend directly upon the design of the seating and restraint systems in the aircraft. Evaluating the design of these systems, and ensuring their protective characteristics, requires both scientific and engineering talents.
- *Cabin Safety Research* — The ability to survive following aircraft-related emergencies

depends upon the systems, structures and procedures that are developed and investigated in CAMI's aircraft evacuation facility where researchers conduct occupant evacuations from current aircraft configurations and develop evacuation research for larger, more complex aerospace vehicles of the future.

- *Aviation Environment Safety Research* — Breathing and oxygen delivery systems for all aircraft occupants in normal and emergency situations are investigated. Threats to visual integrity and pilot performance from intense light emitters and ground-based lasers are defined. Improved measures of galactic cosmic radiation levels at various altitudes are developed by CAMI scientists to ensure that those who work and travel in the aviation system are not at a disproportionate risk for health problems from radiation exposures.

William J. Hughes Technical Center

The FAA William J. Hughes Technical Center (WJHTC) is one of the world's leading engineering, research, development, and testing facilities for nearly every aspect of aviation. Representative areas of involvement of this diverse and extensive facility include:

- *NAS Modernization* — The center uses currently fielded and newly developed systems to perform R&D encompassing every aspect of air traffic operations. Its laboratories contain current and advanced radar display systems capable of intricate simulations for the testing, development, and evaluation of both air and ground traffic procedures and en route operational concepts.
- *Services and Operations* — Every NAS service provided by the FAA is either on-site or accessible at the center. The Integration Interoperability Facility (I2F) allows staff to simulate actual operating conditions, including adverse weather, to test and evaluate systems without impacting air traffic operations or ARTCC site personnel.
- *Air Traffic Management* — The powerful capability of the Traffic Flow Management Laboratory allows for a "fast-tracked" development approach ideal for meeting escalating NAS modernization needs without extensive, traditional prototyping.
- *Human Factors* — The multiple "what if" capabilities of the Research, Development and Human Factors Laboratory apply principles derived from the behavioral sciences to plan and test the deployment of next generation NAS capabilities such as displays and workstations. As NAS modernization will increasingly rely on the automation of suitable tasks, improved and reliable computer-human interfaces are critical to the avoidance or mitigation of system-induced operator errors.
- *Navigation and Surveillance* — WJHTC scientists conduct flight tests with actual GPS signals and prototype ground stations to maximize GPS accuracy in connection with existing and projected communications capabilities. Similarly, they perform tests and evaluations of Automatic Dependent Surveillance — Broadcast capabilities to provide reliable aircraft position data to airborne and ground-based users.
- *Communications* — Simulation and live research is being performed to improve the reliability of both voice and digital data (data link) transmission.
- *Terminal Areas* — The improvement of airports' capacity is a difficult problem facing NAS modernization. Center staff work with simulation tools and test environments to refine proposed changes in takeoff and landing patterns, improvements in lighting and visual aids, and new procedures.
- *Security* — The Aviation Security Laboratory conducts extensive simulated and live testing in the areas of explosives and weapons detection, aircraft hardening, human factors, and security technology integration to provide the civil aviation system with maximum security while minimizing the adverse impacts on airline and airport operation.
- *Safety* — The Airport and Aircraft Safety R&D Division conducts research in continued airworthiness using some unique, world-class facilities. Fire and accident testing on aircraft, components, and engines requires very specialized facilities and experienced people. The center's facilities in these and ar-

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