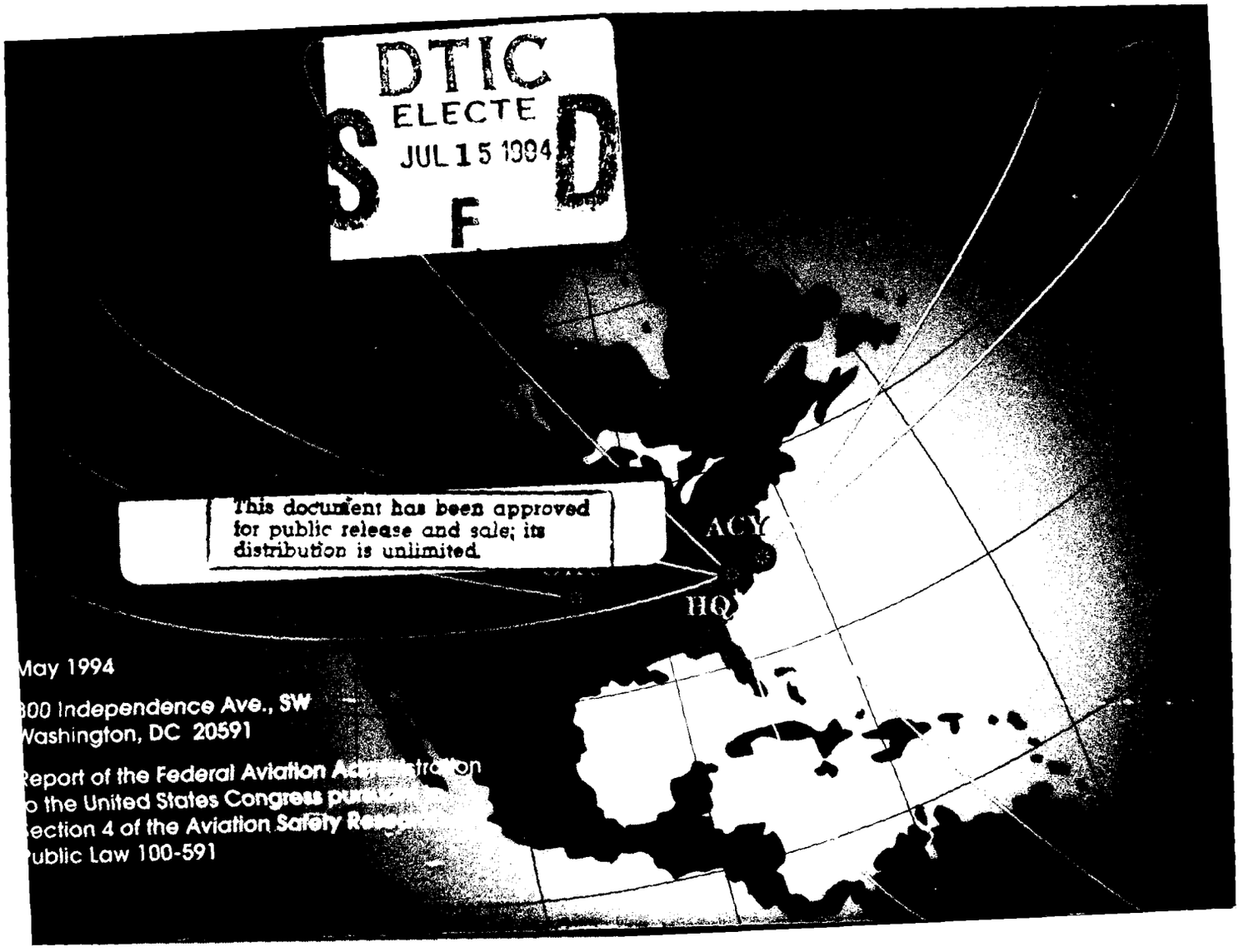


May 1994

800 Independence Ave., SW
Washington, DC 20591

Report of the Federal Aviation Administration
to the United States Congress pursuant to
Section 4 of the Aviation Safety Research Act
Public Law 100-591

U.S. Department
of Transportation
Federal Aviation
Administration

Office of the Administrator

800 Independence Ave., S.W.
Washington, D.C. 20591

The last few years have clearly demonstrated the rapid changes and growing challenges that the aviation industry and the Federal Aviation Administration (FAA) must face. To meet these challenges, the FAA cannot proceed with a "business as usual" attitude. We must develop innovative, cost-effective solutions to problems in the National Airspace System (NAS) that meet the aviation industry's needs in a timely manner. Also, we must take a total system approach when developing new systems so that we do not create a new problem in our attempt to solve an existing one.

The 1994 FAA Plan for Research, Engineering and Development (R,E&D) describes the FAA's efforts to develop technologies that address both current and projected NAS issues so that our Nation can maintain a competitive, robust aviation infrastructure. Continuing with the R,E&D Plan's evolution as a living document, this year the FAA will refine the R,E&D review process that was introduced last year. This new process ensures that projects selected for funding address the agency's top priorities. More importantly, the new process strengthens the R,E&D Plan's system engineering approach so that new systems developed for future field implementation will have a smooth transition phase and function as an integrated whole within the NAS.

It is important to remember that this plan is not meant to function in a vacuum or as a rigid, inflexible blueprint for the FAA to follow. Just as new systems must be integrated to achieve a total systems approach, the R,E&D Plan must be integrated with other FAA plans to create a system development and implementation pipeline. The Capital Investment Plan and Airport Improvement Program are examples of other plans the FAA uses to implement the new systems, materials, or procedures that satisfactorily complete their development phase in the R,E&D Plan. Also, the R,E&D Plan must be as dynamic as the aviation industry so that the FAA can respond in a timely manner to new requirements from its "customers" in every segment of the aviation community.

We at the FAA are committed to ensuring a successful R,E&D program by fostering a closer partnership with our NAS users and operators while exploiting innovative technologies. In this context, the R,E&D efforts described in this plan contribute to maintaining the global aviation leadership of the United States.

David R. Hinson
Administrator

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# 1.0 OVERVIEW

## 1.1 Introduction To The Research, Engineering and Development (R,E&D) Program

The Federal Aviation Administration (FAA) manages and operates the National Airspace System (NAS), a significant national resource. However, the demands on this system are continuously growing, and changing technologies provide the opportunity to improve system effectiveness and efficiency. To this end, the FAA's R,E&D Program is an investment in the future that will sustain the United States preeminence in aviation throughout the world. Without this investment, the United States leadership would erode. Thus, the importance of aviation to the Nation mandates a comprehensive research, engineering, and development program to ensure both the safety of public air transportation and the fulfillment of national priorities and policy goals.

The contributions of aviation to the Nation's economy cannot be overstated. Aviation and related industries contribute over $600 billion to the United States economy (5.5 percent gross domestic product (GDP)), encompassing over 8 million jobs. Aviation is critical to business travel, tourism, and travel services (a $47.5 billion industry), as well as aircraft components ($24.7 billion), cargo and mail transport, and industrial national and international competitiveness.

Aerospace is by far the largest exporting industry for the United States, with a 1990 industry trade surplus of $27 billion. The United States is currently the recognized world leader in aerospace, aviation, and air traffic control. However, this leadership role cannot be sustained without continued research into new and evolving technologies.

Today, 23 of the country's largest airports are plagued by more than 20,000 hours of delay per year, which is projected to grow to 40 major airports by 2000. Nationally, air traffic delays cost the economy an estimated $6 billion in passenger delays and $3 billion in airline operating costs in 1990. At current trends, these costs will increase 50 percent within 10 years.

Aviation and related industries are also challenged by energy and environmental factors. Currently, 45 percent of air carrier aircraft operating costs are for fuel, a large portion of which is from imported oil. While reducing fuel usage is a priority in terms of energy conservation, it is also an increasingly critical environmental issue, based on recent findings relating to nitrogen oxide emissions at high altitudes. Given the projected increases in aviation activity and stringent environmental standards being proposed in Europe and elsewhere, noise and engine emissions reductions are essential to the national aviation industry's viability.

The FAA must accommodate the increasing demand on limited airport and airspace capacity, deal with crucial airport security issues, and cope with the unforeseen problems of an aging aircraft fleet. These requirements pose unprecedented challenges, which can only be met through a major investment in R,E&D.

In recognizing these challenges, the Aviation Safety Research Act of 1988 requires the FAA to prepare a national aviation research plan describing R,E&D "...to ensure the continued capacity, safety, and efficiency of aviation in the United States, considering emerging technologies and forecasted needs of civil aeronautics, and provide the highest degree of safety in air travel."

## 1.2 National Priorities: Quality Results; Quality Delivery

The FAA R,E&D Plan is focused on an ambitious, but attainable, program that spans eight thrust areas and impacts the five key national priorities: (1) Economic Health and Productivity; (2) Technological Leadership and Competitiveness; (3) Aviation Safety and Security; (4) Fostering Intermodalism; (5) Energy Conservation; and (6) Environmental Protection. A discussion of these national priorities and how they relate to this Plan follows:

### Strengthening Transportation's Role in Supporting the Economy

There is little doubt of aviation's significance to the U.S. economy. With no additional major airports planned in the near term, the FAA must expand the current system's capacity while maintaining its safety and reducing its inefficiencies.

More automated air traffic control systems, higher capacity and more reliable communications, improved surveillance, enhanced detection and weather information dissemination, more flexible navigation and landing systems, and improved human/machine interfaces will provide NAS improvements (e.g., reduced delays and increased system capacity), while keeping pace with technology, and help maintain economic growth.

Research, necessary to accommodate and integrate new technological developments, will also help create markets for industry. With the increase in international competition, Government and industry must continue to expand and modernize our aviation transportation system rapidly, or the United States will likely suffer economic consequences in terms of future risk to jobs and business leadership.

### Advancing U.S. Transportation Technology and Expertise

A primary R,E&D Program goal is to introduce technology advancements into the NAS without impeding aviation services or market mechanisms. Such technology advancements include new types of aircraft, avionics, and flight modes. Research is basic to long–term economic competitiveness since it supports developing enabling technologies at precompetitive stages of the R,E&D process. Only by maintaining the flexibility to integrate new technologies can we ensure that the United States will retain its technological leadership.

Aerospace is key to American technological leadership. Most Government and independent organizations compiling "critical technologies" lists have included technologies essential to the aviation industry, such as propulsion technology, advanced materials, simulation, and automated guidance and control. Examples of FAA research activities to accommodate such advances include satellite navigation and communication systems for traffic over oceans or remote areas; more flexible approach control and landing systems; flight profile optimization techniques; and air traffic models and evaluation tools.

### Supporting the Safety of our Transportation System

The overall goal in this area is to reduce the probability and mitigate the results of accidents and terrorism. Research relating to engine and aircraft design will improve airworthiness and crashworthiness, plus eliminate engine and propulsion system failures, aircraft fires, and aging

aircraft safety concerns. Human factors and aeromedical research projects have been established to assess injury/fatality patterns and to develop measures that reduce the severity of these patterns. Developing the safest, most efficient aircraft systems also will benefit industry by increasing global sales for U.S. products.

Terrorism remains a threat, and attacks on aircraft or airports have always been a means to attract attention. During the Persian Gulf War, scheduled passenger miles on U.S. carriers decreased by over 16 percent internationally and by over 5 percent on domestic flights. To maintain public confidence in the NAS, new security technologies are being developed to ensure the highest criminal activity detection and prevention levels, while minimizing the disruption to air traffic services. Key initiatives include weapons and explosives detection measures, which are critical given the increased use of lightweight, nonmetallic materials in such devices; aircraft hardening techniques to minimize the impact of criminal activity; and airport design measures to minimize the risk and disruption to passengers, aircraft, and aviation services.

## Fostering Intermodalism

Through research areas such as the FAA's Technology Transfer, Joint University, and Small Business Innovation Research programs, information and data gained through the R,E&D effort can be shared with Government agencies and industries involved in other transportation modes. While FAA–sponsored R,E&D programs do not necessarily have direct applications for other modal transportation needs, the technologies developed for specific FAA requirements may have spin-off benefits. For example, airport pavement design theories and data gathered in the research process may benefit future highway construction. A major element in the FAA's pavement research is reducing life-cycle costs by extending pavement life through a more comprehensive design theory and improved construction materials.

FAA R,E&D work in navigation and communication satellites can also have benefits for the automotive, rail, and shipping transportation modes. FAA satellite navigation research will adapt global positioning system (GPS) technology for many uses; however, aircraft precision landing is the most stringent application. Other transportation modes with less stringent requirements may be encouraged to use GPS with confidence or to adapt the FAA's technology for their own needs. For example, the FAA augmentations are being considered for use in the Intelligent Vehicle Highway System. FAA communications research in areas such as data link will dovetail with the navigation effort for potential shipping, truck, and rail industry tracking applications.

## Strengthening the Linkage Between Transportation and Environmental Policy

The importance of aviation to the national economy and the projected increases in air travel provide the stimulus to reduce aviation's environmental impact. Key R,E&D areas include reducing engine emissions and aircraft noise. More efficient routes, traffic management, and fuel efficient engines all contribute to reducing emissions into the environment. Improved computer tools to systematically assess environmental effects will lead to better decisions on mitigating the impacts of agency actions.

Research is required to identify new engine designs that reduce emissions and thus counteract the potential impact future standards will have on U.S. manufacturers. The aviation community recommends developing engine/airframe technology that is 4 to 6 decibels quieter than Stage 3

aircraft. Both domestic and international requirements dictate R,E&D for establishing stricter standards that will allow the United States to manufacture engines with reduced emissions and noise while maintaining its world leadership in a competitive market. In addition, developing more cost-effective environmental certification procedures will enhance the aviation industry's economic well-being as well as being fundamental to fulfilling our environmental responsibilities.

Table 1 provides a synopsis of R,E&D programs contained in this plan, their benefits to users, and the national priorities to which they relate:

**Table 1. Impact of R,E&D Programs on National Priorities**

| Program Area | Feature | User Benefits | Principal National Priorities |
|---|---|---|---|
| Air Traffic Management System | Ability to handle increased traffic | Reduce operating costs | Strengthening Transportation's Role in Supporting the Economy |
| | | Reduce flight delays | |
| | | Accommodate requested routes | |
| Oceanic Air Traffic Automation | Ability to handle increased traffic | Reduce operating costs | Strengthening Transportation's Role in Supporting the Economy |
| | | Reduce flight delays | |
| | | Accommodate requested routes | |
| Terminal ATC Automation | Ability to improve aircraft arrival capacities | Reduce operating costs | Strengthening Transportation's Role in Supporting the Economy |
| | | Reduce flight delays | |
| Airport Surface Traffic Automation | Ability to prevent runway accidents/incidents | Improve safety on airport surface | Supporting the Safety of Our Transportation System and Strengthening Transportation's Role in Supporting the Economy |
| Aviation System Capacity Planning | Ability to provide short–term capacity improvements | Reduce impact of projected traffic bottlenecks | Strengthening Transportation's Role in Supporting the Economy |
| Traffic Alert and Collision Avoidance System | Ability to reduce chance for midair collision | Improve safety in air | Supporting the Safety of Our Transportation System and Advancing U.S. Transportation Technology & Expertise |
| National Simulation Capability | Ability to validate ideas | Reduce development risk | Advancing U.S. Transportation Technology & Expertise and Strengthening Transportation's Role in Supporting the Economy |
| | Ability to engage in applied research | Improve human factors | |
| Aeronautical Data Link | Ability to use data link capability fully | Reduce miscommunication between pilot and controller | Supporting the Safety of Our Transportation System and Strengthening Transportation's Role in Supporting the Economy |
| | | Reduce congestion in communication links | |
| Airway Facilities Future Technology | Ability to define advance technology for future operations and management | Reduce operation costs | Supporting the Safety of Our Transportation System and Advancing U.S. Transportation Technology & Expertise |
| | | Increase technology injection and improve NAS integrity | |

**Table 1. Impact of R,E&D Programs on National Priorities**

| Program Area | Feature | User Benefits | Principal National Priorities |
|---|---|---|---|
| Satellite Navigation | Ability to use satellites in aircraft navigation | Reduce operating costs<br>Reduce delays | Strengthening Transportation's Role in Supporting the Economy, Advancing U.S. Transportation Technology & Expertise, and Fostering Intermodalism |
| Terminal Area Surveillance System | Ability to define next generation sensors | Increase terminal area capacity | Supporting the Safety of Our Transportation System |
| Weather Detection/ Dissemination | Ability to reduce impact of weather | Reduce delays due to weather | Strengthening Transportation's Role in Supporting the Economy and Supporting the Safety of Our Transportation System |
| Airport Technology | Ability to improve airport planning and design | Reduce airport and airline operating costs<br>Reduce airport surface accidents | Strengthening Transportation's Role in Supporting the Economy, Supporting the Safety of Our Transportation System, and Fostering Intermodalism |
| Aircraft Systems Fire Safety | Ability to improve fire detection/suppression | Reduce fire-related injuries and deaths | Supporting the Safety of Our Transportation System and Fostering Intermodalism |
| Aircraft Crashworthiness | Ability to increase passenger protection from an accident | Reduce crash-related injuries and deaths | Advancing U.S. Transportation Technology & Expertise and Supporting the Safety of Our Transportation System |
| Propulsion and Fuel Systems | Ability to increase the safety, reliability, and durability of engine installations and fuel systems | Enhance airworthiness<br>Reduce accidents | Advancing U.S. Transportation Technology & Expertise and Supporting the Safety of Our Transportation System |
| Flight Safety/ Atmospheric Hazards Research | Ability to improve methods for dealing with ice, lightning, and other hazards | Reduce accidents<br>Develop criteria for aircraft design | Advancing U.S. Transportation Technology & Expertise and Supporting the Safety of Our Transportation System |
| Aging Aircraft | Ability to detect, control, and prevent aircraft structural weaknesses | Reduce accidents<br>Develop criteria for aircraft design | Supporting the Safety of Our Transportation System and Strengthening Transportation's Role in Supporting the Economy |
| Aircraft Catastrophic Research | Ability to prevent catastrophic aircraft failures | Reduce crash-related injuries and deaths<br>Reduce hull losses | Supporting the Safety of Our Transportation System and Advancing U.S. Transportation Technology & Expertise |
| Threat Detection | Ability to improve weapons and explosives detection | Eliminate civil aviation as a terrorist target<br>Increase public confidence | Supporting the Safety of Our Transportation System and Advancing U.S. Transportation Technology & Expertise |

**Table 1. Impact of R,E&D Programs on National Priorities**

| Program Area | Feature | User Benefits | Principal National Priorities |
|---|---|---|---|
| National Airspace System Security | Ability to evaluate security improvement ideas | Reduce security threats | Supporting the Safety of Our Transportation System |
| Aircraft Hardening | Ability to reduce damage from explosives | Reduce explosive-related injuries and deaths | Supporting the Safety of Our Transportation System and Advancing U.S. Transportation Technology & Expertise |
| | | Reduce hull losses | |
| Human Factors | Ability to reduce human errors or inefficiencies | Reduce human–caused accidents, incidents, and inefficiencies | Supporting the Safety of Our Transportation System and Strengthening Transportation's Role in Supporting the Economy |
| Environment and Energy | Ability to reduce noise and air pollution | Improve air quality | Strengthening the Linkage Between Transportation and the Environmental Policy, and Advancing U.S. Transportation Technology & Expertise |
| | | Reduce aviation noise impacts | |
| Innovative/Cooperative Research | Ability to develop new ideas jointly | Stimulate market productivity | Advancing U.S. Transportation Technology & Expertise and Strengthening Transportation's Role in Supporting the Economy |
| | | Increase technology injection | |

## 1.3 Goals

The NAS goals listed in both the Capital Investment Plan (CIP) and the R,E&D Plan were derived from the R,E&D goals listed in previous R,E&D Plan editions. The FAA is in the process of reviewing and refining these goals to ensure that they are measurable and attainable. For this reason, the NAS and R,E&D goals listed in the charts below are an interim step in the goal development process. When this review is complete, these interim goals will be modified. The charts below depict the NAS goals and R,E&D–specific goals.

**NAS Goals Supported by the R,E&D Plan**

- Reduce the civil aviation fatality rate from all causes by 10 percent by 2000

  For 1990, 1991, and 1992 the respective fatality rates were 14.5, 16.4, and 15.9 fatalities per million departures.

- Reduce the number of accidents attributable to weather by 20 percent by 2000

  For 1990 and 1991 the respective accident and incident rates attributable to weather were 15.9 and 15.2 per million departures.

- Reduce runway incursions by 80 percent by 2000

  For 1990, 1991, and 1992 the respective runway incursion rates showed a decrease from 25.3 to 21.3 to 20.3 incursions per million departures from airports with FAA towers.

- Ensure that system capacity will meet demand

- Reduce weather–related delays by 15 percent by 2005

  For 1990, 1991, and 1992 the respective delay rates for all the delays of 15 minutes or more were 6,647, 5,006, and 4,784 delays per million departures. These delays are caused by a combination of factors, including capacity reduction due to weather.

- Accommodate a projected doubling of oceanic air traffic demand by 2010

  Total oceanic traffic volume in 1990, 1991, and 1992 amounted to 840,000, 853,000, and 862,000, respectively. With a projected growth rate of five percent per year, oceanic traffic is one of the fastest growing areas in air transportation demand.

- Provide more user–preferred routes and altitudes to minimize aircraft operating costs

  The current air traffic system in the oceanic regions consists of a number of fixed tracks and step–climb procedures. Oceanic flights in the Pacific currently use a flexible track procedure, which allows aircraft to fly wind–favored tracks, determined by United States planners on a daily basis. Depending on oceanic traffic volume and congestion, current oceanic procedures allow aircraft step–climbs to reach a more favorable altitude.

**R,E&D–Specific Goals**

- Reduce the costs of pavement expenditure by at least 10 percent by 2010

  Currently over $2 billion is spent each year in pavement design, rehabilitation, construction, repairs, and maintenance.

- Develop advanced aircraft fire safety and crashworthiness technologies by 2005

  During the 15–year period from 1975–1990, there have been over 1,200 fatalities in impact-survivable accidents. Forty percent of these fatalities were attributed to fire.

- Develop advanced technologies that increase assurance of aging and in–service aircraft structural integrity and minimize the potential for aircraft catastrophic failure by 2001

  From 1981-1992, there were 16 accidents and incidents resulting from catastrophic or structural failures involving contemporary and aged aircraft.

- Reduce accidents and incident rates attributable to controller, flightcrew, and maintenance crew human error

  For 1990 and 1991, the respective accident rates attributable to human factors decreased from 60.2 to 58.3 per million departures.

- Field a wide–area differential global positioning system (GPS) to provide satellite–based navigation for all flight phases down to Category I precision approach minima by 1998

  In 1993, the FAA approved the GPS overlay program for 5,000 non-precision approaches at 45 percent of airports (approximately 2,500 of the 5,545 public use airports). Having satisfied the original goal for non-precision approaches, this goal has been updated to include GPS for precision approaches.

- Anticipate new threats and develop and implement new security philosophies, technologies, and systems that operate effectively with minimal interference to passengers and carriers.

## 1.4 R,E&D Initiatives and Accomplishments

The table below is a mapping of goals to R,E&D initiatives and accomplishments. The R,E&D initiatives column outlines broad program areas undertaken by the FAA in support of the corresponding goal. The accomplishments column depicts some of the recent strides made toward achieving the corresponding goal.

**NAS Goals Supported by the R,E&D Plan**

| Goal | R,E&D Initiatives | Accomplishments |
|---|---|---|
| Reduce the civil aviation fatality rate from all causes by 10 percent by 2000 | • Two complementary focuses<br>– reduce accident rate<br>– increase survivability of accidents<br>• Specific programs address<br>– safer aircraft flight operations<br>– improved delivery of weather information to pilots and controllers<br>– advanced collision avoidance technology<br>– improved human factors<br>– elimination of catastrophic failures | • Developed the Traffic Alert and Collision Avoidance System (TCAS) which will be installed on all airlines operating in the United States<br>• Validated innovative, deicing protection technologies and certification techniques |
| Reduce the number of accidents attributable to weather by 20 percent by 2000 | • Basic and applied weather research to<br>– improve forecasts<br>– provide real–time warning<br>– develop airborne sensors<br>– develop an airborne windshear evaluation and certification system | • Established multiagency program to provide real–time weather information to pilots and controllers<br>• Demonstrated improved thunderstorm forecasting capability<br>• Completed ground testing of airborne humidity sensor<br>• Completed flight experiments of windshear detection system |
| Reduce runway incursions by 80 percent by 2000 | • The airport surface traffic automation program includes<br>– surveillance sensor integration<br>– aural and visual controller warnings<br>– electronically controlled airfield lights | • Completed testing of airport movement area safety system (AMASS) at San Francisco International airport<br>• Successfully demonstrated automatically controlled runway status light system at Boston's Logan International Airport<br>• Developed standards for stop bar system for controlling aircraft movement in low visibilities |

**NAS Goals Supported by the R,E&D Plan**

| Goal | R,E&D Initiatives | Accomplishments |
|---|---|---|
| Ensure that system capacity will meet demand | • Broad R,E&D thrusts include<br>– automated flow management<br>– ATC automation systems and controller aids<br>– improved information and digital communication systems<br>– improved airport pavements<br>– vertical flight in short–haul transportation system | • Began implementation of automated demand resolution functions<br>• Completed instrument approach procedures for triple parallel runways at 5,000 feet apart<br>• Predeparture clearance procedures now operat[illegible]at 31 airports<br>• Demonstra[illegible]gital automated terminal information system (ATIS) at three airports<br>• Began field development of automated Center–TRACON automation system (CTAS)<br>• Completed design of pavement testing machines |
| Reduce weather–related delays by 15 percent by 2005 | • Capacity improvements under instrument meteorological conditions (IMC)<br>– automated flow management<br>– improved information and communication systems<br>• Basic and applied weather research to<br>– improve forecasts<br>– provide real–time warning<br>– develop airborne sensors | • Began implementation of automated demand resolution functions<br>• Converging runway display aid (CRDA) field implementation at St. Louis<br>• Developing programs to provide real–time weather information to pilots and controllers<br>• Completed ground testing of airborne humidity sensor |

**NAS Goals Supported by the R,E&D Plan**

| Goal | R,E&D Initiatives | Accomplishments |
|---|---|---|
| Accommodate a projected doubling of oceanic air traffic demand by 2010 and<br>Provide more user–preferred routes and altitudes to minimize aircraft operating costs | • Develop satellite–based, direct, two–way (voice & data) communication capability<br>• Develop in–flight rerouting capability to optimize routes<br>• Reduce oceanic separation standards while enhancing safety<br>• Develop automatic transmission of aircraft position to ATC via data link<br>• Develop digital communication system<br>• Develop oceanic track display system<br>• Develop oceanic aircraft conflict resolution capability | • Completed avionics certification standards for supplemental global positioning system use over the ocean<br>• Delivered testbed for digital voice communications<br>• Provided regulatory and implementation materials in support of 1,000 feet vertical aircraft separation standard in the North Atlantic<br>• Developed prototype two–way data communications systems for ATC clearances<br>• Developed traffic management display system<br>• Developed flexible track generation and traffic advisory capabilities in the Central Pacific |

**R,E&D-Specific Goals**

| Goal | R,E&D Initiatives | Accomplishments |
|---|---|---|
| Reduce the costs of pavement expenditure by at least 10 percent by 2010 | • The pavement initiatives include:<br>– pavement design and evaluation<br>– pavement materials and construction<br>– pavement maintenance and repairs | • Developed a comprehensive long and short term pavement research plan<br>• Completed instrumentation installation at the new Denver airport for pavement evaluation<br>• Completed development of layered elastic theory for pavement design<br>• Completed design specification for national pavement test machine |
| Develop advanced aircraft fire safety and crashworthiness technologies by 2005 | • Aircraft safety and crashworthiness initiatives include:<br>– ultra fire resistant aircraft cabin<br>– improved aircraft structures/materials<br>– improved occupant protection/ evacuation | • Completed fire suppression and containment tests, including a new technology water spray system<br>• Completed fuselage fire-hardening tests<br>• Developed mechanical property test methods for composite aircraft structures |
| Develop advanced technologies that increase assurance of aging and in–service aircraft structural integrity and minimize the potential for aircraft catastrophic failure by 2001 | • Aircraft structural technology research addressing:<br>– aging aircraft structural design, improved maintenance and inspection and performance analysis<br>– catastrophic failure prevention relating to aircraft airframes and all aircraft systems | • Developed criteria for estimating residual strength of aging aircraft structural components<br>• Developed aging aircraft training material for inspectors and advisory information for industry<br>• Developed prototype systems for non-destructive inspections<br>• Developed risk analysis assessments for in-service aircraft. |
| Reduce accident and incident rates attributable to controller, flightcrew, and maintenance crew human error | • Specific human factors technologies addressing<br>– aircraft flight deck<br>– air traffic control (ATC)<br>– aircraft maintenance<br>– airway facilities<br>– flight deck/ATC integration | • Completed prototype flight deck information management system<br>• Advisory circular on controlled in–place crew rest<br>• Developed prototype intelligent tutoring systems for maintenance specialists |

**R,E&D-Specific Goals**

| Goal | R,E&D Initiatives | Accomplishments |
|---|---|---|
| Field a wide–area differential global positioning system (GPS) to provide satellite–based navigation for all flight phases down to Category I precision approach minima by 1998 | • Global Navigation Satellite System (GNSS) research program – national and international | • Completed avionics certification standards<br>• Approved procedures for 5,000 certified global positioning system non–precision approaches at 2,500 U.S. airports |
| Anticipate new threats and implement new security philosophies, technologies, and systems that operate effectively with minimal interference to passengers and carriers | • Several interrelated thrust areas include advances in:<br>– explosives detection<br>– weapons detection<br>– airport security<br>– security systems integration<br>– aircraft hardening<br>• Cooperative efforts with other U.S. agencies as well as several international working agreements | • Conducted vulnerability assessment of FAA facilities<br>• Developed prototype weapons and explosive detection technology<br>• Deployed dual–sensor nuclear and X–ray technology systems for explosive detection at international gateway airports<br>• Demonstrated feasibility of explosive resistant luggage container |

## 1.5 Planning For The Future Aviation System

The 21st century aviation system will have less noise, fewer fatal accidents, fewer acts of terrorism, and reduced passenger delays. The future system will be planned to accommodate a broad user spectrum that includes single engine general aviation aircraft, business aircraft, helicopters, commercial aircraft, and military aircraft of all types. It will also be able to accommodate new generation designs such as tiltrotor vehicles, supersonic, and possibly even hypersonic aircraft.

The aviation system will be international in scope. The changes that are taking place around the world and the rapid increases in the demand for aviation services worldwide, all underscore that we cannot operate independently. The future system will be designed by sharing key technologies with other aviation authorities.

System development will be evolutionary. While it is tempting to design on a "clean sheet of paper" and to propose radical changes, the reality is that changes will evolve systematically.

The Secretary of Transportation's comprehensive policy vividly describes the Nation's transportation infrastructure needs. The FAA's Strategic Plan provides the long–term goals and objectives that the agency is working toward. The R,E&D Program will be used to determine which systems and technologies should be pursued to accomplish these goals and objectives. As R,E&D programs near completion, they may begin a transition stage to the Capital Investment Plan (CIP). The CIP provides the framework for investing in the facilities and equipment needed to improve the NAS.

The FAA has documented a description of the future air traffic management (ATM) system. The description and technical basis for this vision appear in the Administrator's Operational and Strategic Plans.

The vision has broad support from the R,E&D Advisory Committee, users, industry, and the international community through the International Civil Aviation Organization. However, to bring the vision to operational reality in a reasonable time requires a substantive and aggressive R,E&D Program. Among the vision's elements are:

- Satellite communication technology for air/ground communications over oceans and sparsely populated areas.

- Satellite navigation systems for aviation (and all transportation) over oceans, in less developed parts of the world, and in providing high quality approach guidance to any runway end anywhere in the world.

- Air traffic control (ATC) digital communications, or data link, to increase safety by reducing misunderstood communications, and, most importantly, in connecting aircraft systems with ATC automation systems.

- Airborne collision avoidance systems, in themselves a major safety tool, that are available to create, in the cockpit, a valuable picture of the traffic situation around the aircraft. Working with the ATC system, such capabilities will lay the basis for a system having greater capacity and enhanced safety.

- Flight management systems, increasingly available in modern transport aircraft, that can facilitate major improvements in working with ATC to create optimal flight profiles.

- Air traffic management and control automation technology that will create major improvements in strategic flow management across the country, providing users more direct routes. Automation in terminal airspace

will significantly increase capacities while reducing controller workload.

- Better air traffic surveillance systems. Mode S Secondary Surveillance Radar, satellite and terrestrially based Automatic Dependent Surveillance, new surface surveillance tools, and fast–scan radar will revolutionize the ability to track an aircraft's position.

- Better ways to acquire and use weather and environmental data are on the horizon. Major strides have been made in windshear detection, gathering winds aloft data, and severe storm forecasts. Reducing the impact of wake vortices, a detriment to airport capacity, is possible.

- Airway Facilities Operation Control Center to improve operational integrity of all fielded systems.

Additionally, the FAA is pursuing a vision to enhance safety and security for aircraft occupants. Elements include:

- Materials that further protect the fuselage and cabin interior from burnthrough.

- Water spray systems for fire protection inside the cabin.

- In–flight smoke venting systems to discharge smoke and noxious fumes prior to landing.

- Expanding technologies to detect explosives carried by passengers, in baggage, or in cargo.

- Aircraft hardening techniques to better contain explosive forces.

- Improved nondestructive inspection techniques to identify fuselage cracks and corrosion.

- Aircraft design materials and construction techniques to enhance long-term airworthiness, improve crashworthiness, and prevent catastrophic failure from all sources.

## 1.6 R,E&D Plan Components

This year's R,E&D Plan describes the FAA's program for achieving the future system vision. It provides the underpinnings of a comprehensive program designed to carry us from the present to the next generation National Airspace System. The Plan contains details to meet the challenges from a dynamic aviation system posed by growing demand, limited capacity, a changing work force, threats to security, and emerging key technologies adaptable to aviation.

To help the reader understand the FAA's integrated R,E&D efforts, the Plan groups this comprehensive program into eight research areas:

- Capacity and Air Traffic Management Technology (Chapter 2).

- Communications, Navigation, and Surveillance (Chapter 3).

- Weather (Chapter 4).

- Airport Technology (Chapter 5).

- Aircraft Safety Technology (Chapter 6).

- System Security Technology (Chapter 7).

- Human Factors and Aviation Medicine (Chapter 8).
- Environment and Energy (Chapter 9).1/

## 1.7 The Imperative

In the final analysis, the FAA must pursue an effective R,E&D Program because the country cannot afford anything less. Transportation, commerce, national defense, and the national welfare demand increased system capacity and security with no reduction in safety levels. These goals can only be achieved and maintained by aggressively pursuing new and better ways to do things. The Plan is a "snapshot" of a continuous process that cannot follow a fully predictable path, but that does have clear vision of where it is headed.

The projects in this Plan are those needed to bring the FAA's vision of the future system to reality in the context of a continuing top–level system engineering process. The Plan has enjoyed contributions from across the spectrum of scientific, operational, and user communities.

These contributions from both inside and outside Government are solicited and greatly appreciated.

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1/ The research areas are comprised of one or more projects that are described in the subsequent chapters of this R,E&D Plan. Each project is identified by a six–digit number. This number ties the project to a research area and correlates it with the FAA budget.

# 2.0 CAPACITY AND AIR TRAFFIC MANAGEMENT TECHNOLOGY

## ATC SYSTEM CAPACITY AND AUTOMATION TECHNOLOGY

A major FAA Research, Engineering and Development (R,E&D) aim is to increase air traffic control (ATC) system capacity. Automating the ATC information gathering process is already advanced, but requires major improvement and augmentation in the supporting technologies. The need to help controllers/system managers cope successfully and efficiently with increasing numbers of more demanding and capable aircraft requires introducing automation aids for conducting the ATC process itself. While in the past it was possible to spread the work among a variety of separable functions (oceanic, en route, terminal, tower/airport, etc.), efficient operations now demand carefully integrating and managing aircraft flows throughout the operating regime without artificial "walls."

Increasingly, the air traffic management (ATM) process and its supporting elements must be considered a single system. In the following material, the term "air traffic control" refers to the tactical safety separation service that prevents collisions between aircraft and between aircraft and obstructions. "Traffic flow management" refers to the process that allocates traffi flows to scarce capacity resources. "Air traffic management" is the composite process ensuring safe, efficient, and expeditious aircraft movement. Air traffic control and traffic flow management are components of the air traffic management process.

Further ATM system development must be evolutionary. There is often the temptation to design on a "clean sheet of paper" to take full advantage of new capabilities that new technology offers. The reality is that transition and integration are the most difficult institutional problems facing system designers. However, while change in the system will be evolutionary, the design for the future is intended to provide a well–understood, manageable, cost–effective improvement sequence. These improvements will keep pace with user needs for safety, capacity, efficiency, and environmental demands.

## DEVELOPMENT CHALLENGES

The FAA R,E&D efforts needed to achieve increased ATM system capacity and to introduce automation technology represent a major effort with many important challenges to the FAA's and the Nation's R,E&D community. Among the many challenges, the following may stand out in importance:

- To develop a system architecture and create a system design that recognizes and accommodates the full ATM system demands as an integrated whole.
- To establish the appropriate balance between the basic ATC separation processes and the overlying flow management/control system.
- To establish the best ways for controllers/system managers to interact with and effectively use automation systems to handle more variables safely and efficiently.
- To achieve the correct balance between strategic planning, tactical execution, and modifying the ATM as near as possible to the

flight environment. This balance will be accomplished by rapid information exchange from all available sources, and by using alternative plans created by rule-based computers.

- To establish the best tactical responsibility balance between participating flightcrews with increasingly capable aircraft systems and the centralized ATM system.

- To achieve basic increases in airport capacity and en route/transition sector capacity.

- To create a digital communications system architecture that permits implementing a variety of data link services (space, terrestrial, airport surface, administrative) without requiring multiple data links or excessive overhead communication burdens.

- To create a new level of safety and operational efficiency by developing a full–time airport surface traffic management system.

- To create an ATM system for oceanic areas and remote land areas that emulates U.S. domestic airspace standards by using new surveillance, navigation, and communications technologies.

- To use environmental information from participating aircraft in operating the ATM system.

## 2.1 Capacity and ATM Technology Project Descriptions

### 021–110 Advanced Traffic Management System (ATMS)

**Purpose:** This project will develop automated techniques to enhance and better use system capacity resources and eliminate unnecessary flow restrictions. The result will reduce operating costs and flight delays through a more efficient and effective national flow management process.

**Approach:** The ATMS project is the research extension for the operational Enhanced Traffic Management System (ETMS) Program. The project captures the classic problem-solving approach to enhance the national flow management process. This approach has identified six discrete and evolutionary automation enhancements, including a need to enhance airspace usage coordination between military and civil agencies. The six automated elements are: (1) displaying the traffic situation (aircraft situation display (ASD)), (2) alerting flow managers to projected congestion conditions (monitor alert function (MA)), (3) generating alternative flow management strategies (automated demand resolution (ADR)), (4) integrating military airspace planning into the civil flow management process (dynamic special use airspace (DSUA)), (5) evaluating the operational impact of those alternative strategies (strategy evaluation (SE)), and (6) automatically selecting and implementing the "best" strategy (automatic execution function (AEX)).

The migration of functions from research to operational applications is facilitated through a computer complex shared by the ATMS and ETMS programs. This complex, located at the Department of Transportation's Volpe National Transportation Systems Center (VNTSC), has five groups/strings of distributed processors. The ATMS flow functions are initially researched on the developmental D–string; more mature functions migrate to the E–string for operational evaluations, and finally, flow functions identified as operational requirements transition to the ETMS Program Office where they migrate to the operational A–, B–, and C–strings.

**Related Projects:** 021–140 Oceanic Air Traffic Automation, 021–180 Terminal ATC Automation (TATCA), 021–190 Airport Surface Traffic Automation (ASTA), and 025–120 Operational Traffic Flow Planning. Capital Investment Plan projects: 21–06 Traffic Management System (TMS), 21–13 Automated En Route Air Traffic Control (AERA), 61–22 ATC Applications of Automatic Dependent Surveillance (ADS), 61–23 Oceanic Automation System (OAS), and 62–20 Terminal ATC Automation (TATCA).

**Products:** The following products build upon the completed Aircraft Situation Display and Monitor Alert functions:

- Automated Demand Resolution Function
- Strategy Evaluation Function
- Automated Execution Function
- Dynamic Special Use Airspace Function

**1994 Accomplishments:**

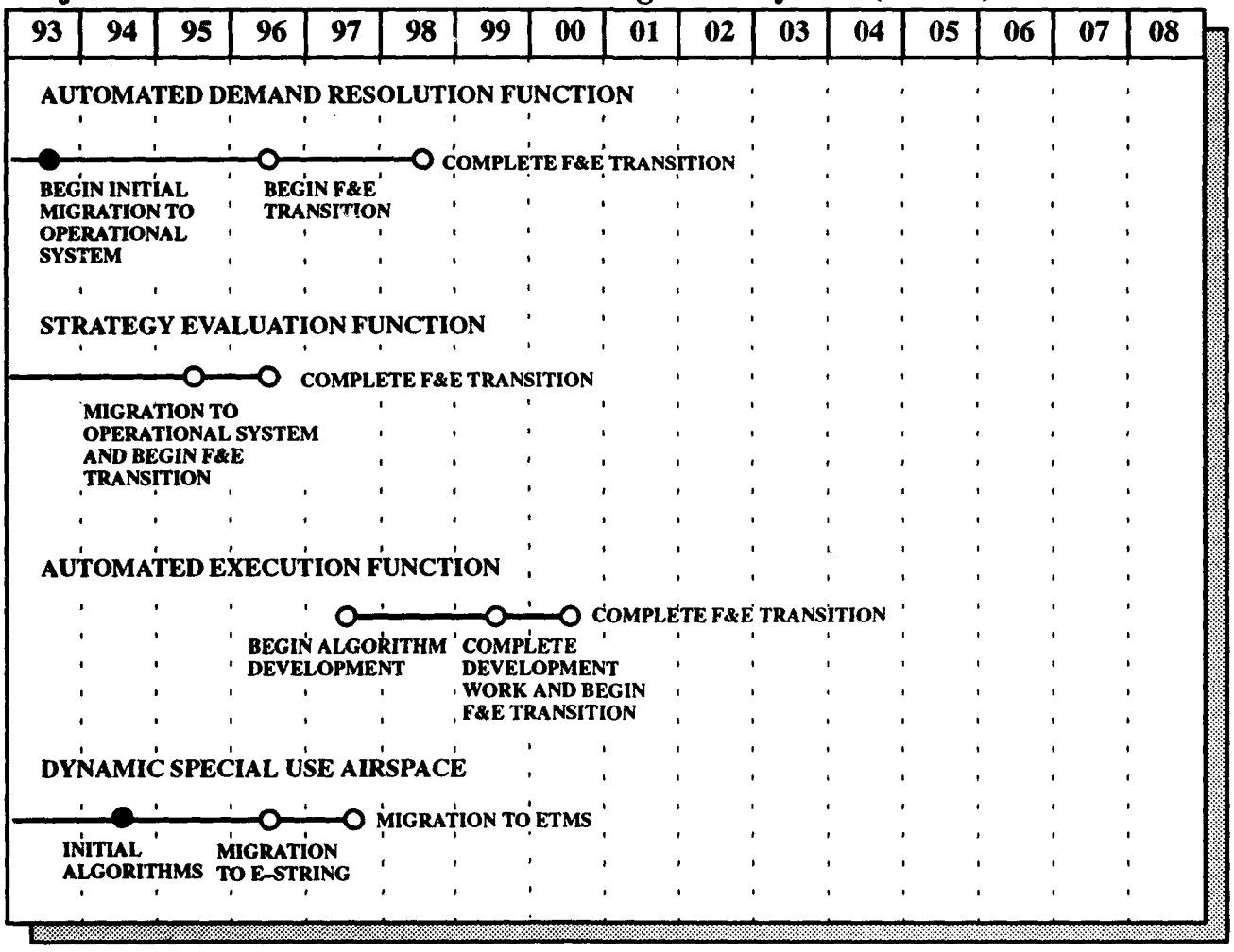
- Completed ADR–1 re–route function and ADR–2 multiple airport scheduler function evaluations on the E–string.
- Completed SE function.
- Developed initial DSUA algorithm.

**Planned Activities:** The remaining ADR functions that incorporate en route congestion, airport dynamics, weather conditions, and military airspace usage will be developed through 1996. Facilities and Equipment (F&E) transition will begin in 1996 and be completed in 1998. The ADR function will provide incremental enhancements to generate real–time, system level, alternative national flow management strategies that reflect demand, weather, and special use airspace conditions.

Dynamic special use airspace automation algorithm development will continue in 1995 with migration to the E–string beginning in 1996. The DSUA function will automate and coordinate military special use airspace with the FAA flow management system. The dynamic special use airspace function will be evaluated and refined for planned transition to the ETMS in 1997.

In 1995, the SE function will migrate to the operational system. F&E transition will begin in 1995 with projected completion in 1996. The SE function will provide the capability to compute real–time operational impact analysis on alternative national flow management strategies. The AEX function development will complete the domestic flow management automation system. This function will generate and distribute facility and/or aircraft specific flow management instructions that implement a selected national flow strategy. The AEX algorithmic development will begin in 1997 and be completed in 1998. AEX F&E transition will begin in 1999 and be completed in 2000.

## Project 021–110: Advanced Traffic Management System (ATMS)



## 021–140 Oceanic Air Traffic Automation

**Purpose:** The current oceanic system is different from the rest of the domestic National Airspace System (NAS) and has some inherent limitations. The oceanic environment has no radar coverage and navigation is handled using only aircraft onboard systems. Air traffic operations are performed manually or with limited automation, and air/ground communications are through third party via high frequency (HF) radios that are subject to a variety of atmospheric as well as human error. Consequently, there is a requirement for large separation standards that limit user–preferred route flexibility and efficiency. Without improvements, oceanic airspace will be unable to support continued air traffic growth.

This project is aimed directly at enhancing capabilities to increase oceanic air traffic capacity and efficiency without degradation to safety.

**Approach:** Research efforts will focus on requirements analysis; national/international standards and procedures; traffic management and control automation; and comprehensive, full–system simulation testing capabilities.

The Oceanic Automation project combines three oceanic R,E&D projects (ADS, Dynamic Ocean Track System (DOTS), Oceanic Automation) to achieve a total systems engineering approach.

Standards/Requirements

The FAA must adhere to International Civil Aviation Organization (ICAO) standards for the airspace delegated to the United States. The Oceanic Project Office will participate on international committees to coordinate agreement for global standards and requirements.

Studies and Analyses

The studies program will identify new air traffic control procedures and automation necessary to increase the airspace users' operating efficiency. The R,E&D Oceanic Program Office completed a Technical Management Plan to focus and prioritize the requirements for Oceanic R,E&D Studies. The studies are categorized into three major areas: Airspace Utilization, System Development, and Advanced Functions.

Traffic Management

The traffic management effort will provide oceanic traffic managers with automation designed to improve fuel and time efficiencies for oceanic airspace users. Development efforts include the DOTS functions of generating flexible tracks to take advantage of favorable weather conditions and providing traffic managers with a traffic display system. Another effort will include a track advisory function that electronically provides airlines with anticipated traffic conditions. Also, capabilities will be developed for transferring traffic management information between international ATC facilities. These oceanic traffic management functions will ultimately be integrated with the domestic traffic management system (TMS).

When fully developed, the traffic management system will provide airspace structuring that will reduce controller workload and safely increase system capacity to help cope with the ever-increasing demand for transoceanic travel.

Air Traffic Control

Air traffic control is based on three core elements: communications, navigation, and surveillance. This subproject concentrates on the communications and surveillance core areas. Project efforts are focused on developing ground–based systems utilizing ADS technology and satellite communication links. Specifically, development efforts will upgrade oceanic display and planning system (ODAPS) technology with new displays

and controller input–output devices. Added capabilities will include electronic ATC clearance delivery to aircraft, enhanced conflict detection and resolution, and electronic flight strip displays.

Testing

Standards, requirements, and procedures will be tested to validate system performance and capabilities prior to a production decision. Interfaces will be tested to ensure new automation can be integrated into the overall Oceanic Automation System (OAS).

An initial testing capability exists at the Oceanic Development Facility (ODF). This capability will be enhanced to conduct the full–range testing needed to complete this project. The facility will provide the capability to conduct end–to–end testing utilizing real satellites, real ground/earth stations, and aircraft cockpits to identify total system performance and to highlight areas needing improvements.

Engineering trials will be conducted with other civil aviation authorities to validate global compatibility of new automation systems.

**Related Projects:** 021–110 Air Traffic Management System, 031–110 Aeronautical Data Link Communications and Applications, 031–120 Satellite Communications, and 032–110 Satellite Navigation. Capital Investment Plan projects: 21–05 Oceanic Display and Planning System (ODAPS) and 21–12 Advanced Automation System (AAS).

**Products:**

- Telecommunications processor for flight data input/output (FDIO) hardware replacement and software emulation
- Ground/ground data communications capability
- Oceanic controller situation display
- Oceanic traffic planning and management functionality into domestic TMS
- Automated data interchange/transfer to and from foreign Civil Aeronautics Administrations (CAA)
- Oceanic airspace coordination functions
- Two–way communications between aircrews and oceanic controllers
- Enhanced conflict detection/resolution capability
- Next generation flight data processor
- Dynamic aircraft route planning study (DARPS) in South Pacific
- Track advisory capability for Oakland and New York Oceanic Centers

**1994 Accomplishments:**

- Developed Separation Improvement Program Plan and completed analysis for U.S.-led initiative to reduce oceanic separation standards.
- Completed ground/ground data communications function that lays the groundwork for full two–way data link communications between pilots and controllers.
- Installed interim situation display at the ODF.

**Planned Activities:**

Standards/Requirements

In 1995, efforts will continue toward coordinating industry standards in the areas of avionics characteristics and minimum operational

performance standards. These same standards will also be coordinated on an international basis.

In 1995 and beyond, coordination work will continue on industry standards for avionics characteristics and minimum operational performance standards, both nationally and internationally. This coordination will ensure that standards and procedures are in place to use the advanced technology being developed for Oceanic Automation.

In 1995, engineering trials in the Atlantic and Pacific will be completed. These trials will be used for developing requirements and standards for ADS functions, dynamic re–routing, track generation, and other oceanic automation features.

Studies and Analyses

In 1995, an ODAPS central processor replacement study and an oceanic electronic flight data display computer human interface study will be completed. These studies will be used in 1996 with a study on ADS reporting rates to support transitioning ODAPS to an advanced oceanic automation system.

In 1996 through 1997, studies will be completed for advanced functions such as ADS/radar data integration and automatic 4–dimensional clearance generation.

Air Traffic Management

In 1995, the flight plan processing system will be completed. This project will begin developing a prototype South Pacific strategic planning system which will connect international service providers in the South Pacific with DOTS at the Oakland Center to share traffic management information. This system will be used as a basis for the "International Interfacility Planning" follow–on work.

In 1995 through 1998, this project will expand the South Pacific strategic planning system concept to incorporate foreign traffic management systems. The goal is to integrate U.S. traffic management systems with foreign systems to create an international traffic management/planning system. Development will be completed in 1997.

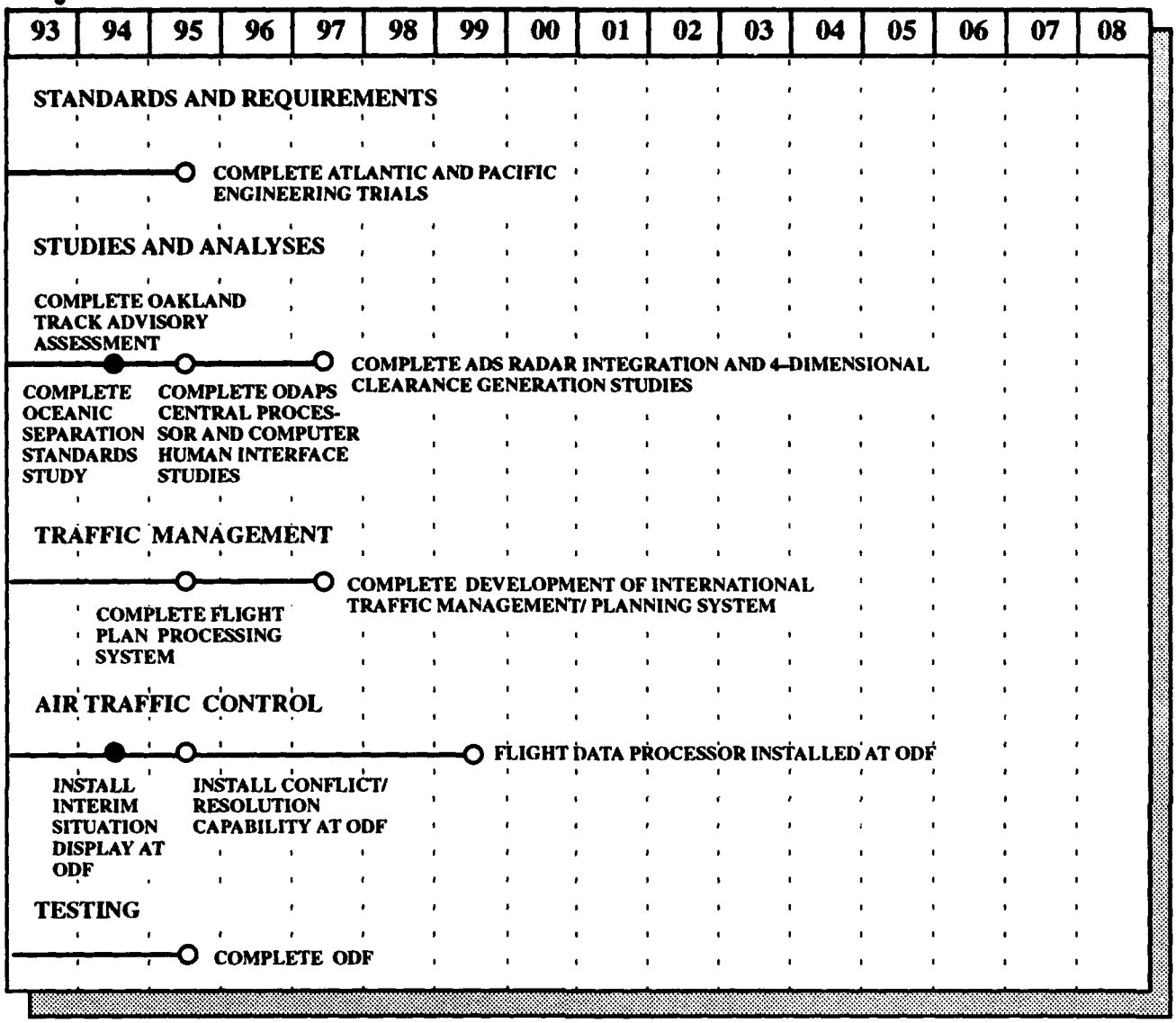
Traffic Control

In 1995, electronic flight strips and a conflict detection/resolution capability will be delivered to the Oceanic Development Facility. Evolutionary development will continue on display enhancements for integration into the interim situation display hardware. In 1996, a final software version will be completed that provides controllers with aircraft separation recommendations. Additionally, development will begin on a new flight data processor with ODF installation planned for 1999.

Testing

In 1995, the Oceanic Development Facility will be completed when the cockpit interface to the end–to–end simulation capability is installed. The ODF will be the primary test facility for all oceanic developmental and implementation testing.

## Project 021–140: Oceanic Air Traffic Automation




## 021–180 Terminal ATC Automation (TATCA)

**Purpose:** This project will develop air traffic automation aids to assist both controllers and managers in optimizing traffic flow in terminal airspace. This project will also facilitate expeditious implementation of these aids at selected ARTCC's and/or TRACON's.

**Approach:** The TATCA program consists of three projects: the Converging Runway Display Aid (CRDA), the Controller Automated Spacing Aid (CASA), and the Center/TRACON Automation System (CTAS). Terminal operations analyses show that a leading cause of delays is losing

capacity during instrument meteorological conditions (IMC). For example, many airports use multiple runways to land aircraft during visual meteorological conditions (VMC), but are restricted to a single arrival runway during IMC. CRDA is proving to be an effective automation tool for maintaining throughput capacity during IMC. In particular, CRDA allows two converging runway arrival streams to be maintained in IMC. Through software changes in existing ARTS processors, CRDA uses the ghosting technique to provide geometric spacing aids on existing displays for sequencing and spacing aircraft. The CRDA project transitioned to an F&E phase in 1992 and provides the basis for developing ghosting applications under CASA. CASA will explore using the ghosting technique to merge traffic streams to a fix. The ghosting technique enhances a controller's ability to space merging aircraft precisely, thereby improving airspace utilization.

The CTAS project is currently undergoing laboratory development and field development/evaluation. CTAS uses auxiliary workstation processors interfaced to existing ATC processors to project future aircraft locations, develop a coordinated arrival traffic plan, and provide ATC advisories to help controllers meet the plan. The four CTAS products are the traffic management advisor (TMA), the final approach spacing tool (FAST), the descent advisor (DA), and the expedite departure path (EDP). The TMA provides ARTCC and TRACON controllers with automation aids for sequencing and spacing aircraft in a coordinated plan as far as 200 nautical miles from the airport. FAST provides optional advisories for TRACON controllers to sequence and space aircraft on final approach. The DA will provide Center sector controllers with top–of–descent points, speed, altitude, and heading advisories that will help them meet the TMA-generated traffic plan. EDP provides controllers with optional advisories to integrate peripheral airport traffic with the main airport traffic flow. Longer–term TATCA activities focus on fully developed terminal automation techniques integrated with other ATC and cockpit automation capabilities.

To minimize technical risk and provide early products, the project places priority on delivering a developmental system to the field at the earliest possible date. Prototyping in developmental laboratories is used to develop the automation logic and its associated human–system interfaces. Prototypes are then taken to ATC facilities for field development in an operational environment. Limited deployment of an operational system will be made at selected sites prior to a decision for national implementation. In parallel with field evaluation, developmental prototype software is being restructured, hardened, and documented under MIL–STD–2167A in preparation for operational testing. At the conclusion of this effort, all software and hardware intended for operational use will be tested at the Federal Aviation Administration Technical Center (FAATC) prior to limited deployment. CTAS products are being designed to interface with existing equipment, and later, with the Advanced Automation System.

**Related Projects:** 021–110 Advanced Traffic Management System (ATMS) and 021–190 Airport Surface Traffic Automation (ASTA). Capital Investment Plan projects: 21–06 Traffic Management System (TMS), 21–12 Advanced Automation System (AAS), 21–13 Automated En Route Air Traffic Control (AERA), 41–21 En Route Software Development, 62–20 Terminal ATC Automation (TATCA), 62–21 Airport Surface Traffic Automation (ASTA), 62–24 National Implementation of the Imaging Aid For Dependent Converging Runway Approaches, and 63–21 Integrated Terminal Weather System.

**Products:**

- TMA, FAST, DA, and EDP hardware/software limited deployment
- CTAS interface specifications to the Advanced Automation System (AAS)

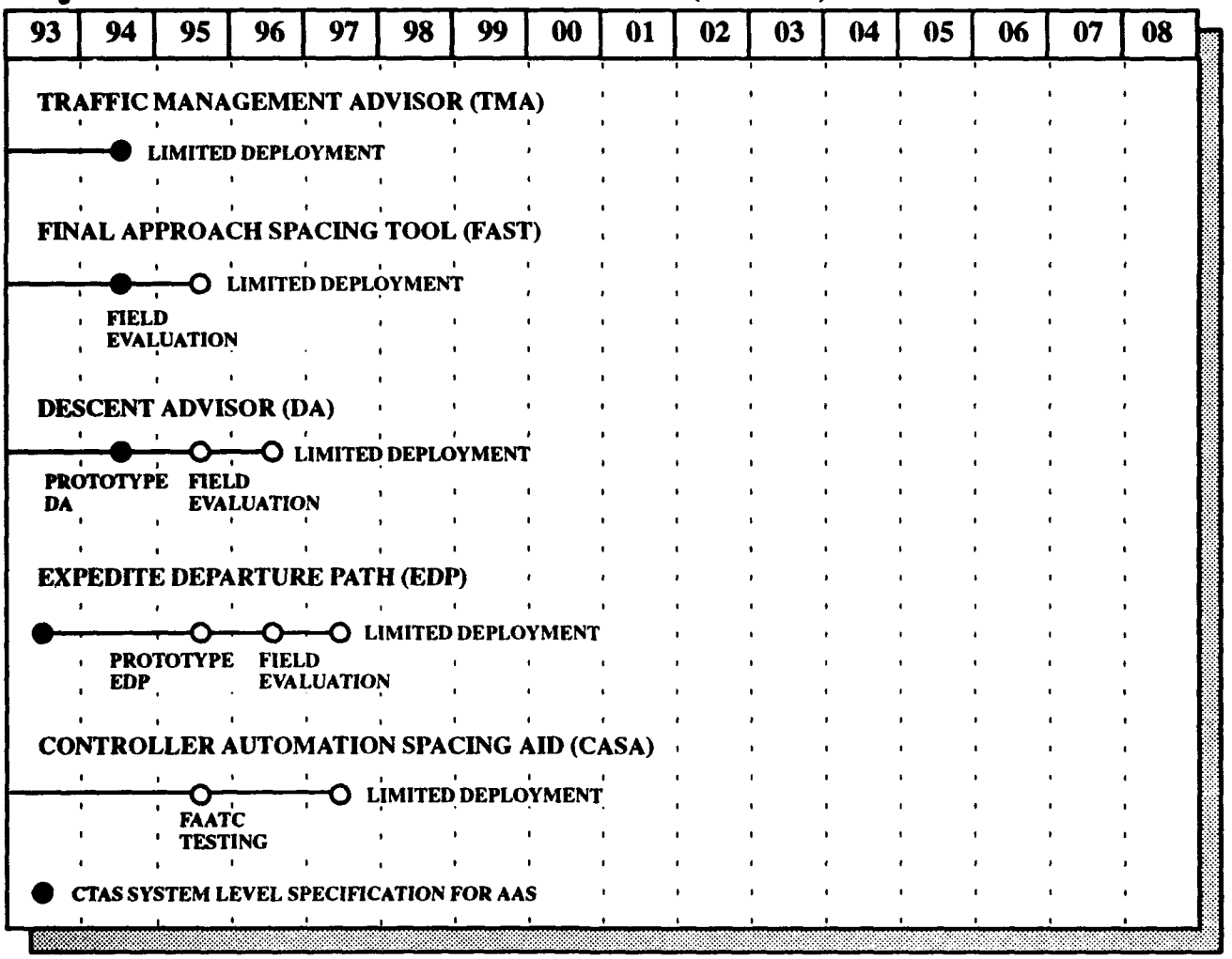
**1994 Accomplishments:**

- Began TMA limited deployment.
- Completed FAST field evaluation.
- Fielded prototype DA.

**Planned Activities:** In 1995, CASA functionality prototyping and simulation with active controller participation will continue. The Controller Automation Spacing Aid project will continue research into possible extensions of the automation technique utilized in the CRDA to applications in both terminal and en route environments. New applications will be identified and tested in a laboratory environment; successful products will undergo testing at the Technical Center prior to deployment.

Development activities will continue on the TMA, FAST, DA, and EDP components of CTAS. FAST will be ready for limited deployment in 1995. Prototype DA evaluations will be completed in 1995 in preparation for limited deployment in 1996. A prototype EDP will be fielded in 1995, with evaluations completed in 1996 and limited deployment in 1997. CASA testing at the FAATC will be completed in 1995, with limited deployment completed in 1997.

## Project 021–180: Terminal ATC Automation (TATCA)



## 021–190 Airport Surface Traffic Automation (ASTA)

**Purpose:** This project will develop an enhanced surface safety system, utilizing ground sensor primary radar airport surface detection equipment (ASDE–3), automated radar terminal system (ARTS), differential corrected global positioning system (DGPS), and airport movement area safety system (AMASS) to help prevent runway incursions. ASTA will provide controllers with automatically generated alerts and cautions in all weather conditions, as well as data tags to identify all aircraft and special vehicles on the airport movement area. Future enhancements will include a traffic planner and cockpit display of surface traffic information (CDTI).

**Approach:** To prevent runway incursions, automatic backup systems must be developed and implemented to guard against human failures. The ASTA program examines the roles and responsibilities of controllers, pilots, and ground vehicle operators operating on the airport. The ASTA program comprises five elements: a runway status light system, a surveillance data link, aural and visual warnings, data tags, and a traffic planner. ASTA is a streamlined program starting with technical and operational specification development and evolving into one preproduction prototype unit and 40–60 production level systems. A critical part of the overall ASTA project is to share information with the Terminal Air Traffic Control Automation project to create an interrelated runway incursion prevention system.

The runway status light system (RSLS) will automatically control lights developed by the ASTA project to show pilots if the runway is occupied. ASTA will further enhance this demonstration system by providing new surveillance data and interface software to enable the RSLS to function with ASDE–3 sensors, AMASS, and ARTS. As part of the upgrade, commercial off–the–shelf (COTS) runway incursion system software will be demonstrated as a possible alternative.

For the surveillance data link, ASTA will combine surveillance information from ASDE–3 radars, DGPS, and other potential ground movement sensors. All airports slated to receive ASDE–3/AMASS equipment under the F&E program will also receive ASTA. At those airports not equipped with ASDE–3/AMASS, ASTA will use other potential ground movement sensors, such as DGPS surveillance data link, for detecting aircraft and vehicles.

ASTA will utilize this combined surveillance data with the appropriate safety logic to provide controllers with prioritized aural and visual warnings and cautions on ARTS equipment. ASTA will utilize elevation information to prevent helicopter/vertical flight operations from causing unnecessary automatic safety alerts. Additionally, the ASTA project is laying the groundwork for future tower control computer complex (TCCC) interface requirements.

Data tag generation is a key ASTA functionality. Currently, there is no requirement for AMASS to display data tags. ASTA will assist controllers by displaying target locations with alpha–numeric data tags. Furthermore, ASTA will provide positive target identification for special vehicles such as fire, rescue, and snow plows.

Other ASTA add–on capabilities will include developing enhancements such as a traffic planner and cockpit display of traffic information for surface operations. All enhancements will stem from an approved ASTA operational concepts document.

**Related Projects:** 021–110 Advanced Traffic Management System (ATMS), 021–220 Multiple Runway Procedures Development, 021–180 Terminal ATC Automation (TATCA), 031–110 Aeronautical Data Link Communications and Applications, and 051–130 Airport Safety Technology. Capital Investment Plan projects:

21–13 Automated En Route Air Traffic Control Automation (AERA), 24–12 Mode S, 24–14 Airport Surface Detection Equipment (ASDE–3) Radar, 62–20 Terminal ATC Automation (TATCA), 62–21 Airport Surface Traffic Automation (ASTA), and 62–23 Airport Movement Area Safety System (AMASS).

**Products:**

- Concept development and demonstration
- Communications architecture
- Automatic runway entrance status light system
- Aircraft and vehicle identification tags on the ASDE–3/AMASS display
- Aircraft and special vehicle movement conformance monitoring and alerting system
- Dynamic surface traffic management planning process for arrivals, departures, and taxiing aircraft
- Automatic coordination of surface traffic management automation with other ATC automation systems
- Preproduction prototype and testbed
- System specifications to produce 40–60 ASTA systems

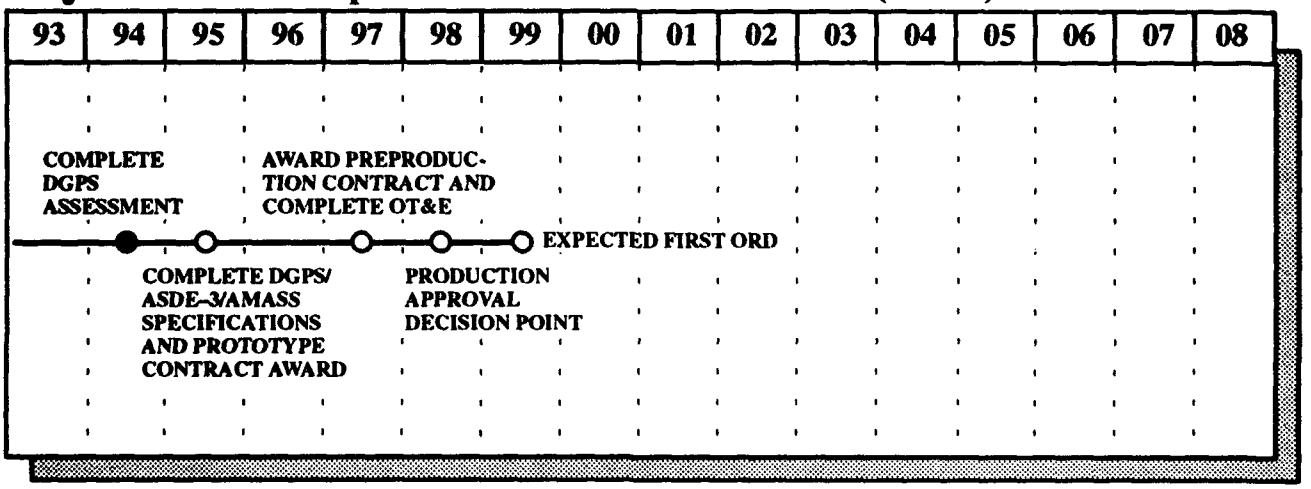
**1994 Accomplishments:**

- Completed technical performance assessments on DGPS position/velocity/heading data and integrated this data with ASDE–3/AMASS inputs.

**Planned Activities:** In 1995, a detailed system specification for integrating differential global positioning system (GPS) data with ASDE–3/AMASS and aircraft/vehicle data tags will be completed. This specification will be used to award a contract for developing an ASTA prototype by 1996.

In 1996, an RFP for developing a preproduction unit and 40–60 production units will be released. Contract award and Operational Test and Evaluation (OT&E) are scheduled for 1997. An ASTA production approval decision point is scheduled for 1998, with first operational readiness date (ORD) scheduled for 1999.

## Project 021–190: Airport Surface Traffic Automation (ASTA)



## 021–210 Tower Integrated Display System (TIDS)

**Purpose:** This project will resolve tower space constraints and make available much needed space for future enhancements. TIDS will consolidate the displays and instrumentation for airport environmental data and control equipment used in towers.

**Approach:** The TIDS project will be accomplished in two phases. In Phase 1, a market survey will be conducted to determine the availability of systems capable of meeting air traffic requirements with a minimal developmental effort. The results of the market survey will be used to determine an initial set of TIDS requirements and an appropriate acquisition strategy in order to field a TIDS in the near term. These requirements will be developed through a team effort within the FAA. Documentation for transition to a Facilities and Equipment program will be developed, including the program documents and production specifications to support implementation of the initial TIDS.

In parallel with Phase 1 activities, Phase 2 will be initiated to assess and integrate TIDS enhancements packages to meet the full range of air traffic's TIDS requirements. These enhancements could be implemented on a periodic basis.

**Related Projects:** 021–190 Airport Surface Traffic Automation (ASTA). Capital Investment Plan projects: 23–09 Automated Weather Observing System (AWOS), 24–08 Runway Visual Range (RVR), 43–12 Upgrade Low–Level Windshear Alert System (LLWAS) to Expanded Network Configuration, and 43–13 Digital Altimeter Setting Indicator (DASI) Replacement.

**Products:**

Phase I

- Initial TIDS requirements
- Prototype TIDS

Phase II

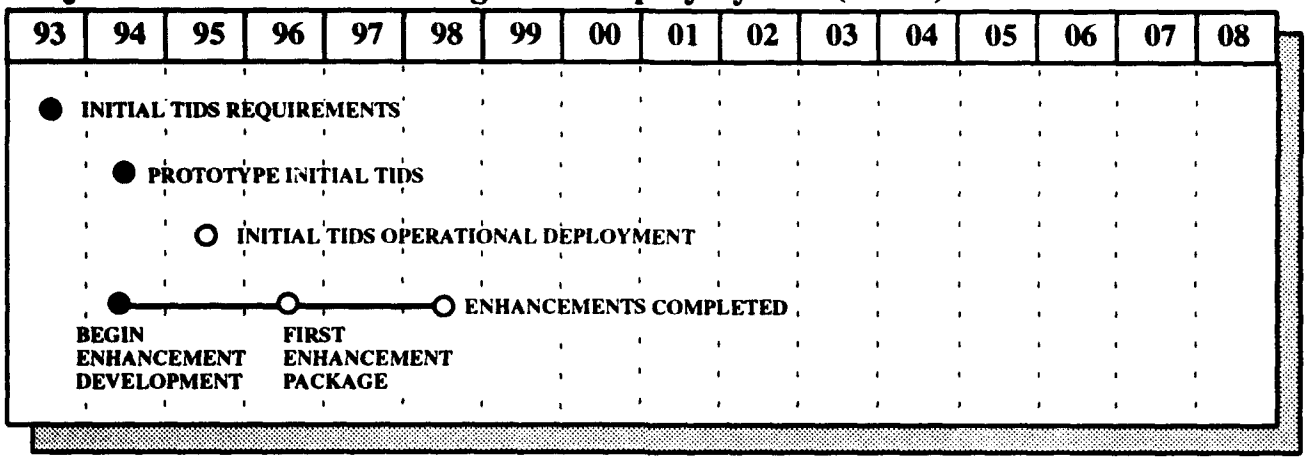
- TIDS enhancement requirements
- TIDS enhancement prototype

**1994 Accomplishments:**

- Awarded contract for initial TIDS capability with options for enhancements.
- Developed prototype TIDS.

**Planned Activities:** Integrated Operational Test and Evaluation activities will be completed using the TIDS prototype and will lead to a potential initial TIDS deployment in 1995. TIDS enhancement activities will continue in 1995, leading to a potential first enhancement package in 1996. Further enhancement packages will be investigated through 1998.

**Project 021–210: Tower Integrated Display System (TIDS)**




## 021–220 Multiple Runway Procedures Development

**Purpose:** This project will develop ATC procedures to reduce airport delays by more fully utilizing multiple–runway capacity during instrument meteorological conditions. This project will investigate using precision runway monitor (PRM) technology, including electronically scanned antenna systems with higher update rates, in conjunction with advanced techniques for reducing parallel runway spacing standards to less than 3,400 feet. Air traffic procedures and flight standards criteria for simultaneous triple and quadruple instrument flight rule (IFR) parallel approaches will also be developed and validated. Requirements and techniques for improved surveillance and navigation capabilities will be developed to support these procedures. Additionally, this project will develop a terminal airspace visualization and design tool to assist the airspace planner in rapid terminal airspace reconfiguration to accommodate multiple arrivals and departures.

**Approach:** The FAA has completed demonstrations of electronically scanned and "back-to-back" antenna PRM technologies resulting in acceptance of simultaneous, independent approaches to parallel runways spaced as closely as 3,400 feet. The PRM Program Office is currently upgrading the Raleigh-Durham PRM system to commissionable status and procuring additional PRM systems for five airports that satisfy the 3,400 feet spacing standard. Additionally, real-time simulations have shown the value of a final monitor aid (FMA), based on high–resolution color displays with controller alert aid and surveillance inputs from ASR–9 or Mode S, for monitoring parallel runway operations. This project will conduct additional simulations and analyses to develop national standards and ATC procedures for parallel runways using PRM and FMA technologies. Further research efforts on reducing runway spacing standards will focus on allowing approaches to parallel runways with less than 3,400 feet separation. The results of these studies for dual parallel runways will provide the basis for developing the spacing standards for closely spaced triple and quadruple parallel runways. This project will provide data and recommendations to the Air Traffic Service for formulating standards and procedures.

Along with developing the new procedures for parallel runway operations, the project must also improve terminal airspace structure to facilitate traffic flow from the terminal area boundaries to final approach. This program will develop a prototype computer–based system to assist airspace designers in rapid terminal airspace design and

reconfiguration. This graphics–oriented workstation system will capture the rules and procedures of ATC airspace design and analyze the alternative design's efficiency.

**Related Projects:** 021–180 Terminal ATC Automation (TATCA), 025–130 Air Traffic Models and Evaluation Tools, and 033–110 Terminal Area Surveillance System (TASS). Capital Investment Plan projects: 62–20 Terminal ATC Automation (TATCA) and 64–27 Precision Runway Monitor.

**Products:**

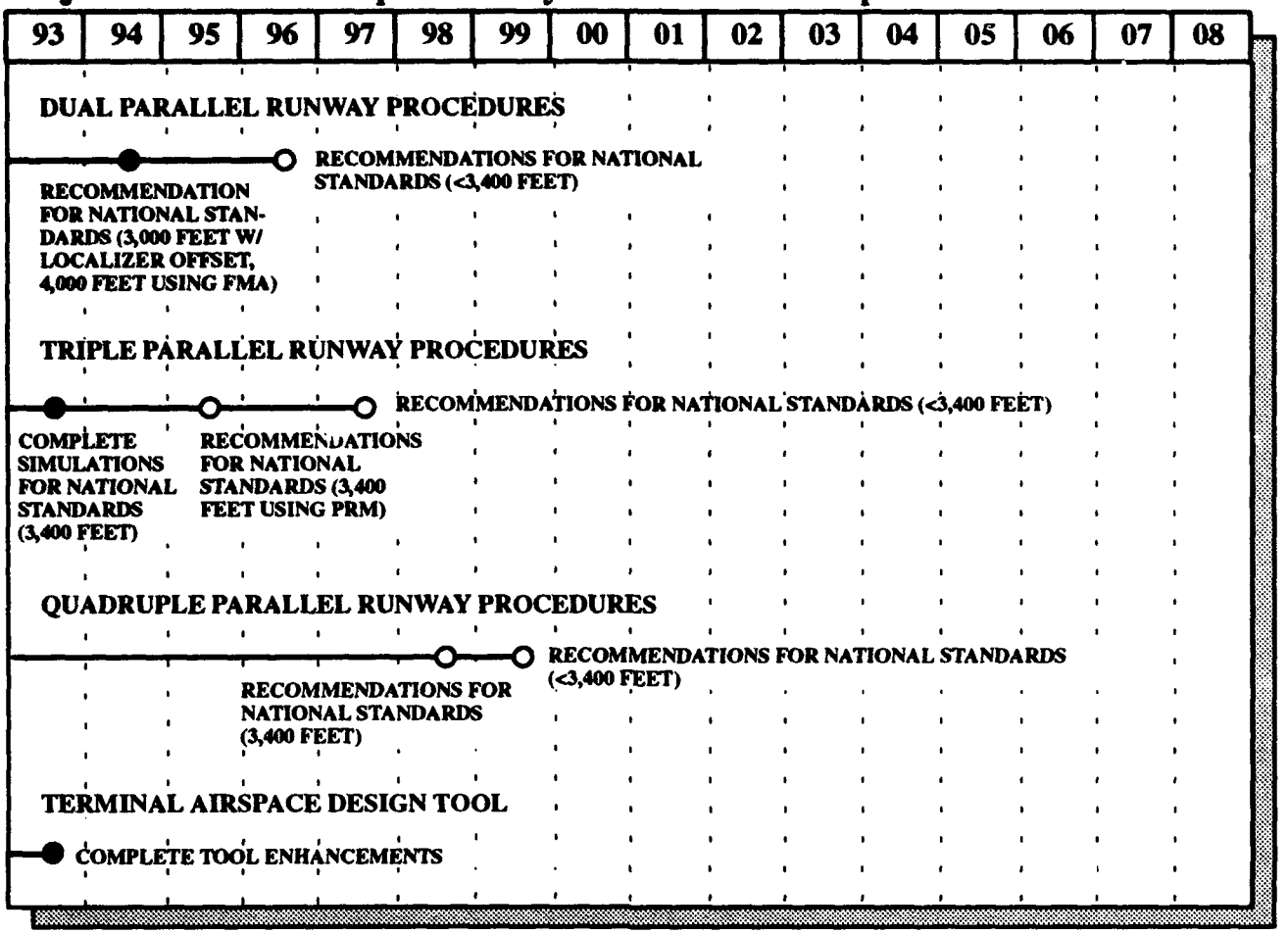
- Data and recommendations to develop approach standards for closely spaced dual, triple, and quadruple runways
- ATC simulation evaluations of IFR procedures for triple and quadruple parallel runways using existing and improved runway monitoring systems
- Technical reports on simulation results and risk analyses
- Prototype graphics–oriented computer tool for displaying airspace structures and for evaluating airspace design performance

**1994 Accomplishments:**

- Developed recommendations for national standards for dual parallel runways that have approximately 4,000 feet spacing using the FMA system with airport surveillance radar (ASR)–9 or Mode S.
- Developed recommendations for national standards for triple parallel runways that have approximately 4,000 feet spacing using the FMA system with airport surveillance radar (ASR)–9 or Mode S.
- Developed recommendations for national standards for dual parallel runways with 3,000 feet spacing using the PRM and offset localizer.

**Planned Activities:** In 1995, research will continue on the combined use of electronically scanned PRM technology and advanced techniques for possible further reduction of runway separation standards to less than 3,400 feet. Recommendations will be developed for approaches to triple and quadruple parallel runways with 3,400 feet separation using PRM in 1995 and 1998, respectively. Dual, triple, and quadruple standards for parallel runways with less than 3,400 feet spacing will be accomplished in 1996, 1997, and 1999, based on PRM and advanced navigation/landing systems. Advanced techniques include the potential use of state–of–the–art autopilots, microwave landing system, global positioning system, and collision avoidance logic in controller displays.

## Project 021–220: Multiple Runway Procedures Development




## 021–230 Wake–Vortex Separation Standards Reduction

**Purpose:** Wake–vortices, particularly those generated by large transport aircraft, can present significant hazards to following aircraft in single runway operations. Parallel runway operations may also be severely affected by vortices which can propagate great distances while in ground effect. This project will focus on safely reducing separation standards leading to increased capacity in the terminal area. These gains will be accomplished by understanding wake–vortex strength, duration, and transport characteristics, particularly as the vortices experience ground effect in the terminal environment. Potential methods will be examined for minimizing the wake–vortex effect to enhance airspace use, decrease delays, and increase airport capacity in instrument meteorological conditions.

**Approach:** Current air traffic operations will be assessed to determine actual traffic spacing being used under visual flight rules (VFR) conditions. Vortex strength, decay, and transport characteristics, as well as the metrological conditions that affect these characteristics, will be examined at selected, high traffic airports. Data from tower fly–by tests and other previously collected data

will be combined with new data to provide a basis for reviewing existing separation standards and recommending modifications. Flight test simulations will be designed and conducted to determine if reducing the separation standards currently being used under IFR conditions is feasible. Issues such as closely spaced parallel and converging runways, departure delays, and potential departure sequencing will also be explored through simulation.

Existing aircraft weight classifications will be reviewed, and a determination will be made as to whether the weight classifications and corresponding separations can be modified to improve single runway operations.

**Related Projects:** 021–180 Terminal ATC Automation (TATCA) and 024–110 Aviation System Capacity Planning. Capital Investment Plan projects: 62–20 Terminal ATC Automation (TATCA) and 63–21 Integrated Terminal Weather System (ITWS).

**Products:**

- Feasibility report on reducing separation standards in the terminal area
- Recommendations on aircraft weight classifications
- Separation algorithms to TATCA based on leading/following aircraft types

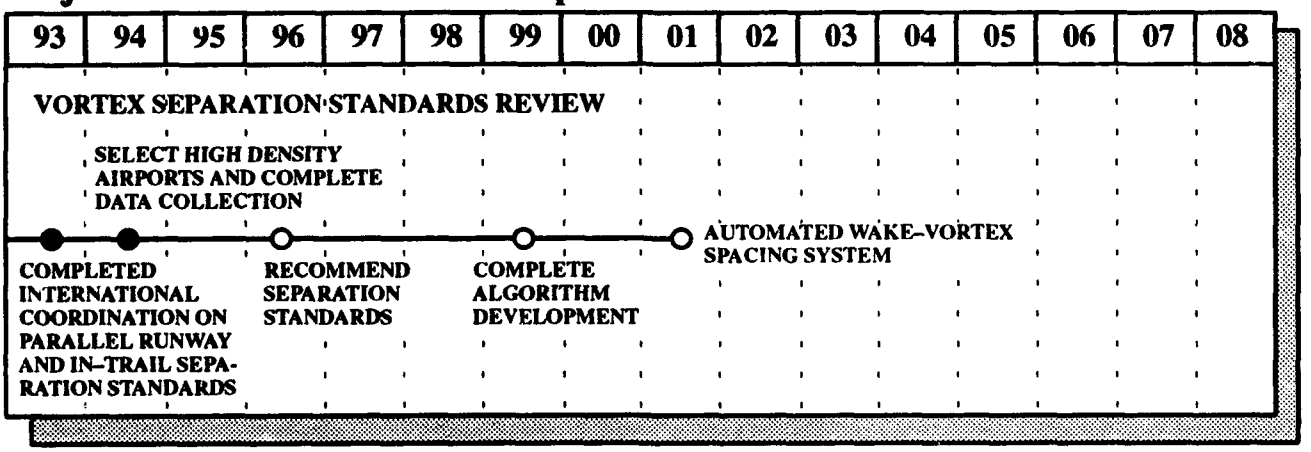
**1994 Accomplishments:**

- Selected appropriate high–traffic density airport for data–collection–based capacity analyses.
- Conducted flight tests to collect data on closely spaced parallel runways.

**Planned Activities:** Flight test data on closely spaced parallel runways will be analyzed in 1995 to develop new parallel runway separation criteria for FAA approval in 1996.

In 1995, development work will continue on an automated wake–vortex spacing system to be completed in 2001. In 1995, a joint effort with the National Aeronautics and Space Administration (NASA) will continue to develop models and simulation techniques that characterize wake–vortex hazards. These efforts are expected to continue through 1997. In 1998, flight tests will be conducted to validate the models and simulations. In parallel with developing models, work will continue on developing algorithms to integrate sensor inputs and provide the information to ATC automation systems by 1999.

## Project 021–230: Wake–Vortex Separation Standards Reduction



## 022–110 Traffic Alert and Collision Avoidance System (TCAS)

**Purpose:** This project will develop, demonstrate, and assist in implementing an independent airborne collision avoidance capability to increase the safety and capacity of the National Airspace System. Safety will be increased by reducing the potential for midair collisions. Capacity will be increased by using the improved cockpit display capability provided by TCAS to aid capacity enhancements such as simultaneous approaches to parallel runways and pilot-maintained in–trail spacing. The aviation community will be provided with the standards and certification guidance materials required for implementing the system. TCAS will reduce midair collision risks.

**Approach:** There are three TCAS versions: I, II, and III, each with successively increasing capability. TCAS I is under evaluation through a Limited Implementation Program (LIP). TCAS II development has been completed, and operational implementation has started. TCAS III development is continuing with the intention of conducting an LIP in 1998.

TCAS I

TCAS I generates traffic advisories to assist pilots in locating potential midair collision threats. The FAA has established a cost–shared contract with an avionics manufacturer to furnish TCAS I avionics for an LIP evaluation on several types of in-service commuter aircraft. This effort will provide operational and performance data on commercial TCAS I equipment in actual service.

TCAS II

TCAS II equipment, which includes a Mode S transponder, is intended for installation in transport category and high performance general aviation aircraft. TCAS II equipment will not only provide traffic advisories, but will also compute vertical–plane resolution advisories, that indicate the direction the aircraft should maneuver to avoid collisions. To ensure that maneuvers from two TCAS–equipped aircraft do not conflict, resolution advisories are coordinated between aircraft using the integral Mode S transponder.

Through an LIP, an operational TCAS II evaluation has been carried out on a number of in–service airline aircraft. Currently, TCAS II operational installation and use has begun. Federal Aviation Regulations require that all airplanes with more than 30 passenger seats operating in U.S. airspace be equipped with TCAS II by December 30, 1993.

TCAS III

TCAS III equipment, intended for installation in transport category aircraft, is designed to generate traffic advisories and resolution advisories in both the horizontal and vertical planes. Maneuvers will be coordinated between similarly equipped aircraft.

The FAA is supporting minimum operational performance standards (MOPS) development for TCAS III by a Radio Technical Commission for Aeronautics (RTCA) special committee.

In response to congressional direction, the FAA has developed a plan to complete the remaining development and test efforts, and evaluate the TCAS III system on airline aircraft in an LIP. Completing the development program and the LIP for TCAS III will enable the aviation community to implement the most advanced airborne collision avoidance system as a user option.

**Related Projects:** 024–110 Aviation System Capacity Planning. Capital Investment Plan projects: 24–12 Mode S.

**Products:**

TCAS I

- LIP — Reports on the TCAS I avionics evaluation to provide industry with guidance for TCAS I certification and operation

TCAS II

- LIP — Reports on TCAS II installation, certification, and operation on air carrier aircraft during routine operations
- TCAS II transition program report documenting TCAS II implementation program results and any required modifications
- TCAS II requirements document for TCAS II certification in transport category aircraft
- ICAO standards and recommended practices (SARP's) that provide a basis for international certification and operational approval

TCAS III

- RTCA MOPS that define required performance under standard operating conditions
- System safety study assessing the overall safety characteristics associated with using the TCAS III collision avoidance system
- LIP — Report on TCAS III installation, certification, and operation in air carrier aircraft

**1994 Accomplishments:**

- Completed TCAS I LIP.
- Completed full TCAS II implementation.

**Planned Activities:**

TCAS I

All 10 to 30 seat turbine–powered commuter aircraft must be equipped with TCAS I by February 9, 1995, in accordance with Federal Aviation Regulations. In 1995, the FAA will continue a multiyear TCAS I transition program to assist aircraft operators with TCAS I implementation in the National Airspace System. Periodic transition program reports will provide guidance in the installation, crew training, and system operation.

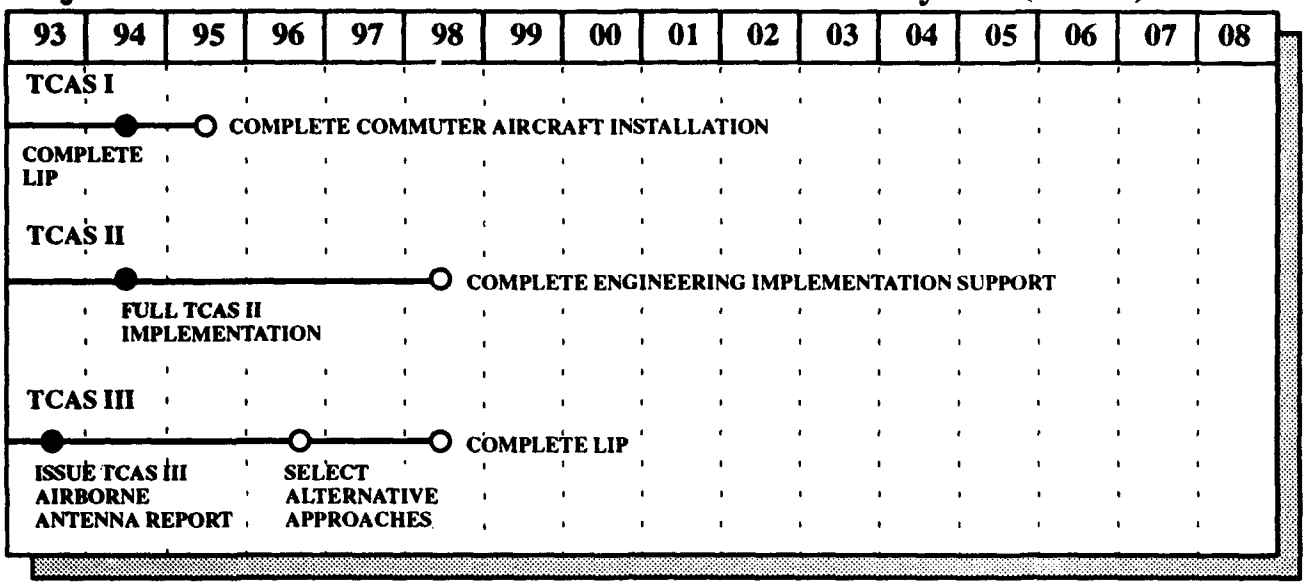
TCAS II

All commercial turbine–powered aircraft with more than 30 passenger seats were required to be equipped with TCAS II by December 30, 1993, in accordance with Federal Aviation Regulations. In 1995, the FAA will continue to work with the aviation community to resolve technical and operational issues associated with TCAS II implementation. Engineering support, such as developing logic modifications to reduce unnecessary alert rates, will continue through 1998.

TCAS III

The TCAS III airborne antenna report suggests that current, state-of-the-art TCAS antennas will not support the horizontal resolution advisories for TCAS III. Alternate approaches will be evaluated during 1995 and the most promising approaches will be selected in 1996 for flight testing during 1996–1997. An LIP will be conducted in 1998 to determine the certification and operational requirements for TCAS III. At the conclusion of the LIP, TCAS III will be available for airline implementation.

## Project 022–110: Traffic Alert and Collision Avoidance System (TCAS)




## 022–140 Vertical Flight Program

**Purpose:** This project will help improve the safety and efficiency of vertical flight (VF) operations and increase NAS capacity through research, engineering, and development into air traffic rules and operational procedures; heliport/vertiport design and planning; and aircraft/aircrew certification and training. The term vertical flight, in addition to conventional rotorcraft (helicopters), includes advanced technology designs for aircraft that have the ability to hover, take off, and land vertically, such as the tiltrotor, tiltwing, fan–in–wing, and vectored–thrust aircraft. These aircraft are also referred to as "powered–lift" aircraft. The Rotorcraft Master Plan (RMP) envisions using advanced VF technologies, such as the tiltrotor, to provide scheduled short–haul passenger and cargo service for up to 10 percent of the projected domestic air travel. Significant reductions in the estimated $5 billion national annual aviation delay cost could be realized by such aircraft.

Recognizing the potential for advanced VF aircraft to provide passenger service, Public Law 102–581 requested that a Civil Tiltrotor (CTR) Development Advisory Committee be established. This committee will evaluate the technical feasibility and economic viability of developing CTR aircraft and infrastructure to support incorporating tiltrotor technology into the national transportation system.

To meet the Public Law requirements and the RMP goals, research will be conducted in the following areas: (1) air and ground infrastructures to permit VF operations under visual and instrument flight conditions en route and in the terminal area; (2) VF operations safety; (3) VF operations noise reduction; (4) VF training and certification procedures; (5) integrating civil tiltrotor (CTR) and other maturing advanced technologies into VF operations; and (6) CTR

technology economic viability and potential benefits analyses.

**Approach:** To accomplish this expanded use of vertical flight, the FAA is responsible for developing the appropriate infrastructure and regulations in parallel with industry's actions and commitment to develop and operate market–responsive aircraft. The VF program will focus on the following technical subprogram areas: air infrastructure, ground infrastructure, and aircraft/aircrew. R,E&D efforts will consist primarily of studies and analyses, simulations, model development, and flight testing. The work will be performed by NASA, MITRE, the Volpe National Transportation Systems Center, university grants, the FAA Technical Center, and support contractors.

Air Infrastructure

For advanced VF operations to achieve the potential to increase the NAS capacity and enhance safety, vertical flight aircraft must operate in all weather conditions. This capability will enhance the economic viability of VF operations.

This subproject will provide research to enable reliable, all–weather operations for VF passenger and cargo aircraft. The research results will include developing both visual and instrument terminal approach and departure procedures, steeper IFR approach angles, improvements in low altitude navigation and air traffic control services, VF air route design, and noise abatement procedures. GPS will be a major element in this enhancement.

Research will focus on the ability to operate at heliports and vertiports in terminal airspace without interfering with fixed–wing traffic flow. Much of the initial work relating to emerging technologies, such as tiltrotor, will be done through simulation, and will be validated with actual flight test data as the aircraft become available.

Ground Infrastructure

Any current or future VF transportation system success will largely depend on the ability to land near demand centers. This ability means operating in obstacle–rich environments and landing in or near city centers.

The ground infrastructure subproject will provide R,E&D into heliport and vertiport design and planning issues, including the terminal area facilities and ground–based support systems that will be needed to implement safe, all–weather, 24–hour flight operations. Developing obstacle avoidance capabilities is a critical design–related effort. Research will include applying lessons learned from detailed accident and rotorcraft operations analyses. Simulation will be used extensively to collect data, analyze scenarios, and provide training to facilitate safe operations.

Aircraft/Aircrew

With the necessity for increased simulation use, this subproject will develop the criteria and guidance for VF simulators used for crew member training/evaluation. Training procedures will be established to reduce the human element causal factor in VF accidents.

Aircraft/aircrew research will: (1) develop minimum performance criteria for visual scenes and motion–base simulators; (2) evaluate state–of–the–art flight performance for cockpit design technology; and (3) develop crew and aircraft performance standards for display and control integration requirements. Research will also be conducted to develop certification standards for both conventional and advanced technology VF aircraft.

**Related Projects:** 021–140 Oceanic Air Traffic Automation, 024–110 Aviation System Capacity Planning, 025–110 National Simulation Capability (NSC), 031–120 Satellite Communications

Program, and 032–110 Satellite Navigation Program. Capital Investment Plan projects: 24–07 Microwave Landing System (MLS) and 61–22 ATC Applications of Automatic Dependent Surveillance (ADS).

**Products:**

- Terminal area approach procedure requirements
- ATC route standards, procedures, and models
- Vertiport/heliport design standards
- Improved VF noise planning model
- VF noise abatement procedures
- Rotorcraft simulator standards
- VF aircrew training and certification requirements
- Benefit/cost assessment for deploying advanced VF technologies

**1994 Accomplishments:**

- Published 1996 Olympics vertiport design requirements.
- Produced audio/visual training aids and workbooks for expert decisionmaking techniques.
- Published reports on benefit/cost and CTR short-haul economic viability.
- Delivered night vision enhancement device operations and training advisory circular materials.

**Planned Activities:** In 1995, advanced technology VF performance and demonstration guideline will be published. In 1996, national–level guidelines for the joint industry/local Government advanced technology VF demonstration program will be published.

Air Infrastructure

In 1996, VF noise data collection will be conducted. In 1997, low noise conversion corridor criteria for tiltrotors will be developed, and terminal area procedures for steep angle approaches and departures will be published.

In 1998, VF terminal, en route, and corridor route standards will be published as well as ATC systems integration guidelines for VF. In addition, minimum IFR and VFR airspace requirements for both conventional and advanced VF will be published. Also in 1998, VF noise abatement and control advisory circular materials will be delivered, and VF noise abatement corridor standards will be published. A VF demonstration programs advisory circular will be delivered in 1999.

Ground Infrastructure

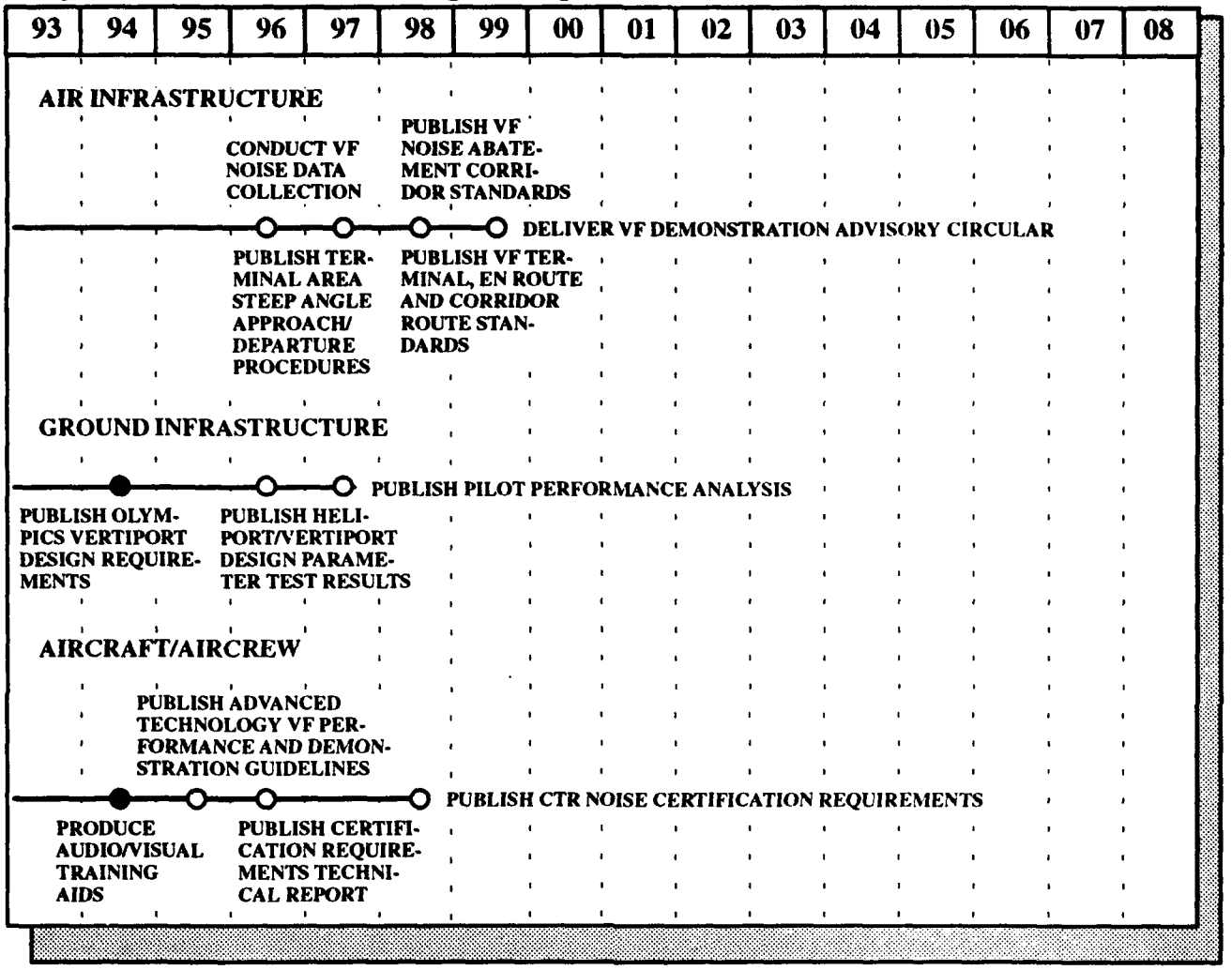
In 1995, community handbooks and computer planning aids to assist civic planners on rotorcraft noise issues will be published. In 1996, test results and analyses of heliport and vertiport design parameters, including minimum required VFR airspace for curved approaches and departures, minimum parking and maneuvering areas, marking and lighting, and rotorwash protection requirements, will be published. A simulation-based analysis of pilot performance in an obstacle–rich environment will be published in 1997. Results of this study will be used to evaluate necessary heliport and vertiport design criteria.

Aircraft/Aircrew

In 1995, Advanced Technology Performance and Demonstration Guidelines will be published.

In 1996, a technical report supporting VF aircraft display certification requirements will be published. In 1998, CTR noise certification requirements will be published.

## Project 022–140: Vertical Flight Program




## 022–150 Flight Operations and Air Traffic Management Integration

**Purpose:** A cornerstone of the future air traffic management system will be the direct information exchange between flight management system (FMS) computers and ground–based ATM computers via data link. This project will develop the capability to integrate flight management computer operations with ground–based air traffic management automation. Integrating FMS and ATM operations via data link is expected to increase airspace capacity and ensure more efficient flight operations along more flexible, conflict–free route trajectories.

**Approach:** This project will establish the operational requirements for flight operations procedures and standards that will fully utilize existing

FMS capabilities to enhance system capacity and flight efficiency in oceanic, en route, and terminal airspace in the near term. This analysis, which supports flight standards for FMS–guided curved approaches to selected airports and FMS–guided departures, will lead to standards for nationwide FMS–guided terminal operations.

This project will develop a standard set of operational requirements for advanced FMS capabilities to support the next generation (1996) FMS's with work accomplished through a cooperative effort between the FAA and industry. This effort will integrate existing and planned capabilities of the ATM system and the FMS/aircraft flight deck.

A key to successful ATM/FMS integration is developing automated communications between aircraft FMS and ground ATM computers. This goal will be accomplished by developing a set of flight operations and air traffic management integration (FTMI)–specific data link operational requirements. These requirements will be included as part of an FAA/industry set of data link operational requirements that support air traffic and flight information services.

Related to operational requirements work is developing and validating FTMI operational concepts. Simulation experiments, coupled with aviation community–supported flight trials, will be used to evaluate FTMI scenarios and validate associated procedures.

In addition to enhanced ATM/FMS integration, this project will explore the benefits of including airline operation control (AOC), the third component to the air transportation system, with ATM/FMS. A high-speed information exchange network between AOC and ground ATM could provide fuel savings, more efficient airspace utilization, and reduced delays.

**Related Projects:** 021–110 Advanced Traffic Management System (ATMS), 021–140 Oceanic Air Traffic Automation, 021–180 Terminal ATC Automation (TATCA), 031–110 Aeronautical Data Link Communications and Applications, and 084–110 Flight Deck/ATC System Integration. Capital Investment Plan projects: 21–06 Traffic Management System (TMS), 21–13 Automated En Route Air Traffic Control (AERA), 61–22 ATC Applications of Automatic Dependent Surveillance (ADS), 62–20 Terminal ATC Automation (TATCA), and 63–05 Aeronautical Data Link Communications and Applications.

**Products:**

- Flight operations procedures and standards for FMS–guided curved approaches to selected airports
- Flight operations procedures and standards for FMS–guided departures to selected airports
- Flight operations procedures and standards for FMS–guided terminal operations nationwide
- ATM/industry operational requirements document for the next generation FMS
- Flight operations procedures and standards for FMS–guided oceanic operations
- Flight operations procedures and standards for FMS–guided en route operations

**1994 Accomplishments:**

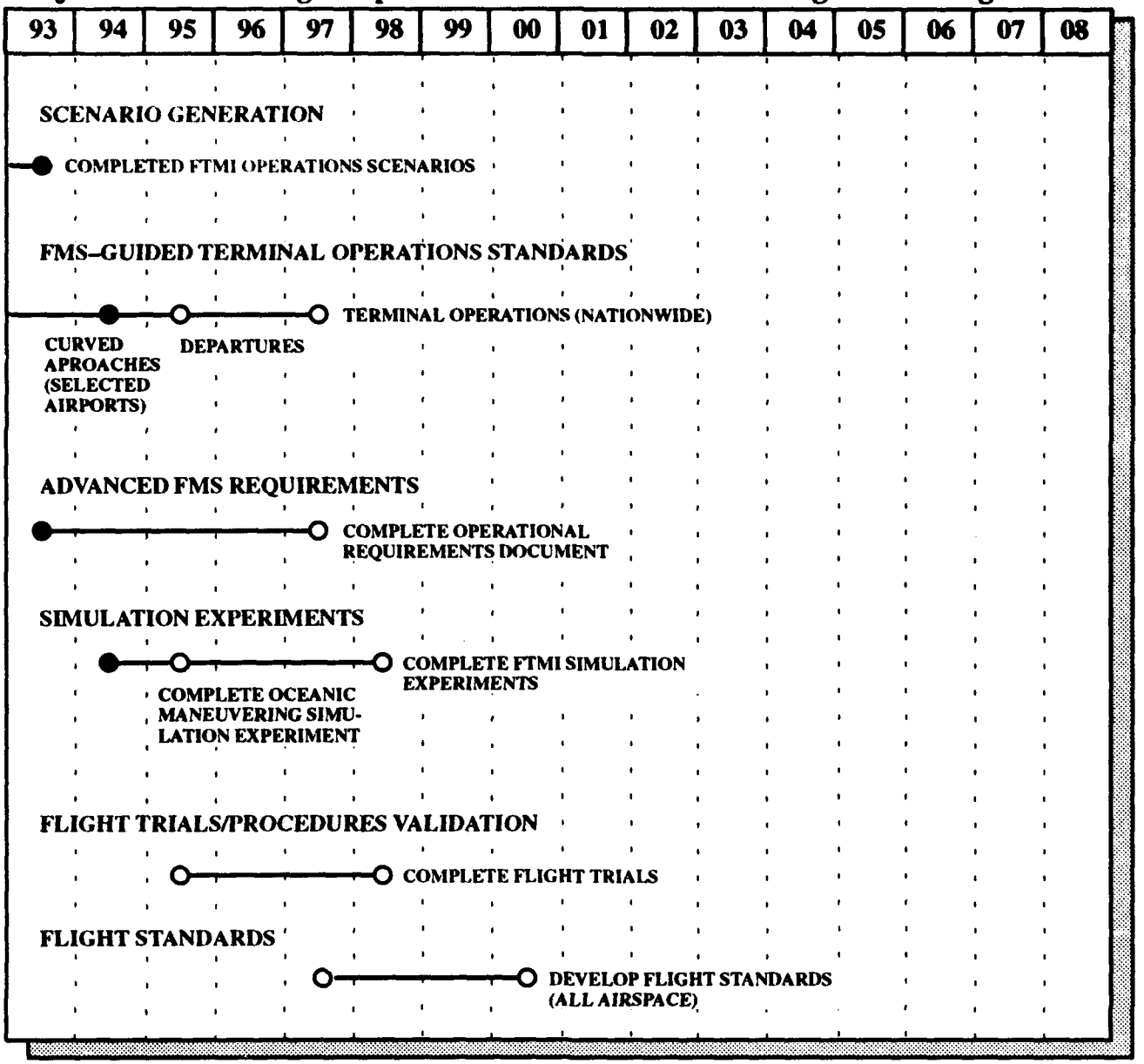
- Completed analysis to support flight standards for developing FMS–guided curved approaches.

**Planned Activities:** Analyses will be completed to support flight standards for developing FMS–guided departures at selected airports in 1995, leading to nationwide FMS–guided terminal operations standards in 1997.

A simulation experiment involving route maneuvering in oceanic airspace will be completed in 1995. This experiment will demonstrate FMS capabilities to improve oceanic airspace utilization and flight efficiency. In 1995 – 1998, further simulation experiments involving FTMI scenarios will be conducted. In parallel to this activity, flight trials will be conducted with industry to validate procedures generated as a result of these simulations. Analysis of simulation experiments and flight trials will yield flight standards by 2000.

An activity will continue in 1995 to develop an operational requirements document by 1997 for advanced FMS capabilities to ensure full integration of flight management and ATM operations.

## Project 022–150: Flight Operations and Air Traffic Management Integration



## 023–120 Separation Standards

**Purpose:** This project will provide quantitative guidance for domestic and international efforts to establish minimum vertical and horizontal separation standards. The ability to increase system capacity is directly related to separation standards. As new technology is introduced, separation standards will be reduced, resulting in increased system capacity and efficiency.

**Approach:** Tests will be conducted to provide quantitative guidance for determining domestic and oceanic separation minima permissible as new technologies are introduced. This effort will establish separation minima based on improved navigation, ADS, other new technologies, and ATC improvements.

This project will analyze separation standards in the North Atlantic, Central East Pacific, North Pacific, and West Atlantic route systems. It will examine the impact of various system improvements on horizontal and vertical separation. Time–based navigation capabilities and associated ATC procedures will be analyzed to determine if time–based separation standards are feasible.

**Related Projects:** 021–140 Oceanic Air Traffic Automation, 031–110 Aeronautical Data Link Communications and Applications, 031–120 Satellite Communications Program, 032–110 Satellite Navigation Program, and 032–120 Navigation Systems Development. Capital Investment Plan projects: 61–22 ATC Applications of Automatic Dependent Surveillance (ADS), 61–23 Oceanic Automation System (OAS), 63–05 Aeronautical Data Link Communications and Applications, and 64–05 Global Navigation Satellite System (GNSS).

**Products:**

- Reports on reduced horizontal oceanic separation feasibility
- Report on domestic and international general guidance material for establishing separation standard minima
- Data packages for coordinating international horizontal oceanic separation standards
- Reduced domestic vertical separation data analyses, operational tests, and evaluations
- Recommendations for rulemaking on reduced vertical separation standards

**1994 Accomplishments:**

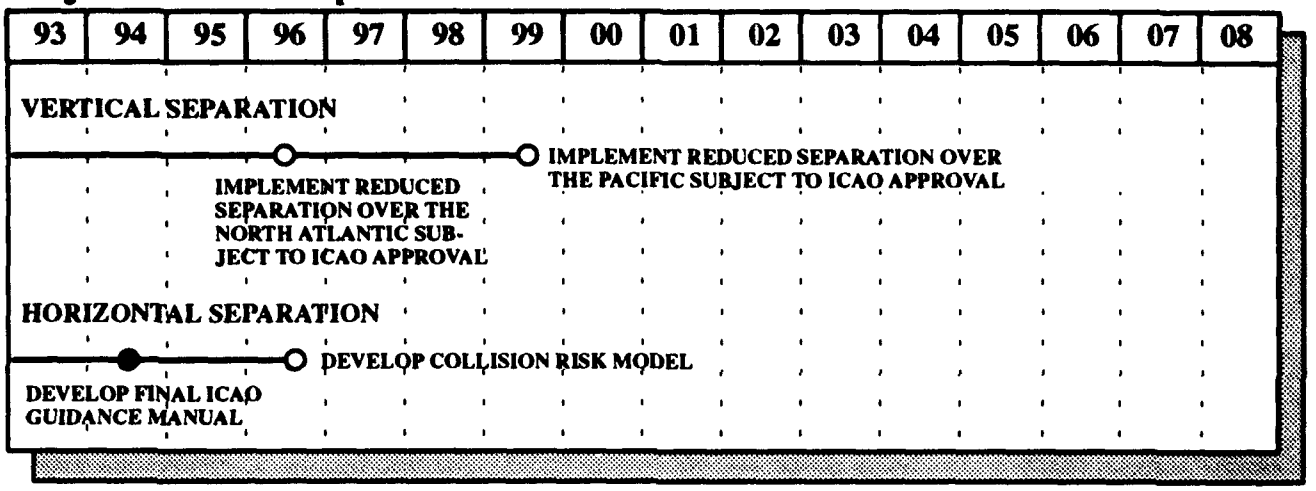
- Developed ICAO general separation standards guidance manual.

**Planned Activities:** The North Atlantic Systems Planning Group will continue planning for vertical separation reduction over the North Atlantic. The FAA's goal is to implement these standards by 1996, subject to ICAO approval. Planning will continue for vertical separation standards reduction in Pacific airspace with possible implementation by 1999, subject to ICAO approval.

In conjunction with ICAO, the FAA has developed a general separation standards guidance manual for domestic and international airspace for planned ICAO adoption in 1995–1996. This manual will consider such items as improved navigation accuracy based on satellite capability, ADS, TCAS, improved ATC automation, and improved air–ground communications.

A new or modified collision risk model is being developed to provide quantitative guidance for establishing separation standards where ADS is used. This effort is expected to be completed during 1996.

## Project 023–120: Separation Standards




## 024–110 Aviation System Capacity Planning

**Purpose:** This project will provide system capacity planning and identify/develop near– and long–term capacity improvements.

**Approach:** Airport capacity design teams, currently active at 12 airports, are comprised of airport operators, airlines, other users, and FAA representatives. Each team starts with a current airport and adjacent airspace environment simulation using actual operating data to establish a baseline. The team then develops a list of potential improvements to increase capacity and using a variety of simulation and queuing models, tests their effect in the specific airport environment. Among the improvements investigated are airfield improvements, such as new runways and runway extensions; improved approach procedures; and new facilities and equipment, such as the microwave landing system. Those improvements found to produce the greatest capacity increases, together with the estimated delay reductions and cost savings, are described and recommended for implementation in the final design team plans.

Design teams also address airspace structure and develop new designs and traffic flow modifications to accommodate more aircraft. Airspace redesign begins with simulating the air traffic control center airway environment using operational data to establish the baseline. The airspace design team then develops alternatives such as more direct routings; segregating jet, turboprop, and piston engine traffic; and relocating corner-post navigational aids to allow for more arrival and departure routes. These alternatives are simulated to determine their effect on delay, travel time, sector loading, and aircraft operating cost. The most successful alternatives are incorporated into a plan to redesign the airspace for increased capacity.

The Aviation Capacity Enhancement (ACE) action team program, on the other hand, works to develop achievable, near–term solutions for chronic delay airports by focusing on resources under FAA control. This program is limited to initiatives that will produce results within 2 years.

**Related Projects:** 021–230 Wake Vortex Separation Standards Reduction, 022–110 Traffic Alert and Collision Avoidance System (TCAS), 022–140 Vertical Flight Program, 025–130 Air Traffic Models and Evaluation Tools, and 091–110 Environment and Energy.

**Products:**

- Aviation System Capacity Plan
- Airport Capacity Design Team Plans
- Airspace Analysis Technical Plans
- Aviation Capacity Enhancement Action Plans
- Near- and long-term capacity enhancement report
- Aviation System Capacity Enhancement video

**1994 Accomplishments:**

- Developed improved independent converging approach procedures and standards.
- Produced 1994 Aviation System Capacity Plan.
- Completed Airport Capacity Design Team plans for Detroit, Milwaukee, and Tulsa.
- Completed airspace analysis technical plans.
- Completed ACE Action Team plans.

**Planned Activities:** Airport Capacity design team efforts will continue at Detroit, Tulsa, Milwaukee, West Palm Beach, and Southern California (Burbank, Ontario, and Santa Anna). These teams will develop Airport Capacity Plans for each airport by 1995.

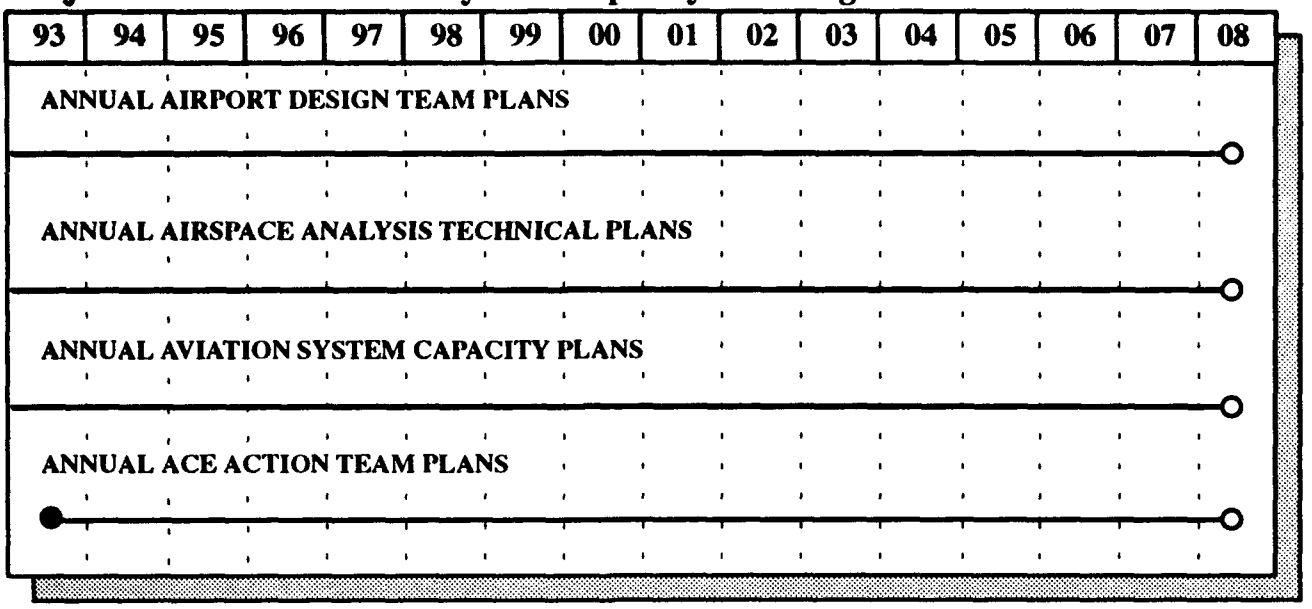
Airspace analyses efforts at Albuquerque, Boston, and Memphis ARTCC's will continue, and their data bases will complement those for the Atlanta, New York, and Washington ARTCC's. These analyses will lead to plans to redesign airspace usage at these locations during 1995.

From 1995 to 1998, simulations and flight demonstrations will be conducted to determine if TCAS can be expanded for separation assistance. The FAA Strategic Plan goals are improved system efficiency, a reduction in controller workload, and enhanced safety.

In 1995, ACE action team program work will continue. These teams will investigate near–term solutions to problems at the top 24 airports experiencing chronic delay. As technology evolves, the ACE action teams will continually analyze delay problems and develop new, near–term solutions.

The Aviation System Capacity Plan will continue to be produced annually.

## Project 024–110: Aviation System Capacity Planning




## 025–110 National Simulation Capability (NSC)

**Purpose:** The NSC will aid and support the R,E&D and systems engineering missions of the FAA by integrating the various R,E&D program elements across the NAS environment. The capability to integrate future ATC subsystems during the conceptual stage of a project permits early requirements validation, problem identification, solution development for those problems, and system capability demonstrations. It permits early injection of human factors and system user inputs in the concept formulation process. The net result is a reduced risk in developing products for the National Airspace System, faster infusion of new technology, early acceptance of new NAS concepts by system users, and greater efficiency in performing the R,E&D and systems engineering missions.

**Approach:** The NSC will be a unique capability in that it will not exist in any one place but will be achieved by linking together, on a distributed interactive network, existing simulation capabilities. That capability will allow the FAA to horizontally integrate components of future ATC systems and assess their suitability and capability before production investment decisions are made. Horizontal integration will bring together diverse system components such as terminal automation, en route automation, oceanic control, aircraft flight management systems, and mixes of aircraft types and performance in a flexible, interchangeable, and dynamic simulation environment. The NSC will permit the evaluation of new operational concepts, human interfaces, and failure modes in a realistic, real–time interactive ATC environment capable of simulating new or modified systems at forecast traffic levels. Simulation capabilities will be expanded through the interface with various remote research centers that possess nationally unique facilities and expertise.

**Related Projects:** All major operational subsystems.

**Products:**

- NSC Operating Plan
- NSC documentation including: configuration management plan, software development plan, coding standards, experimental protocol standards, external program interface requirements, and experimentation plans and reports
- Operational Integration Laboratory (I–Lab)
- Operational NSC at the FAA Technical Center

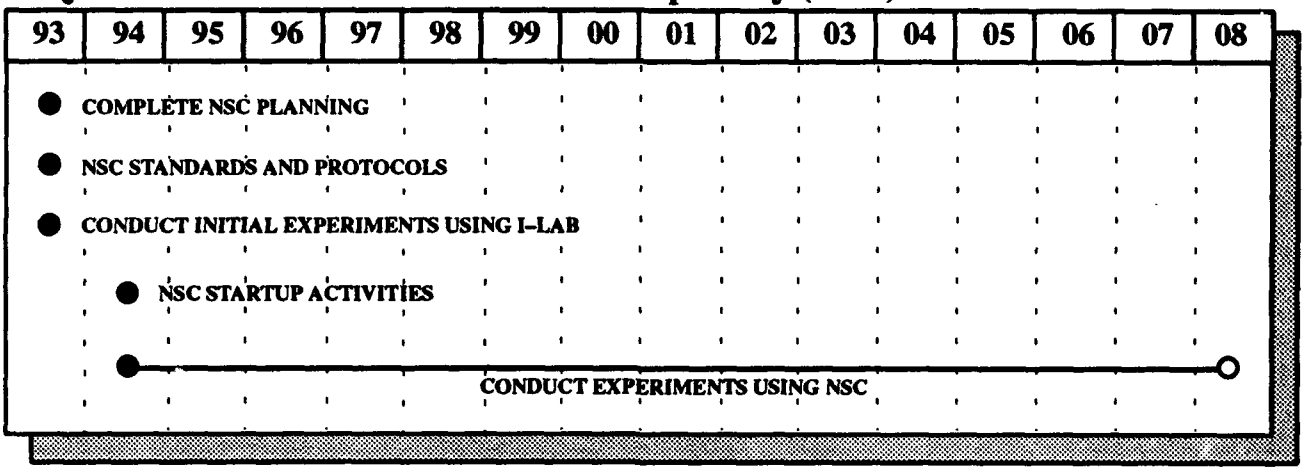
**1994 Accomplishments:**

- Completed NSC startup activities and began conducting experiments.

**Planned Activities:** NSC will continue to support developing expanded experimentation capability at both the I–Lab and the FAA Technical Center that will be responsive to FAA sponsor organization requirements. New experiments will be conducted that take full advantage of the additional NSC functionality.

As more issues are identified, experiments will be developed and conducted in the NSC during the out years.

## Project 025–110: National Simulation Capability (NSC)




## 025–120 Operational Traffic Flow Planning

**Purpose:** The OTFP project produces near–term improvements in national–level traffic flow management (TFM) conducted at the FAA's Air Traffic Control Systems Command Center (ATCSCC) which will: improve airspace use by providing optimal traffic flows; minimize delay, fuel consumption, and service disruption to increase aircraft operators' efficiency; and balance demand and capacity to reduce controller workload.

The OTFP project involves operational concept exploration, rapid–prototyping, and proof–of–concept evaluation using advanced operations research (OR) techniques and computer modeling. The OTFP System consists of a coordinated set of

computer–based decis support tools to assist the TFM specialists of the ATCSCC.

**Approach:** The FAA's Operations Research Service (AOR) and the ATCSCC have identified four crucial requirements that, when met, will equip the TFM specialist with a decision support system to increase the overall efficiency of NAS operations. Meeting these requirements is the objective of the OTFP Project. The four ATCSCC requirements are:

Availability of C cal TFM Information

The amount of data generated during NAS operations is enormous and includes filed flight plans, aircraft position data from radar, and weather, to mention a few. The OTFP Program is developing ways to transform these data into information regarding past, present, and projected NAS conditions. The OTFP System will present this information to the TFM specialist in an intuitive manner using graphics and data visualization extensively to improve the rapid comprehension of large amounts of data.

TFM Strategy Evaluation

The ATCSCC must resolve demand/capacity imbalances in the NAS. Currently, the TFM specialist relies solely on expertise to derive a traffic flow management strategy. The OTFP System will evaluate the proposed strategy before implementation, allowing the specialist the opportunity to review the predicted NAS effects. If necessary, the specialist can alter the strategy or propose alternative ones.

TFM Strategy Generation

The OTFP System generates optimal strategies for current or anticipated NAS conditions. OTFP supplies the TFM specialist with one or more highly efficient strategies to consider. This process is analogous to having a computer analyze numerous possible moves for a chess game in advance. Performed in real–time, this capability provided by OTFP significantly improves the final choice of strategies.

TFM Decision Support Tool Testbed

There are many ways to use computers to characterize the current NAS condition, generate effective plans, and predict the impact of alternative strategies. The ATCSCC needs quick, economical means to experiment with various automated traffic flow planning techniques and computer–based OR methods. The OTFP System provides a testbed for decision support tools that minimizes the costs and time required for such efforts. OTFP eliminates duplicate efforts in both data access and graphical user interfaces that operations research projects typically need.

**Related Projects:** 021–110 Advanced Traffic Management System (ATMS), 021–180 Terminal Air Traffic Control Automation (TATCA), and 025–130 Air Traffic Models and Evaluation Tools. Capital Investment Plan projects: 21–06 Traffic Management System (TMS), 61–23 Oceanic Automation System (OAS), and 62–20 Terminal ATC Automation (TATCA).

**Products:** The OTFP project will develop the following coordinated set of computer models and decision support tools tailored to meet the four critical ATCSCC requirements.

Availability of Critical TFM Information

- Daily decision analysis system (DDAS) to analyze airline schedule change impacts quickly
- ATCSCC analyses to evaluate ATCSCC traffic management operations
- Ground Delay Program Substitution Visualizer to demonstrate the TFM effects of airline substitution practices

TFM Strategy Evaluation

- Daily flow simulation model (FLOWSIM) for fast–time national pacer airport traffic flow simulation
- NAS simulation (NASSIM) for detailed NAS–wide traffic prediction and simulation

TFM Strategy Generation

- High altitude route system (HARS) for optimized, fuel efficient jet routes
- Planned arrival and departure system (PADS) for developing optimal departure and arrival scheduling plans
- Knowledge–based flow planning (SMARTFLO) for quick response flow advisories using expert systems
- Optimized flow planning (OPTIFLOW) for dynamic national traffic flow optimization

TFM Decision Support Tool Testbed

- Conterminous United States data model (CONDAT) to provide a common data source for all OTFP simulation and optimization efforts
- OTFP System to integrate functions of the individual project initiatives

**1994 Accomplishments:**

- Expanded HARS planning capabilities to include enhanced communications software for FAA/airline interactive planning.
- Completed PADS demonstration/evaluation.
- Developed FLOWSIM field prototype.
- Completed CONDAT prototype demonstration and testing.
- Developed initial NASSIM prototype testbed.
- Completed SMARTFLO field prototype development, demonstration, and testing.
- Demonstrated ground delay program substitution visualizer prototype.

**Planned Activities:** Continuing HARS field prototype development will provide follow–on enhancements to enable full track generation and traffic optimization for high altitude traffic anywhere within the United States. It will also develop the integration necessary to provide interoperability with national and oceanic traffic management systems. In 1995, ADS and data link system interfaces will be developed to provide real–time communications between ATCSCC and the full range of airspace users. This effort will complete HARS development, and the resulting technologies will migrate into OPTIFLOW.

The PADS functional prototype, scheduled for ATCSCC testing in 1995, will provide a real–time ability to develop airport departure and arrival scheduling plans that optimize daily traffic flows for long–range flights between major city–pairs. The PADS field prototype development and demonstration is planned for 1995–1996. PADS field prototype delivery in 1996 will enable ATCSCC and traffic management unit (TMU) to plan interactively with commercial aviation dispatchers to develop optimized high altitude flight sequencing in conjunction with the HARS and OAS traffic models.

Operations research for the OPTIFLOW model will be completed in 1995. The OPTIFLOW initial prototype testbed demonstration and

ATCSCC evaluation will begin in 1995. OPTIFLOW field prototype development will follow in 1996 with field prototype demonstration and evaluation planned for late 1996 and early 1997. OPTIFLOW field prototype delivery is planned for 1997.

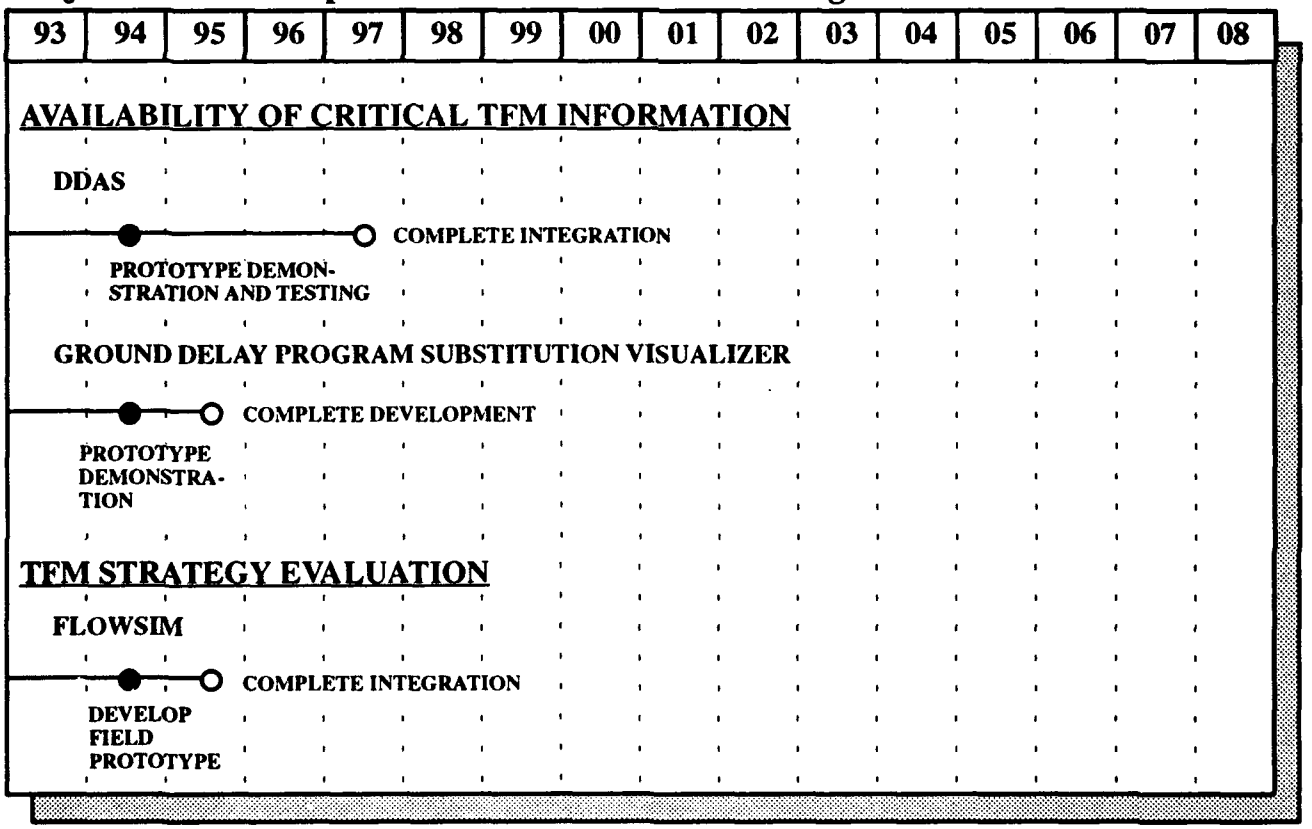
FLOWSIM integration with other tools will be completed in 1995. Work on CONDAT development and integration will continue through 1997. Operations research to develop NASSIM, for predicting and simulating detailed daily traffic and flow strategies, will continue in 1995. NASSIM will utilize and integrate many technologies and tools developed in preceding projects such as HARS, PADS, FLOWSIM, and OPTIFLOW. NASSIM initial prototype demonstration and evaluation is planned for 1995. Follow–on NASSIM field prototype development is planned for 1995–1996, with field prototype demonstration and evaluation scheduled to begin in 1997. NASSIM field prototype delivery to ATCSCC and TMU's is planned for late 1997.

In 1995, SMARTFLO will be delivered to the ATCSCC.

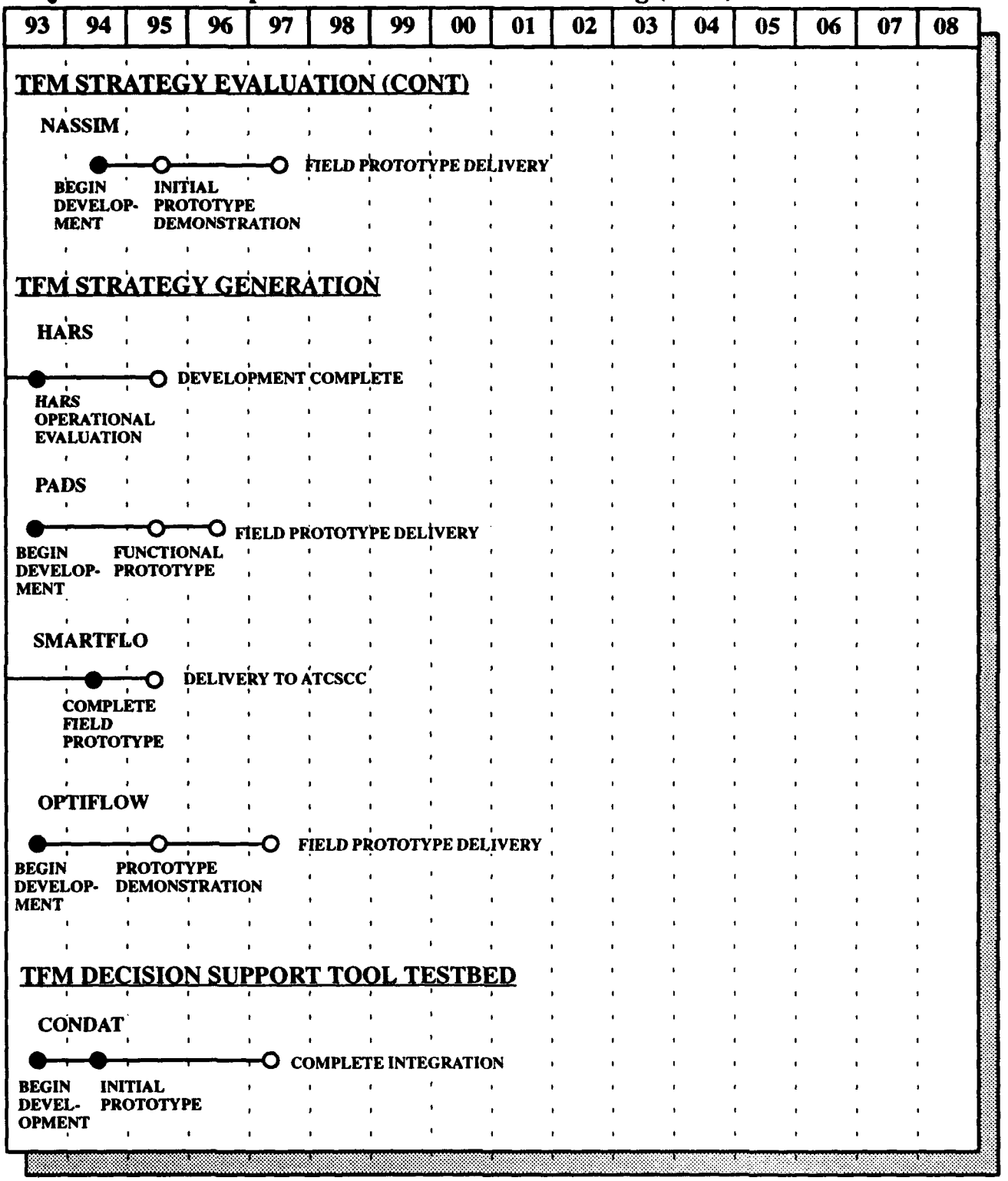
In 1995, DDAS will continue testbed prototype development of tools for dynamic, digital data exchange of scheduling information between the ATCSCC and airlines scheduling facilities. Also, prototype demonstration and testing is scheduled for 1995. DDAS integration with other OTFP projects will follow in 1995–1997.

In 1995, the Ground Delay Program Substitution Visualizer prototype development will be completed. ATCSCC analysis and integration will continue for ATCSCC operations during the Operational Traffic Flow Planning project development and fielding stages from 1995 to 1997.

## Project 025–120: Operational Traffic Flow Planning



## Project 025–120: Operational Traffic Flow Planning (cont.)



## 025–130 Air Traffic Models and Evaluation Tools

**Purpose:** This project will produce modeling and analytic tools to support operational improvements, airspace and airport design, environmental analysis, investment decisionmaking, and ATC system design analysis. The products from this project will provide ATC with the ability to plan, evaluate, and update operational changes rapidly to accommodate the more dynamic airport/airspace environment. This project's models will respond to the dynamic changes resulting from satellite navigation and increased ATC and cockpit automation. The program will emphasize improvements to existing models and new model developments that produce the highest payoff. Modeling products will be improved to make them simpler, faster, more effective, and more widely used and accepted.

**Approach:** Development will focus on integrated airport and airspace modeling. Previously developed models, such as National Airspace System performance analysis capability (NASPAC) and SIMMOD, will be made easier, faster, and more flexible to use. New model variants will enable clients to make fast approximations to complex situations. SIMMOD, an FAA trademark software program, is used by the FAA, industry, and foreign governments to design airport layouts and airspace routings.

The sector design analysis tool (SDAT) aids in redesigning en route airspace to increase capacity and balance the controller workload. SDAT derivatives are the terminal airspace sector design analysis tool (T–SDAT) and the national airspace sector design analysis tool (N–SDAT) that provide new capabilities for evaluating terminal and multicenter en route airspace design. Additionally, a critical sector detector (CSD) will be developed to determine when airspace sectors will reach critical traffic density levels based on controller workload limits.

**Related Projects:** 021–220 Multiple Runway Procedures Development, 024–110 Aviation System Capacity Planning, 025–110 National Simulation Capability (NSC), and 025–120 Operational Traffic Flow Planning.

**Products:**

- Enhanced SIMMOD airport and airspace simulation model
- SIMMOD capability installed in ARTCC's, TRACON's, and FAA regional offices
- NASPAC U.S. airspace simulation production model
- SDAT, T–SDAT, and N–SDAT
- Critical Sector Detector

**1994 Accomplishments:**

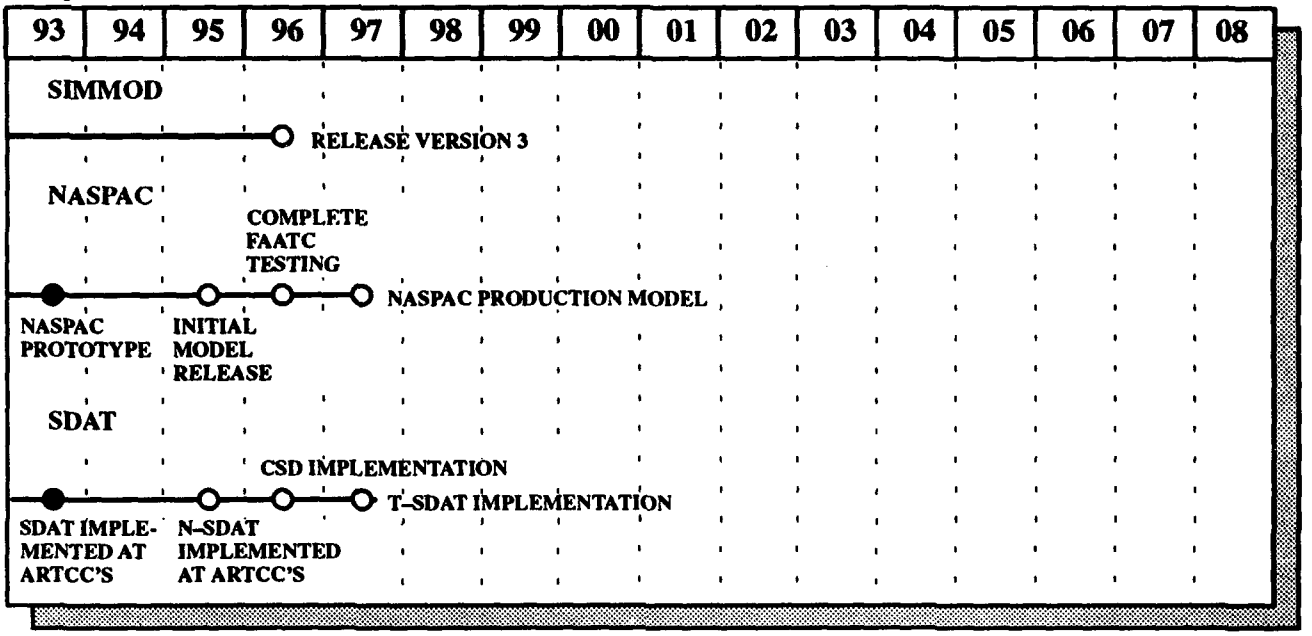
- Established SIMMOD capabilities in an ARTCC, a TRACON, and an FAA regional office.
- Developed N–SDAT.

**Planned Activities:** New SIMMOD logic enhancements will increase simulated traffic dynamic control and account for en route system dislocations. In 1995, SIMMOD capabilities will be established at additional FAA regions and en route centers. In 1996, a new SIMMOD, version 3, will be released to accommodate future airspace requirements for user–preferred direct routing.

In 1995, work will continue on SDAT derivatives. N–SDAT implementation is expected in 1995. Also in 1995, work will continue on CSD development with completion/implementation in 1996. T–SDAT testing will be conducted in 1995, with completion/implementation in 1997.

In 1995, work will continue on NASPAC to develop a user–friendly workstation production version. The current NASPAC version is a prototype developed by MITRE Corporation that considers various performance measures for determining NAS–wide impacts from proposed system improvements. The production model will permit analysts to conduct studies more easily and quickly, and will provide more sensitivity to proposed changes in the overall airspace system design. In 1995, an initial NASPAC production model version will be released. NASPAC testing will be conducted at the FAA Technical Center through 1996, with implementation expected in 1997.

**Project 025–130: Air Traffic Models and Evaluation Tools**




## 026–110 Airway Facilities Future Technologies

**Purpose:** The traditional Airway Facilities (AF) role is changing dramatically. This change is being driven by new technology, a changing work force, and increasing levels of automated AF system management. While the traditional ways have proven to be effective when replacing a single system or part of a single system, they may be ineffective in the future due to the magnitude and complexity of the planned National Airspace System (NAS) modernization. The transition to the new AF environment must not occur in a vacuum. The current AF organizational structure and assigned functions may not be consistent with achieving projected capabilities from new systems entering the NAS. Management will need to assess AF organizational configuration in response to many issues. Research must investigate interdependencies for total system and operations integration. This project will assess proposed changes to help

guide the FAA in meeting future AF operational needs. The project will develop appropriate policies, identify alternative organizational structures and functions by developing models and evaluation tools, and will examine emerging technologies for applications in the total AF environment.

**Approach:** This project will first develop an overall plan for the Airway Facilities R,E&D Program. The plan will specify the guidelines for determining the AF operational, organizational, functional, and technological baselines as well as analyze their mutual interdependencies. In addition, the plan will specify a program implementation process to ensure that research, engineering, and development in each of the areas is integrated, and that the products lead to an integrated overall system to meet AF's future needs.

This project will develop simulation models for developing and assessing alternative concepts and methodologies for future AF operations. Models will be developed through rapid prototyping to evaluate promising operational concepts. Proposed procedures and operational concepts will be tested in simulated operational environments and scenarios. Alternative organizational structures will be developed and modeled for assessment and refinement. Evaluation tools will be provided to measure correlations between operations concepts, organizational structures, functional capabilities, and technological capabilities.

This project will develop a testbed to investigate various scenarios associated with new technologies such as remote maintenance monitoring, the Operational Control Center, and AF interfaces with satellite systems. Expert diagnostic, predictive, and resolution tools (EDPRT) will be developed to support preventative maintenance and to help isolate and solve equipment problems. The testbeds will be used to develop requirements and design approaches for the EDPRT tools and to investigate their use in simulated operational environments. Also, applications for an intelligent tutoring system (ITS) will be identified to provide additional interactive tools to increase AF productivity. These tools will be fully integrated with the EDPRT's.

**Related Projects:** 025–110 National Simulation Capability, 032–110 Satellite Navigation Program, and 083–110 Airway Facilities Maintenance Human Factors. Capital Investment Plan projects: 26–01 Remote Maintenance Monitoring System and 26–04 Maintenance Control Center.

**Products:**

- Airway Facilities Research Program Plan
- Airway Facilities system testbed
- Simulated Operational Control Centers
- Airway Facilities certification standards for people and equipment
- Expert diagnostic, predictive, and resolution tools
- Intelligent tutoring systems

**1994 Accomplishments:**

- Completed technology assessment to identify key technologies applicable to AF operations.

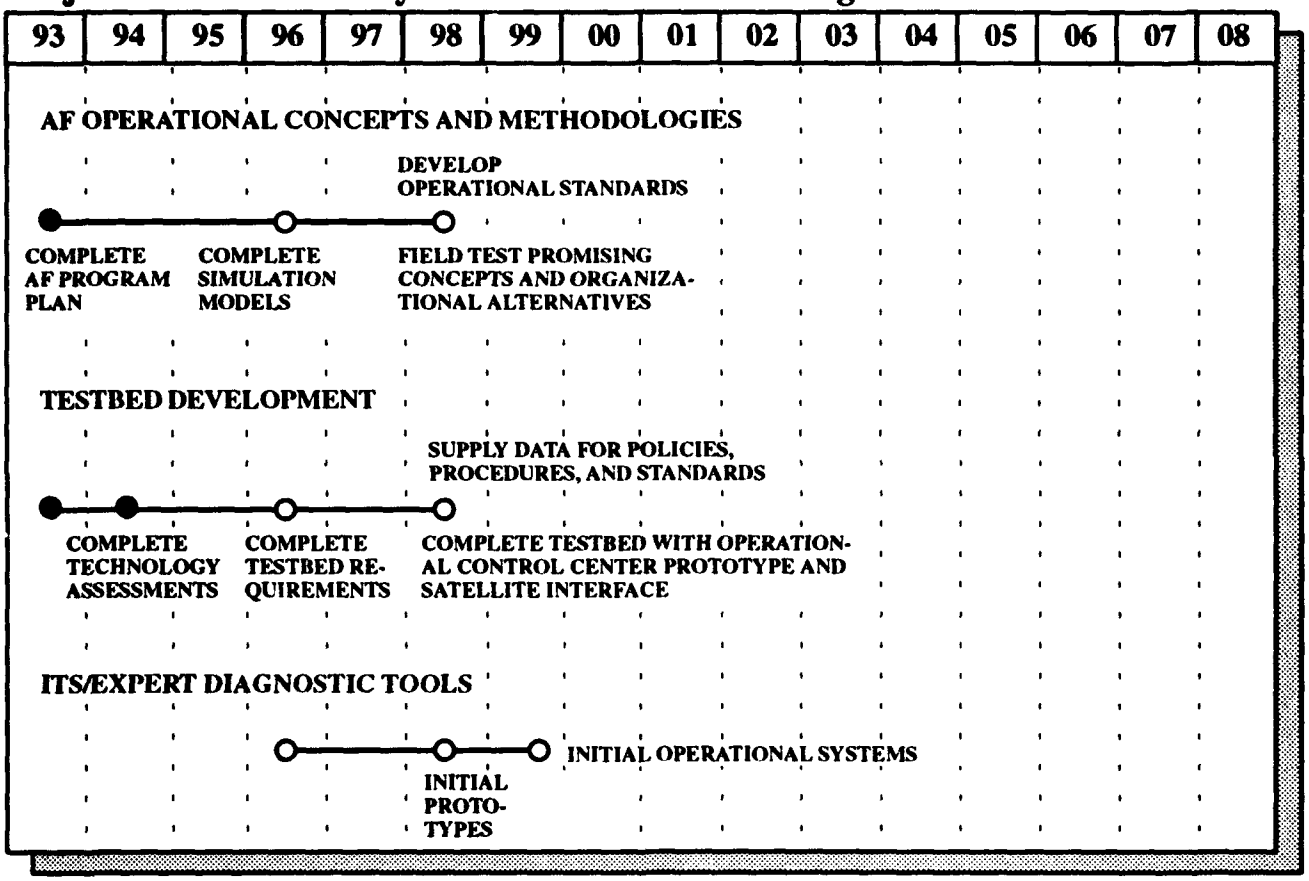
**Planned Activities:** In 1995, work will continue on developing the AF testbed. In 1996, testbed requirements will be completed, leading to an Operational Control Center prototype and GPS software interface in 1998. Analysis results will be available in 1997 and 1998 for developing policies, procedures, and standards.

In 1995, work on integrated modeling tools will be initiated to identify organizational alternatives and to simulate future AF system responsibility/functions in the NAS. These simulation models will be completed in 1996. Also in 1996, work

will begin on organizational structure analysis tools with completion in 1997. The models and tools will be used in 1996–1997 to develop, evaluate, and validate AF strategies, concepts, and methodologies for modernization within the NAS. The models will also be used to measure performance for allocating procedures and technologies used in systems management. Promising concepts and methodologies will be evaluated. In 1998, the concepts and methodologies will undergo final validation via field testing at selected locations. AF operational standards will then be developed in 1998.

In 1996, development will begin on the ITS and the EDPRT's. Prototypes will be completed in 1998 with operational systems available by 1999. Additional ITS/EDPRT development needs will be identified in future years based on future NAS technology.

## Project 026–110: Airway Facilities Future Technologies



# 3.0 COMMUNICATIONS, NAVIGATION, AND SURVEILLANCE

The air traffic management (ATM) system's ability to support safe and efficient future flight operations is critically dependent on a high–performance, reliable, cost–effective communications, navigation, and surveillance (C/N/S) infrastructure. Because these systems require avionics development and certification, the FAA takes an active role in assessing and defining system requirements, strengths, and characteristics for appropriate integration into the ATM system.

The sensor and computer technology to provide the desired C/N/S infrastructure is an extension of successful commercial and military developments during the 1980's. One key technology is a high capacity air mobile communication system that permits automated communications between the cockpit and the ground computer automation products being developed in Chapter 2. The International Civil Aviation Organization (ICAO) has recognized the need to develop international standards for this capability and has directed the Secondary Surveillance Radar Improvements and Collision Avoidance Systems Panel to include this standardization activity in its work program.

Another key technology is applying satellites to ATM. The satellite's role in future C/N/S systems has been highlighted by the Future Air Navigation System (FANS) committee established by ICAO in 1983. The FAA has adopted the FANS recommendation as a basis for its C/N/S research program. This technology offers a number of opportunities to improve C/N/S coverage, accuracy, and reliability. Aircraft users are anticipating sufficient benefits and are aggressively planning to incorporate this technology in future airframe deliveries by developing appropriate interface standards. It is essential that the FAA proactively pursue this technology so that validated standards and certification criteria are available in a responsible timeframe. The Research, Engineering and Development (R,E&D) challenge is to provide this C/N/S infrastructure by the mid-1990's for inclusion in the next generation aircraft.

Enhancements in C/N/S achieved through these R,E&D projects provide the basis for dramatic improvements in system performance including improved safety, reduced delay, increased capacity, and greater efficiency. These three functional areas represent key ATM infrastructure elements. For this reason, many of the quantitative benefits from this area will be realized by implementing projects in the capacity and ATM technology thrust area. For example, the Aeronautical Data Link project, the Satellite Communications project, and the Satellite Navigation project provide the technology necessary to achieve the benefits associated with reducing oceanic separation standards in the Oceanic Air Traffic Control (ATC) Automation program.

Several projects in this thrust area are focused on replacing, at the appropriate time, existing systems with systems that have enhanced capabilities. The future benefits assessment for these projects will only focus on the enhancements' value.

The Department of Defense's (DOD) Global Positioning System (GPS) deployment has been justified by national security requirements. The DOD has stated that GPS will be available, at no direct cost, for civilian applications for the next 10 years. Some projects in this thrust area are designed to use the GPS system, supplemented by the Global Orbiting Navigation Satellite System (GLONASS) or Long–Range Navigation (Loran)–C, as the primary means for air navigation. The benefit from these projects will be the ability to forgo using the present very high frequency omnidirectional range (VOR)/distance measuring equipment (DME) network rather than replace the present electronic equipment. Furthermore, the ability to use differential GPS to provide near Category (CAT)–I landing capabilities could make this service available at virtually all airports.

## SUMMARY

It is imperative that the FAA develop an aggressive and coordinated research program to exploit technological capabilities integrated into a safe and efficient ATM system that will satisfy future needs. The emerging C/N/S systems must be integrated with the automation and weather programs to achieve the safe and efficient ATM system that is required.

## 3.1 Communications, Navigation, and Surveillance Project Descriptions

### 031–110 Aeronautical Data Link Communications and Applications

**Purpose:** This project will develop and validate domestic and international data communications standards and data link services associated with the Aeronautical Telecommunications Network (ATN) as well as special purpose air/ground data link capabilities. The ATN will be used for both air/ground and ground/ground data communications, for National Airspace System (NAS), and international aeronautical communications. This project will also provide the technical framework for all NAS systems that plan to implement data link services/applications.

**Approach:**

Communications

Communications protocols for aviation use will be developed, validated, and standardized both nationally and internationally. Domestic standards are being developed with the Radio Technical Commission for Aeronautics (RTCA) and international standards with ICAO. ATN standards are currently being validated with industry participation.

A critical effort for this project is investigating extended use of the Mode S Squitter for delivering GPS–based aircraft position reports. This automatic dependent surveillance (ADS) concept, if validated, will provide an enabling technology that supports Airport Surface Traffic Automation (ASTA) in developing an airport surface surveillance system. Additionally, this technology will serve as a basis for future cockpit traffic information systems.

Applications

Data link services in oceanic, en route, terminal, and tower environments are defined in coordination with the air traffic and aviation user communities. These services will be developed and evaluated by a team that includes air traffic controllers, pilots, and other system users as appropriate. Demonstrations will then be conducted with both ground and airborne system users to validate the overall operational system effectiveness.

The operational and procedural benefits of data link applications will be verified using full–fidelity airborne and ground simulation facilities. The tower ATC services will be evaluated at selected airports in a fully operational environment with participating air carriers. Routine and hazardous weather applications will be demonstrated and evaluated in various simulation and airborne test bed facilities. Weather and aeronautical services such as traffic advisories, digital automatic terminal information service (ATIS), and ADS–Mode S Squitter applications will be validated using this approach.

**Related Projects:** 021–140 Oceanic Air Traffic Automation, 021–180 Terminal ATC Automation (TATCA), 021–190 Airport Surface Traffic Automation (ASTA), 022–150 Flight Operations and Air Traffic Management Integration, 025–110 National Simulation Capability, 031–120 Satellite Communications Program, 031–130 NAS Telecommunications for the 21st Century, 041–110 Aviation Weather Analysis and Forecasting, 041–120 Airborne Meteorological Sensors, 042–110 Integrated Airborne Windshear Research, and 084–110 Flightdeck/ATC System Integration. Capital Investment Plan Projects: 21–12 Advanced Automation System (AAS), 21–13 Automated En Route Air Traffic

Control (AERA), 24–12 Mode S, 62–20 Terminal Air Traffic Control Automation (TATCA), 62–21 Airport Surface Traffic Automation (ASTA), 63–05 Aeronautical Data Link Communications and Applications, 63–21 Integrated Terminal Weather System (ITWS), and 63–22 Aviation Weather Products Generator (AWPG).

**Products:**

- U.S. and international ATN data communications and applications standards
- Specifications for production automation and communication systems that utilize/support data link
- Prototype systems to support operational data link service evaluations
- Demonstration test beds for developing advanced weather, flight information, and ATC services
- Test bed for ATN development, evaluation, and validation

**1994 Accomplishments:**

- Completed ATN internetwork communication standards.
- Developed computer–generated voice and digital ATIS.
- Completed RTCA flight information services minimum operational performance standards (MOPS).

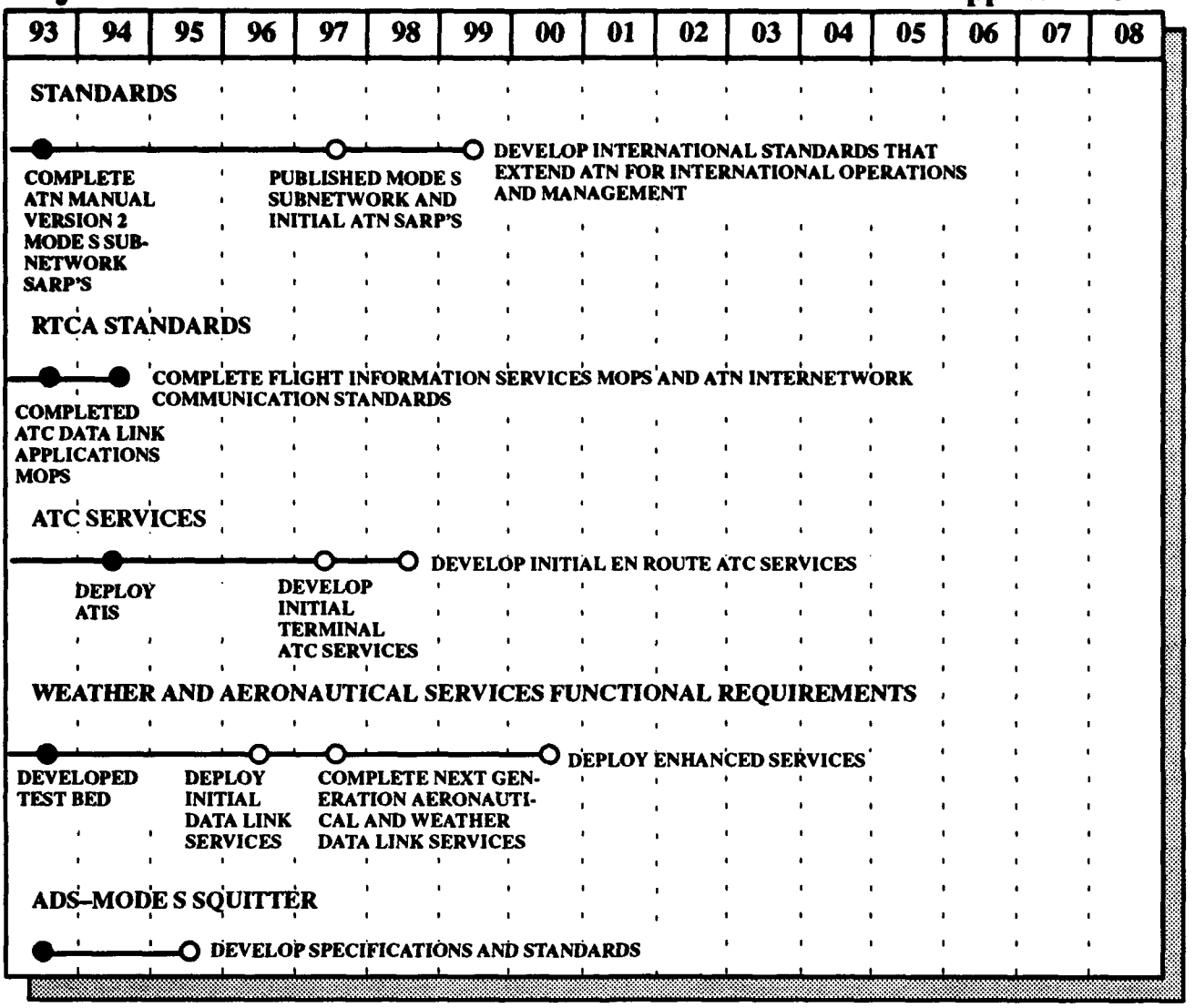
**Planned Activities:** In 1995, operational procedures development will continue for ATC air/ground data link applications in en route, terminal, and tower environments. First operations for the initial terminal ATC data link services are planned for the 1996–1997 timeframe, followed by en route services in 1997–1998.

ICAO standards and recommended practices (SARP's) for Mode–S data link and ATN will be published in 1997 for the initial ATN. R,E&D activities will continue through 1999 to support developing and validating standards that extend the ATN for international operations and management. ATN research, jointly sponsored by FAA and industry, will validate the ATN protocols and standards. This effort will be accomplished through a cooperative flight test program that will be completed in 1997 to support initial ATN validation and provide ATN operating experience.

In 1996, initial weather and aeronautical data link functions will be deployed. In 1997, functional specifications will be completed for the next generation aeronautical and weather data link services, with implementation targeted for 2000. This research will provide graphical and route–oriented weather information to airborne users via the ATN.

In 1995, development efforts will continue on surface/air surveillance applications that use ADS techniques based on GPS aircraft position information. These applications will employ the Mode S Squitter for delivering this data to airport surface and terminal surveillance systems. Demonstrations are also planned with system specifications and standards completed in 1995.

## Project 031–110: Aeronautical Data Link Communications and Applications




## 031–120 Satellite Communications Program

**Purpose:** This project will develop the standards and perform required testing to support mobile satellite communication (SATCOM) operational use for civil aviation beginning with oceanic, offshore, and remote regions. This capability will be extended to enhance NAS communications and surveillance functions.

**Approach:** This project is separated into four distinct initiatives:

Developing Satellite Communications Data Capabilities for Oceanic and Remote Regions

The FAA will support draft ICAO SARP's and guidelines development for frequency coordination. Additionally, support will be provided to RTCA Special Committee 165 to develop MOPS and ensure that the MOPS are consistent with the SARP's.

SARP's validation will be performed using simulation, analysis, testing, and demonstration. A test plan to validate SARP's and MOPS will be completed. A ground test facility will be developed to conduct system end–to–end and radio frequency (RF) tests to validate standards not currently validated by manufacturers' data. In addition, flight tests will be performed to evaluate state–of–the–art equipment and system enhancements. Aeronautical mobile satellite service (AMSS) testing will be conducted with industry– and FAA–developed equipment. Simulation will be used to evaluate the planned architecture performance and limitation under various communication traffic conditions.

Developing Satellite Communications Voice Capabilities for Oceanic and Remote Regions

This initiative is necessary to provide satellite voice capability between the cockpit and the Air Route Traffic Control Center (ARTCC) in oceanic flight information regions. In conjunction with RTCA, a guidance document will be produced describing the full range of technical requirements to provide satellite voice capability. In coordination with the oceanic project office, an architecture will be developed that will enable controllers to send and receive direct satellite voice communications. This effort includes developing appropriate interfaces for FAA equipment. Flight trials will be conducted with major airlines to demonstrate/evaluate satellite voice capabilities.

Implementing Satellite Communications Services in Oceanic and Remote Regions

This initiative addresses support for the Communications/Surveillance Operational Implementation Team (C/SOIT). This support includes technical expertise, analyses, and technical data. The team is responsible for developing operational regulations and procedures that implement satellite communications. The benefits derived from SATCOM require a combined effort among ATN, ADS, ARTCC automation, and SATCOM. The C/SOIT ensures the joint implementation of these efforts. Technical data will be collected from bilateral and multilateral engineering trials. This effort will integrate real–time end–to–end communications and communication emulation capabilities into the Oceanic Development Facility.

Developing Satellite Communications Services for Selected Domestic Applications

The currently defined oceanic AMSS system may have applications in domestic areas. For example, offshore or mountainous regions where very high frequency (VHF) does not penetrate could benefit from AMSS service. It is also possible that emerging SATCOM technology, including possible Low Earth Orbiting or Medium Earth Orbiting systems, can provide reliable and efficient data/voice capability that meets domestic requirements at a reasonable cost. This project will conduct feasibility studies and evaluations on lower cost, lightweight satellite communications avionics for general aviation and rotorcraft. Additionally, analysis is underway to determine architecture requirements for future SATCOM use.

**Related Projects:** 021–140 Oceanic Air Traffic Automation, 023–120 Separation Standards, 031–110 Aeronautical Data Link Communications and Applications, and 032–110 Satellite Navigation Program. Capital Investment Plan projects: 61–22 ATC Applications of Automatic Dependent Surveillance (ADS) and 63–05

Aeronautical Data Link Communications and Applications.

**Products:**

- International AMSS SARP's with ICAO
- MOPS for AMSS avionics with RTCA
- AMSS voice communications architecture

**1994 Accomplishments:**

- Developed/validated ICAO AMSS SARP's.
- Conducted engineering trials for satellite communications voice capabilities in oceanic and remote regions.
- Published communications/surveillance operational implementation team plan.
- Completed requirements definition on alternative SATCOM technologies for domestic applications.

**Planned Activities:**

Developing Satellite Communications Data Capabilities for Oceanic and Remote Regions

In 1998, ICAO AMSS MOPS and SARP's verification will be completed. Data collected during operational tests will be used in industry avionics bench testing for SARP's compliance certification and ICAO approval in 1998.

Developing Satellite Communications Voice Capabilities for Oceanic and Remote Regions

In 1995, RTCA guidance documentation will be published on SATCOM voice avionics. In 1996, architecture provisions based on this documentation will be completed for ground interfaces with FAA equipment.

Implementing Satellite Communications Services in Oceanic and Remote Regions

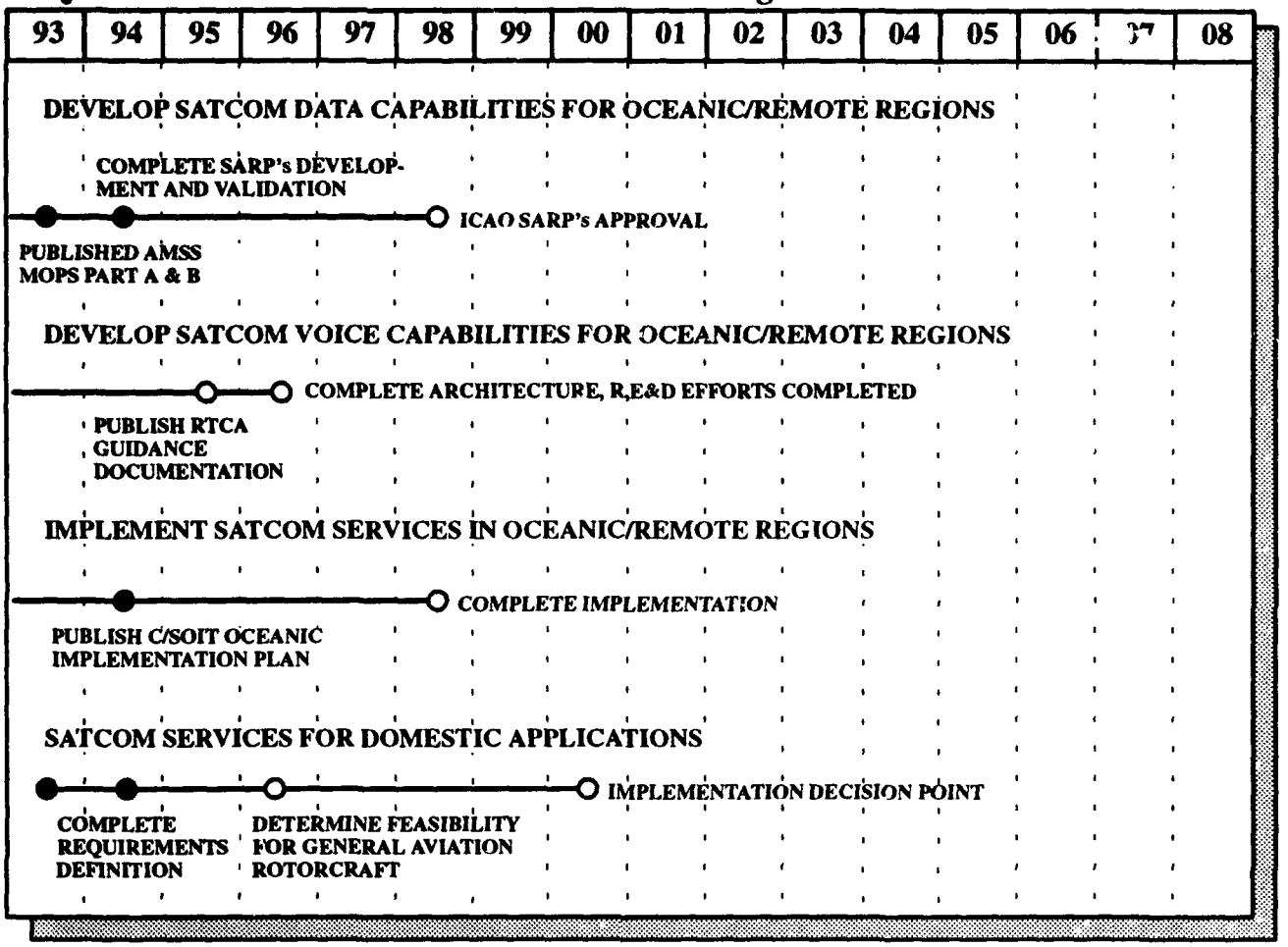
In 1995, data collection will continue from Pacific and Atlantic engineering trials. This data will be provided to the C/SOIT for regulatory and procedural implementation guidance. The C/SOIT plan specifies an incremental oceanic SATCOM implementation program that will be completed by 1998.

Developing Satellite Communications Services for Selected Domestic Applications

In 1996, a feasibility determination will be completed on lower cost, lightweight SATCOM avionics for general aviation and rotorcraft.

In 1995, further research based on the alternative SATCOM technology requirements definition will be initiated on long–term alternatives for providing SATCOM service in domestic areas. Anticipated completion for this effort is expected in 1999. A decision point on implementing proven technologies will occur in 2000.

## Project 031–120: Satellite Communications Program




## 031–130 NAS Telecommunications for the 21st Century

**Purpose:** This project supports the development of the next generation NAS communications system by evaluating alternatives in new communication technology to satisfy future operational NAS requirements and goals. This effort is a multiyear project that is intended to speed the introduction of new technology into the NAS Communications System. The current priority is to improve the air/ground (A/G) communication system.

A key shortfall in the current VHF A/G system is the lack of capacity to accommodate increasing traffic load. Competition for additional frequency spectrum is intense and will constrain internationally allocated VHF frequencies. Expanding VHF system capacity will require new VHF radios for both the FAA and user communities. To effect an orderly transition, planning for this new radio system must begin well before the spectrum capacity is exhausted in the current system. Also, a U.S. position on VHF system improvement must be presented to the International Civil Aviation Organization at the 1995 Montreal conference.

**Approach:** This project will demonstrate how new technology will benefit the next generation NAS communications system. Overall objectives include: focusing R,E&D funding on leveraging new technology; reducing communication system cost; and adhering to a disciplined system engineering approach.

New technologies will be explored to quantify their performance in meeting NAS capacity and reliability requirements. Key factors to consider are: using commercial equipment whenever possible; streamlining operations; developing a transition plan; and integrating with other NAS elements. A cost–benefit study will be completed for each potential technology, and a trade–off analysis will be performed among alternatives.

System requirements, operational concepts, system design, and appropriate standards will be developed for an air/ground digital voice and data communication system. Technology transfer efforts will be initiated to facilitate industry participation in system development. High risk system elements will be thoroughly prototyped and tested. Challenges this project will face during system development include: accommodating evolving national and international communication standards and applying global addressing, routing, and network management technologies.

**Related Projects:** 031–110 Aeronautical Data Link Communications and Applications. Capital Investment Plan projects: 23–05 Aeronautical Data Link and 56–15 NAS Spectrum Engineering Sustained Support.

**Products:**

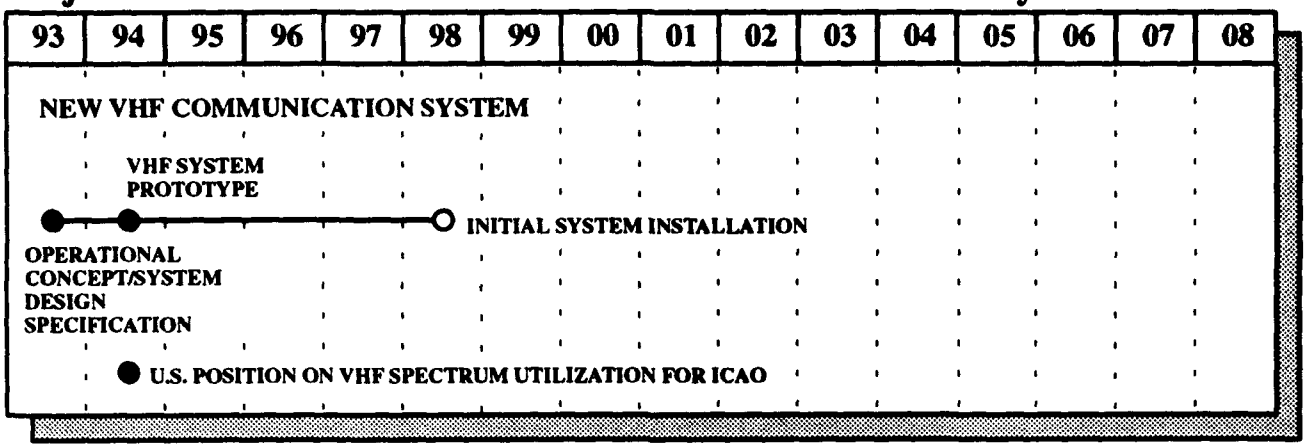
- Internationally compatible requirements and standards for a new VHF air/ground communication system
- Operational concept document for the new communications system
- New VHF communication system design specifications
- New VHF communication system prototype, including flight demonstrations
- RFP for system procurement

**1994 Accomplishments:**

- Developed and flight tested prototype radio system.
- Developed U.S. position on VHF spectrum utilization for ICAO.

**Planned Activities:** Continuing in 1995, procurement specifications will be prepared to support a request for proposal (RFP) in 1996 with contract award expected in 1997. Initial installation of the new system is expected to begin in 1998.

## Project 031–130: NAS Telecommunications for the 21st Century




## 032–110 Satellite Navigation Program

**Purpose:** This project will develop augmentations to navigation satellites (e.g., GPS) to support techniques, procedures, and standards to meet all civil aviation navigation needs using a single navigation receiver. Civil aviation navigation needs to be met include oceanic, en route, terminal, non–precision approach, precision approach, auto–landing, and airport surface navigation. Satellite navigation presents opportunities for standardized worldwide civil aviation operations using a common navigation receiver and for significant improvements in safety, capacity, service flexibility, and operating costs. Adopting satellite navigation systems could lead to phasing out existing National Airspace System ground equipment while maintaining or improving existing service levels. In addition, satellite–based navigation systems provide the potential for new navigation and landing services not currently supported by existing systems.

**Approach:** The initial focus will be on developing standards and methods to use the Global Positioning System with no augmentations as a supplemental aid to meet civil aviation requirements. Project activities will investigate GPS augmented for Required Navigation Performance (RNP) for en route, airport surface, departure, and precision approach applications, including curved and missed approach guidance. The RNP is an internationally defined measure of a navigation system's performance within a defined airspace, including current navigation system operating parameters within that airspace. GPS augmented for RNP will constitute a "stand–alone" configuration with required redundancy. The overall program will be supported by establishing a Satellite Navigation Test Bed at the FAA Technical Center. The test bed will be used to verify theoretical analyses, collect data in a realistic environment, simulate "worst case" scenarios, and provide a means to analyze performance data.

The Satellite Navigation program will be structured with four interrelated and complementary thrusts. These will focus on the Civil Aviation Service, operational implementation of the service, international activities, and related programs.

**Related Projects:** 021–140 Oceanic Air Traffic Automation and 021–190 Airport Surface Traffic

Automation (ASTA). Capital Investment Plan projects: 61–22 ATC Applications of Automatic Dependent Surveillance (ADS) and 62–21 Airport Surface Traffic Automation (ASTA).

**Products:**

- Satellite–based instrument approach procedures
- MOPS for GPS supplemental use in the NAS
- Augmentation requirements for GPS to meet civil aviation RNP
- MOPS for avionics to meet RNP
- Minimum avionic system performance standards (MASPS) for special use CAT I

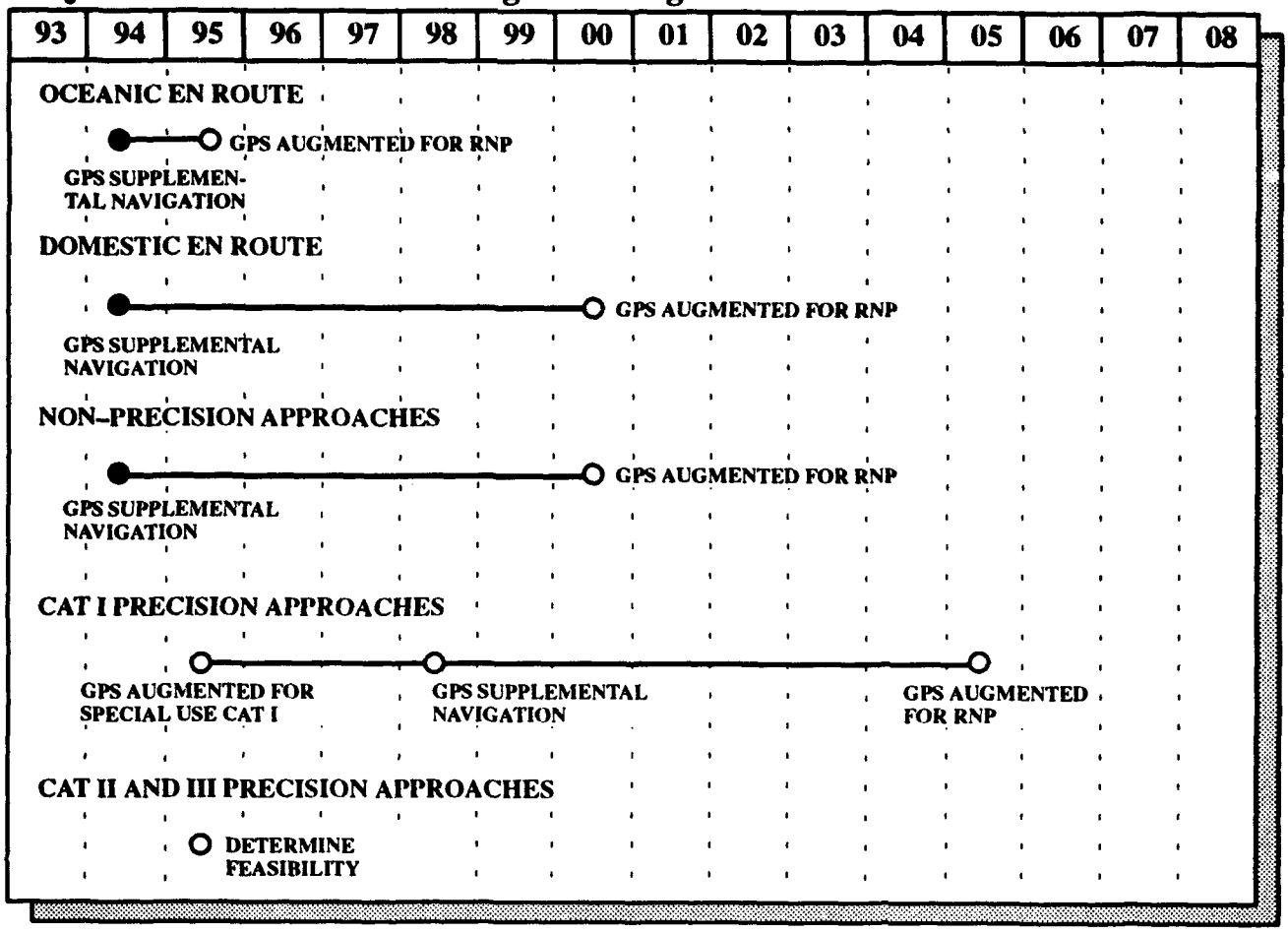
**1994 Accomplishments:**

- Completed MOPS for GPS augmented for RNP.
- Completed experiments/specifications for ground–based integrity monitoring.
- Implemented GPS supplemental use for oceanic en route, domestic en route, and non–precision approaches.

**Planned Activities:** Demonstrations will continue in 1995 for CAT I instrument approaches, non–precision approaches, oceanic, en route, and terminal operations. These activities will support standards and operational procedures development to permit early satellite navigation system implementation for civil aviation. Research will be completed in 1995 on GPS CAT II/III approach feasibility. This data will be used to support Microwave Landing System (MLS)/GPS tradeoff decisions.

In 1995, GPS augmented for RNP will be implemented in oceanic airspace followed by domestic en route airspace in 2000. GPS supplemental precision approaches to CAT I will be approved for private use in 1995, public use in 1998, and RNP scheduled for 2005.

## Project 032–110: Satellite Navigation Program




## 032–120 Navigation Systems Development

**Purpose:** The FAA has the responsibility for the development and implementation of radionavigation systems to meet the needs of all civil and military aviation, except those peculiar to air warfare. This project will identify and evaluate emerging technologies and new concepts for meeting future navigation service requirements. A major effort will be recommending the strategy for transitioning into satellite–based navigation.

This project also supports the Federal Radionavigation Plan (FRP) biennial revision and provides the FAA input to the joint Department of Transportation (DOT) and DOD Radionavigation Working Group.

**Approach:** The key project element is developing a NAS Navigation Plan to provide the strategy for a major shift to satellite technology. This plan will focus on resolving three major issues: current navigation system supportability; transition to satellite–based navigation; and potential ground–based systems phaseout.

Until a transition to satellite systems is completed, research will continue on current

ground–based system supportability issues. An assessment will be conducted to identify potential operating cost reductions, performance enhancements, or new function additions to navigation aids now operated by the FAA. Available technology will be identified and the potential to enhance navigation aids will be examined. Algorithms for enhancements will be developed and applied in laboratory simulations to test their effectiveness. An example is improving the VOR antenna system to reduce sensitivity to the site environment.

The RNP Working Group, including representatives from the satellite and separation standards program offices, will develop criteria for reducing separation standards.

Supplemental studies and analyses will be performed to support developing the FRP. Based on the research results, recommendations will be made on the appropriate system mix to be included in the FRP. A national aviation standard will be prepared and maintained for each system approved for use in the NAS.

**Related Projects:** 021–140 Oceanic Air Traffic Automation, 023–120 Separation Standards, and 032–110 Satellite Navigation Program. Capital Investment Plan projects: 61–22 ATC Applications of Automatic Dependent Surveillance (ADS) and 64–05 Global Navigation Satellite System.

**Products:**

- NAS Navigation Plan
- Reports on enhancing performance and reducing costs of existing ground navigation systems
- GPS Notice to Airmen (NOTAM) capability
- National aviation standards for radionavi tion systems
- Recommendation for the NAS system mix
- Biennial FRP publication

**1994 Accomplishments:**

- Developed NAS Navigation Plan.
- Developed interim GPS NOTAM capability.
- Published 1994 Federal Radionavigation Plan.

**Planned Activities:** In 1995, the NAS Navigation Plan will be published. The Plan will support a decision by 2000 on the phaseout of Omega, Tactical Air Navigation (TACAN), DME, VOR, Non–Directional Beacon (NDB), and Loran–C. The RNP requirements will be completed in 1995 to support separation standards program objectives.

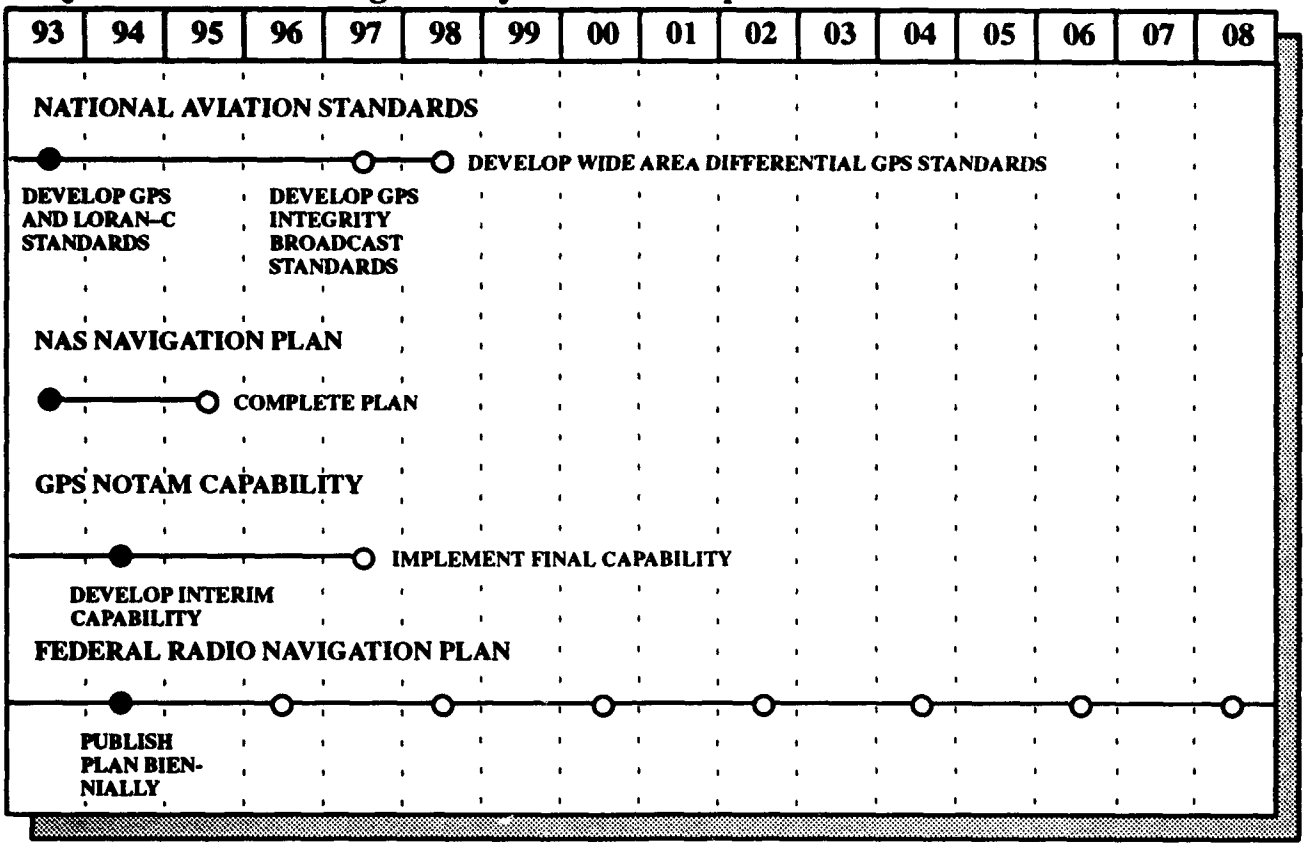
In 1997 and 1998, National Aviation Standards will be developed for the GPS Integrity Broadcast and for Wide Area Differential GPS, respectively. These standards will be used by manufacturers to develop Technical Standard Order approved equipment.

Research on current navigation system supportability will be completed in 1995, leading to a recommendation on replacement system procurement. Systems to be examined include VOR, NDB, and TACAN.

In 1995, work will begin on developing the next edition of the Federal Radionavigation Plan, which is published on a biennial basis.

A final GPS NOTAM capability will be implemented in 1997 to support GPS RNP requirements.

## Project 032–120: Navigation Systems Development




## 033–110 Terminal Area Surveillance System

**Purpose:** This project will develop the next generation terminal surveillance system by: defining system requirements; determining future operational concepts; assessing emerging technology applicability, benefits, and risks; and developing advanced capabilities in weather detection, aircraft detection, and increased data link capacity. The next generation terminal area surveillance system must support a requirement for primary, secondary, and improved weather detection as well as features to support closely spaced runway approaches. Emerging technology will allow the FAA to meet these demands and improve on operational performance limitations imposed by today's technology. The system must have an ability to detect dry microbursts at useful ranges; measure wind fields from which wake–vortex predictions can be made; detect ice, water, hail, and tornadoes; and support aircraft surveillance operations with seamless coverage and flexible routing tailored to the specific terminal site.

**Approach:** System delays and separation criteria will be reduced through more timely and accurate aircraft detection and improved weather detection capabilities. There will be a strong emphasis on rapidly updating the 3–dimensional weather and aircraft display for controllers. Operations research analysis will be used to assess and identify practical airspace safety and capacity enhancing features in emerging technology.

The FAA and industry will assess these technologies, evaluate potential performance against the terminal area sensor primary and secondary surveillance and weather requirements, and assess technical and operational risks.

New terminal surveillance sensors will use a modular architecture to provide for site adaptation and upgrade at minimal cost. A possible option is to combine primary radar, secondary radar, data link, and hazardous/nonhazardous weather detection in a single high data rate multifunction radar. This option will depend on the potential cost savings balanced against the additional program risk that may be incurred.

Concept development analysis and technology demonstration experiments will be implemented as parallel activities to reduce the potential risk of future development. The results from these experiments will lead to multiple selections for prototype development and testing.

**Related Projects:** 021–230 Wake Vortex Separation Standards Reduction, 031–110 Aeronautical Data Link Communications and Applications, 032–110 Satellite Navigation Program, and 041–110 Aviation Weather Analysis and Forecasting. Capital Investment Plan projects: 24–12 Mode S, 24–13 Terminal Radar (ASR) Program, 24–18 Terminal Doppler Weather Radar (TDWR) System, 34–13 Terminal Radar Digitizing, Replacement, and Establishment, and 44–46 Air Traffic Control Beacon Interrogator (ATCBI) Replacement.

**Products:**

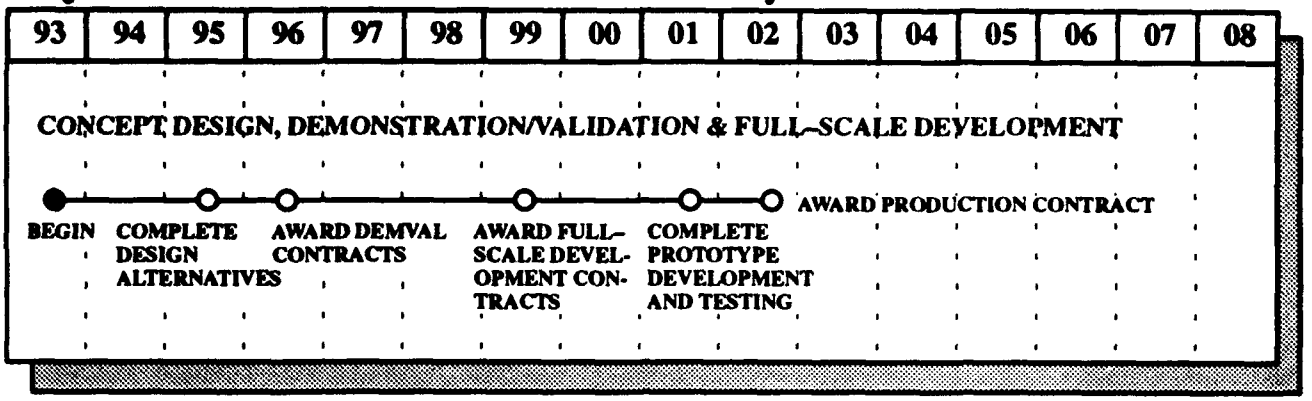
- Operational requirements and design concepts
- Technical requirements feasibility assessments
- Full–scale development prototype
- Production contract

**1994 Accomplishments:**

- Completed Terminal Area Surveillance System (TASS) system definition.
- Awarded TASS concept design contracts.

**Planned Activities:** In 1995, TASS concept designs will be completed. These alternative concepts will be evaluated in 1995, and an RFP will be issued in 1996 for selected demonstration/validation (DEMVAL) design(s). The DEMVAL contract(s) will be awarded in 1996 with the DEMVAL phase completed in 1999. Following this phase, the best design will be selected for full–scale development from 1999–2001. Upon satisfactory completion of prototype testing in 2001, a production contract award is planned for 2002.

## Project 033–110: Terminal Area Surveillance System



# 4.0 WEATHER

The need for weather information in the future air traffic management (ATM) system can be derived from the overall goals for that system: enhance flight safety, increase system capacity, improve flight efficiency, reduce air traffic control (ATC) and pilot workload, improve flight planning, and increase productivity. Weather, perhaps like no other factor, impacts the fundamental aviation mission.

Weather is, and will continue to be, a critical factor in all flight operations. It is the single largest contributor to delays and a major factor in aircraft accidents and incidents. Improved weather forecasts offer the potential for increasing system capacity more cost effectively than most other alternatives, such as new airports and runways. Better short–term forecasts and current information on hazardous weather conditions are critical to ensuring safe flight. Also, timely and accurate weather information is critical to planning fuel- and time–efficient flight plans. Weather service users encompass the entire aviation spectrum, from the student pilot to the operator of the most sophisticated, high–performance commercial aircraft during all flight phases.

The future ATM system will require highly accurate real–time weather warning products and short– and long–term weather forecasts, covering the time period from a few minutes, up to 3, 6, and even 12 hours into the future. Progress in weather research necessary to develop these products, and to implement a system infrastructure to deliver enhanced weather products to end–users, will be critical to addressing this need.

The aviation weather thrust area includes a combination of Research, Engineering and Development (R,E&D) weather projects and new Capital Investment Plan (CIP) weather initiatives that will build upon ongoing weather system development to realize the above needs and goals. Both components are critical to the overall success of the weather system modernization effort. The remainder of this chapter discusses the aviation weather program and is organized as follows:

- Aviation weather mission needs — The overall needs and goals touched upon above are discussed in greater detail.
- Issues associated with satisfying mission needs — Several issues integral to accomplishing the weather mission needs are outlined. Finding solutions to these will be the major emphasis of the FAA's weather research program.
- New CIP weather developments — The aviation weather products generator (AWPG), aviation gridded forecast system (AGFS), integrated terminal weather system (ITWS), and other projects are described in terms of their places in the weather research program.
- Weather System Benefits — A brief overview on the weather system's benefits.

## AVIATION WEATHER MISSION NEEDS

Good flight planning is necessary for all flight operations. The operation starts with an initial flight plan followed by any necessary modifications to the plan as the flight evolves. Flight plan decisions are made by pilot/controller interactions. The aviation weather system needs to provide the necessary weather products and efficiently deliver them to pilots and controllers in a format that will not require interpretation by a meteorologist.

A principal need is the capability to provide weather information to support hazardous weather avoidance. In a planning sense, the aviator

needs to have good forecast information to avoid hazards in flight. Current and near–term information on windshear, hazardous cells, heavy rain, hail, icing, lightning, turbulence, and low visibility, when delivered in time to avoid these events, will support the tactical notion of avoidance. Good strategic planning also requires products directly usable by the aviator or specialist. This requirement is especially true in the terminal area where there is less time to interpret local events, such as windshear, that unfold at a rapid rate.

Efficiency is determined by minimizing time in flight or fuel used. Flight efficiency to a large degree implies the capability for economic or pilot–chosen routing. This capability implies a significant need for timely and accurate strategic weather information during flight planning so that a route can be selected to minimize the need for dynamic rerouting during flight.

In the terminal area, predicting significant wind shifts is needed to optimize runway management. In addition, more accurate wind field analyses will provide terminal air traffic automation systems with optimal descent profiles. Enhanced hazardous weather depiction will mitigate weather impacts on arrival and departure corridors. Improved windshear warnings, microburst detection, thunderstorm predictions, and other products will be particularly important in this regard.

Workload reduction can be accomplished by intelligently applying automated weather information generation and delivery services. Increased direct access to improved weather information will also reduce the negative impact on pilots having to transcribe weather information during critical flight phases (such as Automated Terminal Information Service during arrival). This capability requires products that are timely and accurate using transparent delivery systems and products tailored to the various National Airspace System (NAS) end–user's needs and skills. Systems such as data link and other automated direct delivery will reduce ATC workload, especially for routine weather information. ATC workload would be further reduced by diminishing the tendency to query multiple sectors for weather, especially tactical weather information. Eliminating the need to prepare manually automated broadcasts will also reduce the workload.

Finally, with the increase in oceanic traffic, and in close connection with oceanic air traffic control, there is a need to establish oceanic weather warning and forecast centers that can provide timely weather information. Improved weather information will provide route flexibility commensurate with systems such as Automatic Dependent Surveillance and will enhance trans–oceanic flight safety. This development will be conducted jointly with the National Weather Service (NWS).

## ISSUES ASSOCIATED WITH SATISFYING MISSION NEEDS

The FAA has a number of ongoing programs in the CIP that begin to address the need for weather sensing, data communications, processing facilities, and data display. However, many significant shortfalls will remain in meeting the future ATM system goals:

- The time needed for meteorologists to forecast weather accurately may not meet time requirements for aviation.
- Forecast timeliness, accuracy, and utility will still be inadequate. Forecast data will still be as much as 12 hours old while aviation operations require nowcasts and short–term, 1- to 6-hour, forecasts.
- Important aviation critical weather products such as turbulence forecasts, icing forecasts, enhanced windshear detection and warnings, ceiling/visibility forecasts, and winds aloft

do not meet modern airspace system requirements in terms of accuracy and precision.

- Advanced automated air traffic control systems, such as Automated En Route Air Traffic Control, Terminal ATC Automation (TATCA), and Traffic Management System, require enhanced weather products on an increased frequency with higher resolution to support new functionality.

- Ground–based measurements of humidity and turbulence are inadequate to permit accurate aviation weather forecasting. Therefore, airborne measurements are needed to improve critical aviation weather forecasts. These measurements will be accomplished by increasing ARINC Communications Addressing and Reporting System's (ACARS) weather measurement capability.

- Forward–looking airborne windshear hazard detection and warning will provide flightcrews with windshear warnings at locations where ground systems are not installed.

- The FAA needs to develop automation capabilities to take full advantage of the National Weather Service's modernization and restructuring, including improved forecast products and services.

These shortfalls will be overcome by implementing the new CIP developments and the R,E&D projects. Both the CIP and the R,E&D projects are essential for meeting the aviation weather mission needs and providing the infrastructure necessary to meet future aviation weather needs.

## NEW CIP WEATHER DEVELOPMENTS

The FAA has greatly enhanced the national aviation weather program by developing three new major initiatives: the ITWS, AWPG, and AGFS. Each of these CIP projects provides critical weather product generation and delivery systems that will be a major value-added component to the earlier NAS and NWS modernization programs. These three initiatives were developed to capitalize on the FAA and NWS modernization program that is projected to increase weather information quality and quantity during the 1990's and beyond.

The AGFS, operated as an NWS system, will generate very high resolution gridded (aviation impact) meteorological analyses and forecasts required to produce aviation–specific weather products. The AGFS will include data from national, regional, and local instrumentation platforms, national numerical guidance products, and regional mesoscale model output.

The ITWS will integrate and process weather data from terminal area sensors and the NWS. It will provide automated products to the air traffic control tower, Terminal Radar Approach Control (TRACON), traffic managers, pilots, and other airport area users of time–critical weather information. In its first phase, ITWS completes the windshear integration task first identified and tested as part of the CIP Terminal Doppler Weather Radar (TDWR) and Low–Level Windshear Alert System (LLWAS) projects. The ITWS will also provide weather data and information to the AWPG system and the NWS.

The AWPG system, consisting of regional (RAWPG) and national (NAWPG) components, will collect, integrate, and process data from both the AGFS and ITWS providing user specific, aviation weather products to regional and national FAA facilities. The RAWPG and NAWPG will reside at the Air Route Traffic Control Centers and the Air Traffic Control System Command Center, respectively. The major AWPG goals are to generate aviation–specific weather products tailored for a variety of aviation users and to improve product distribution. Initial AWPG

capabilities will be installed on existing or planned platforms before initial AWPG system deployment.

Rapid prototyping and operational evaluation capabilities will be provided by the Aviation Weather Development Laboratory in Boulder, Colorado, and the Experimental Forecast Facility at Kansas City, Missouri. These development and evaluation activities will be further validated in the FAA's National Simulation Capability, resulting in operationally acceptable products and services.

Improved thunderstorm and microburst forecast products will be developed in direct support to AWPG and ITWS, and demonstrated in the Aviation Weather Development Laboratory. Finally, refinements to TDWR, Airport Surveillance Radar–9, and Enhanced LLWAS capabilities will be provided.

An integral part of the CIP weather elements will be providing weather services to other NAS, CIP, and external elements, such as flight service station, airport, and airline operators.

## WEATHER SYSTEM BENEFITS

Weather detection and forecasts provide a description of the environment surrounding aircraft during all flight phases. Improvements in our ability to understand, forecast, and accommodate changes in the weather, particularly hazardous weather, will yield a wide variety of benefits.

The Airborne Meteorological Sensors project will provide the ability to detect and measure turbulence and humidity in flight. When coupled with the data link project to down–link this information to forecasting systems on the ground, this project will provide improved data for flight planning and improve the weather forecasts used in all flight phases.

The Integrated Airborne Windshear research will be used to detect airborne windshear hazards. When coupled with the ground–based LLWAS and TDWR, this research will provide increased flight safety.

A benefits evaluation of the FAA's new weather initiatives was performed by the System Engineering and Integration Contractor. The contractor estimated that the projects in the CIP and R,E&D Plan will together provide benefits between the years 1991 and 2006 that total $12 billion. These benefits are distributed as follows: safety – $3.61 billion; delay avoidance – $6.13 billion; user preferred route accommodation – $0.40 billion; improved productivity air traffic/ airway facilities – $0.16 billion; and operations and maintenance – $1.78 billion.

## 4.1 Weather Project Descriptions

### 041–110 Aviation Weather Analysis and Forecasting

**Purpose:** This project will enhance the basic understanding of weather as it affects aviation. Since weather impacts on the NAS are spatially small (mesoscale), this project will be integrated with other national research program activities that focus on the atmospheric mesoscale analysis and prediction problem. A further purpose is to concentrate research efforts on developing new algorithms, numerical weather analysis and prediction models, and methods to detect/predict the impact from weather hazards. This research will significantly improve weather product and forecast quality, thus enabling aviation weather users to make effective strategic and tactical decisions for aviation operations.

**Approach:** This project includes three major components: (1) participating in interagency activities to understand aviation weather phenomena better; (2) developing models and algorithms for generating nowcast and short–term aviation–specific products; and (3) developing and testing computer–aided training modules for the users of newly developed forecasting methods and products. These areas include icing forecasts; en route and transition turbulence, ceiling, and visibility; thunderstorm and microburst prediction; wind analysis and forecasting; and oceanic weather observation, analysis, and forecasting.

The objectives in the weather R,E&D program are incorporated in the stated goals of the U.S. Weather Research Program (USWRP), which is a congressionally mandated interagency program under the lead of the National Oceanic and Atmospheric Administration. The FAA will participate in the USWRP to address regional and local scale weather phenomena that are unique to aviation. The USWRP's strategic priorities of most interest to the FAA are to "improve local and regional weather forecasts" and to "achieve efficiencies by coordinating efforts of federal agencies, state institutions, the academic research community, and the private sector." Involvement in the USWRP will benefit a significant portion of the R,E&D program.

The major objective for icing forecasting improvements is to develop an aircraft structural icing forecast capability. This capability will provide accurate delineation of actual and expected icing areas by location, altitude, duration, and potential severity. Another element in the structural icing program is to create a capability to forecast the onset, intensity, and cessation of structural icing on the ground to support deicing activities.

Detecting and avoiding clear air turbulence can improve NAS safety and capacity. This research effort will develop a model for short–term en route and transition turbulence forecasting using wind, temperature, and moisture data. A variety of models will be developed and applied to forecasting wind flow patterns, downbursts, wind direction changes, windshear, and gust fronts for the lower atmosphere.

This research and development project is being coordinated with and accomplished through an interagency agreement with the National Science Foundation and National Center for Atmospheric Research. The Aviation Weather Analysis and Forecasting project will provide current analyses, nowcasts, and short–range predictions of relevant atmospheric fields and hazardous weather phenomena. Products derived from the above information will be tested and evaluated by the Aviation Weather Development Laboratory (AWDL) at Boulder, Colorado, and the Experimental Forecast Facility (EFF) at Kansas City, Missouri, to facilitate transition of appropriate

products to operational aviation weather services.

**Related Projects:** 021–140 Oceanic Air Traffic Automation, 031–110 Aeronautical Data Link Communications and Applications, and 033–110 Terminal Area Surveillance System. Capital Investment Plan projects: 21–12 Advanced Automation System (AAS), 61–22 ATC Applications of Automatic Dependent Surveillance (ADS), 61–23 Oceanic Automation System (OAS), 63–05 Aeronautical Data Link Communications and Applications, 63–21 Integrated Terminal Weather System (ITWS), and 63–22 Aviation Weather Products Generator (AWPG).

**Products:**

- Precise and usable algorithms and/or numerical models related to icing, turbulence, convective initiation, visibility, ceiling, and snowstorm forecasting
- New mesoscale numerical data assimilation and prediction models adapted to aviation needs and new methods for nowcasting
- New prototype aviation weather products for AWDL and EFF test and evaluation
- Automated techniques for detecting, quantifying, and forecasting meteorological events
- Computer–aided training modules for using new forecasting techniques and products

**1994 Accomplishments:**

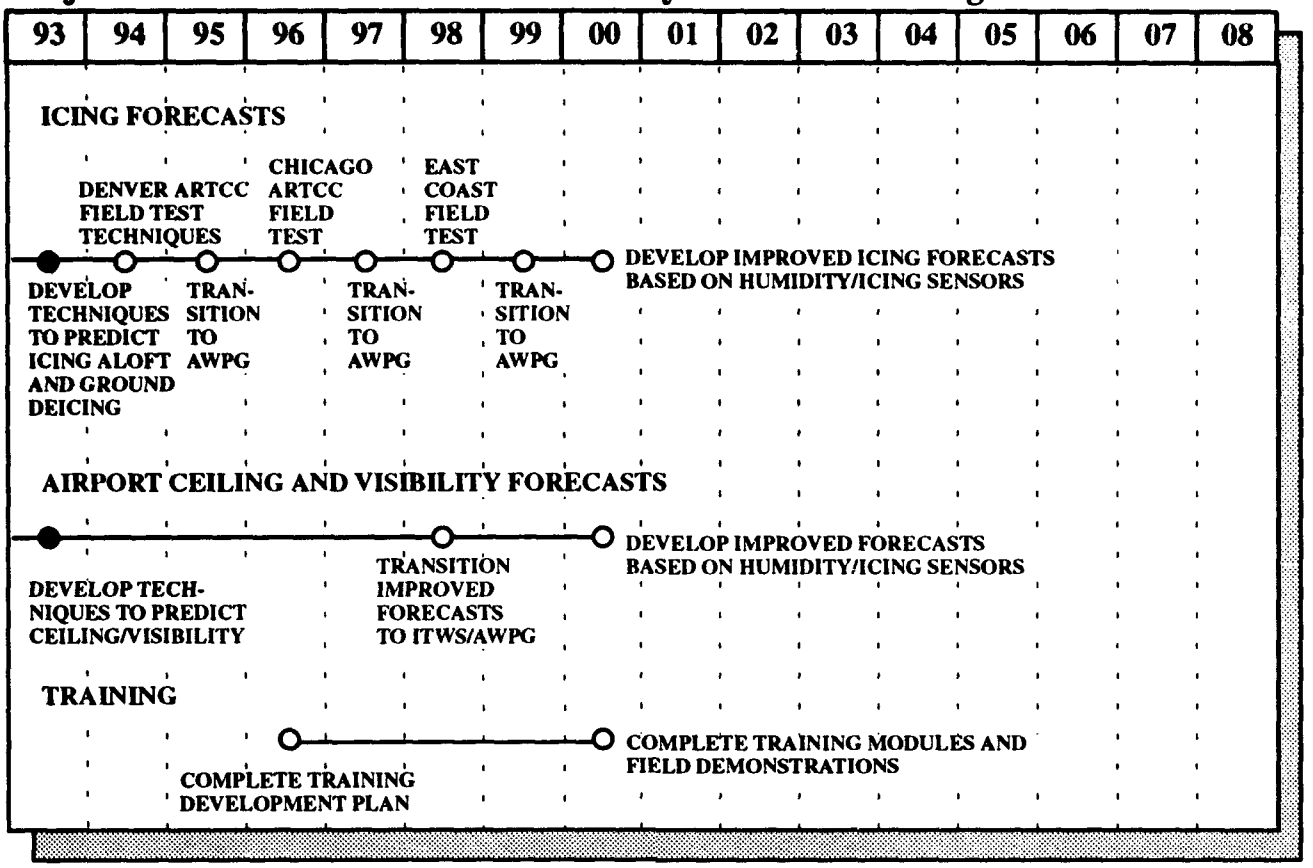
- Field tested winter icing forecasting techniques at Denver ARTCC.

**Planned Activities:** Field testing and demonstrations on winter icing forecasting techniques for the Chicago and east coast ARTCC's will be accomplished in 1996 and 1998, respectively. These techniques will then transition the Denver test results to the AWPG in 1995, the Chicago results in 1997, and the east coast results in 1999. Improvements in icing forecasts will continue to 2000 using the high resolution humidity data available from the airborne humidity sensor developed in Project 041–120.

In 1995, research will continue on automating forecasted changes in ceiling and visibility at airports, with improved forecasts transitioning to ITWS/AWPG in 1998. Further improvements will be developed between 1998 and 2000 using the high resolution humidity data from the airborne humidity sensor.

In 1996, a training development plan will be completed. Individual computer–aided training modules will be developed and demonstrated in 1997–2000.

## Project 041–110: Aviation Weather Analysis and Forecasting




## 041–120 Airborne Meteorological Sensors

**Purpose:** This project will develop specialized airborne meteorological sensors to meet unique, critical aviation weather requirements for 3–dimensional basic meteorological data and aviation–related weather characteristics. Ground–based sensors alone cannot provide the 3–dimensional information needed to create accurate icing, turbulence, and visibility forecast products. These airborne sensors will provide early hazardous weather warning in the terminal and en route airspace. The improvements will reduce passenger and crew discomfort, in–flight injuries, and aircraft accidents.

**Approach:** Meteorological sensors to measure humidity and icing will be developed that can be carried aboard aircraft to provide near–real–time 3–dimensional weather data currently not available from remote sensors. The data obtained from these airborne sensors will automatically be transferred to FAA and National Weather Service weather processing systems by the meteorological data collection and reporting system (MDCRS) operated by ARINC.

The technology developed will provide design guidelines and engineering data to support

industry production and certification initiatives for airborne meteorological sensors. The FAA will work with manufacturers and operators to accelerate sensor development and deployment. Aviation weather products derived from these sensors will be provided to air carriers in the test and validation phase to validate the user requirements and encourage rapid deployment in the air carrier fleet. Prototype airborne sensors will be developed and evaluated in conjunction with Integrated Terminal Weather System and Aviation Weather Products Generator operational testing. This testing will validate the operational usefulness of adding the airborne data.

An aircraft independent turbulence index can be computed from aircraft dynamic response parameters and pressure field spatial variations. These variations are aircraft frame independent, but have a complicated relationship to the turbulence index. Airframe motion estimates of turbulence must be corrected for airspeed, wing loading, and airframe type to yield a universal turbulence index. Research will be carried out to determine the most cost–effective approach to providing the desired turbulence index. Candidate designs will be tested simultaneously in a test aircraft and the resulting predictions compared with the results of turbulence encounters. Algorithms to estimate significant turbulence areas will be developed and tested operationally at the ITWS/AWPG prototype test sites.

Spaceborne, airborne, and/or ground–based icing sensors may be considered in the future to meet the space and time detection requirements for atmospheric icing. Alternative concepts will be evaluated, prototype sensors will be tested and evaluated, and engineering specifications will be prepared to implement an operational system.

**Related Projects:** 021–180 Terminal ATC Automation (TATCA) and 031–110 Aeronautical Data Link Communications and Applications. Capital Investment Plan projects: 63–21 Integrated Terminal Weather System (ITWS) and 63–22 Aviation Weather Products Generator (AWPG).

**Products:**

- Prototype humidity and icing sensors
- Certification of sensors that measure humidity and icing aboard air carrier aircraft
- Design guidelines, engineering data, and functional requirements for the sensors
- Turbulence index algorithms for using the sensor data to provide improved turbulence products
- Automated humidity and clear air turbulence reports downlinked from air carrier aircraft

**1994 Accomplishments:**

- Procured prototype humidity sensor and obtained sensor flight certification.
- Developed turbulence index algorithm.

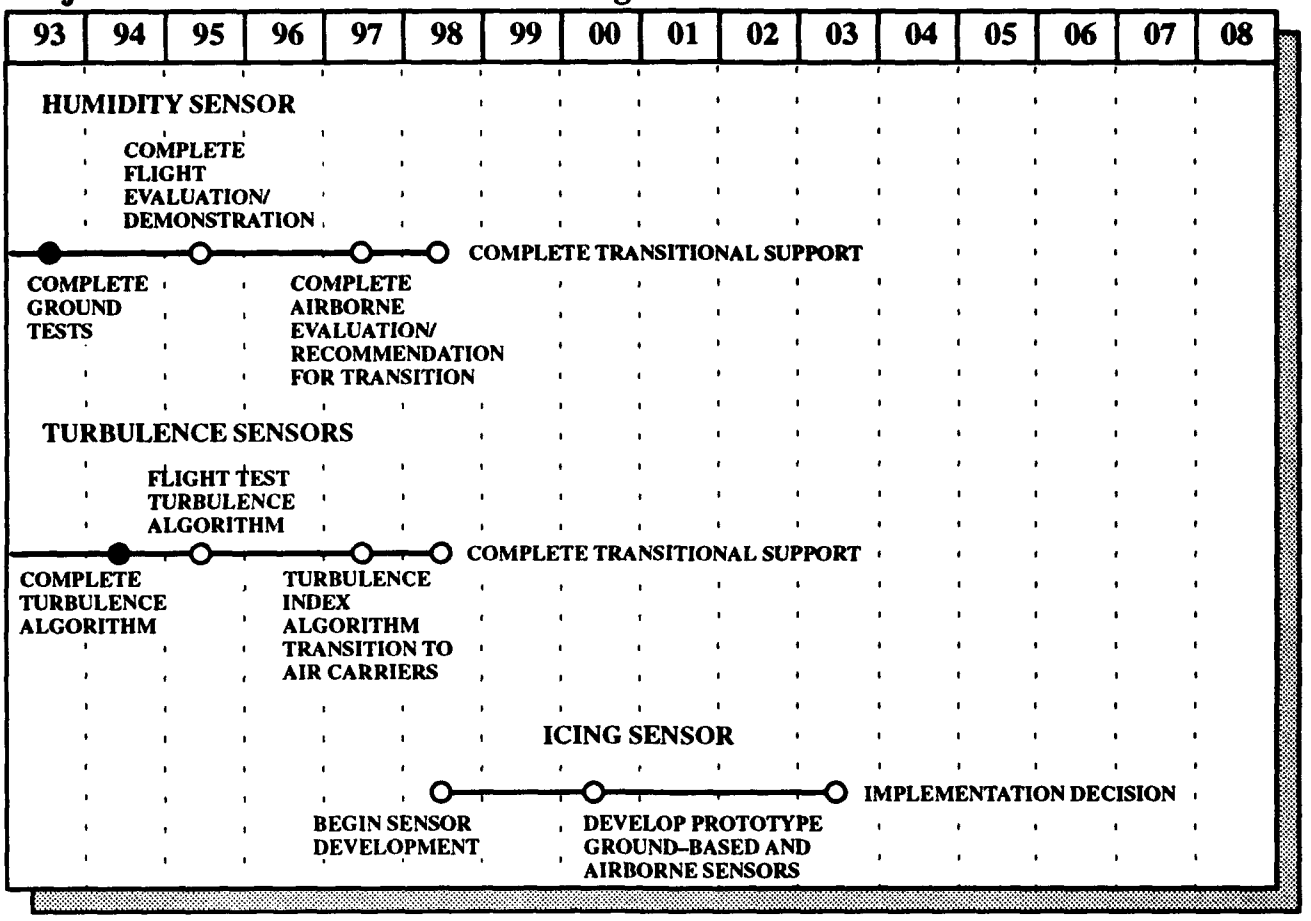
**Planned Activities:** In 1995–1996 experimental humidity sensors will undergo flight test evaluation/demonstration and operational utility assessments. If these assessments suggest a significant cost benefit from more rapid humidity profile updates, multiple off-the-shelf sensors will be recommended for procurement by air carriers in 1997. Transitional support will continue through 1998.

In 1995–1996, the turbulence index algorithm will be flight tested to determine the correlation between the index and aircraft performance. In 1997, the turbulence index algorithm will be transitioned to air carriers for implementation. Transitional support will continue through 1998.

In 1998, work will begin on detecting icing aloft using both ground–based and airborne sensors.

In 2000, an existing ground–based research radar will be modified to detect icing with testing in 2001. An airborne prototype sensor will be developed in 2000, with testing and evaluation completed by 2002. In 2003, a decision will be made on whether ground–based, airborne, or a combination of sensors is required. Once this decision is made, a transition strategy will be developed.

## Project 041–120: Airborne Meteorological Sensors




## 042–110 Integrated Airborne Windshear Research

**Purpose:** This project will develop, test, and analyze systems to provide and validate airborne technology. Windshear is the major cause of weather–related fatalities in the air carrier community. This research will provide an improved operational capability to detect, monitor, and alert flightcrews to windshear hazards.

**Approach:** The program is divided into two areas: (1) airborne windshear advanced technology addresses the equipment certification issues and (2) windshear training applications for Federal Aviation Regulations (FAR) Parts 91 and 135 addresses the training and flightcrew certification issues.

Airborne Windshear Advanced Technology

This work will support airborne windshear equipment development standards and is being accomplished through a cooperative agreement with the National Aeronautics and Space Administration (NASA). The technology developed will provide design guidelines and engineering data to support industry production and certification initiatives for advanced windshear warning systems and flightcrew decision aids. The technology is transferred to manufacturers and operators to accelerate their development and certification programs resulting from FAR 121.358 requirements. The data are provided to FAA certification, regulatory, and compliance offices.

Flight tests will be conducted to evaluate onboard airborne windshear sensor performance by flying the test aircraft into windshear conditions. Additional flight tests will uplink and evaluate available ground products to support time–critical information processing and display in the cockpit. The ground–based ATC system will be supplied airborne-derived information via downlink.

Further research will investigate new applications for windshear sensor technology with an integrated systems approach developed in the joint NASA/FAA windshear program. Results from this research will be applied to clear air phenomena that pose operational and safety problems for civil transport operations.

Windshear Training Applications for FAR Parts 91 and 135

The first effort is to define the implementing issues of the windshear pilot certification in the field combining all the FAR Parts 91, 135, and 121 products into a comprehensive set of documents. Based on these documents, the next task will be to address pilot certification requirements for windshear escape and recovery.

The overall windshear training applications portion is being accomplished in three phases. Phase 1 dealt with crew examination; Phase 2 is developing the four windshear products; and Phase 3 will address windshear training support issues.

**Related Projects:** 031–110 Aeronautical Data Link Communications and Applications and 033–110 Terminal Area Surveillance System. Capital Investment Plan projects: 24–18 Terminal Doppler Weather Radar (TDWR) System, 43–12 Upgrade Low–Level Windshear Alert System (LLWAS) to Expanded Network Configuration, 63–05 Aeronautical Data Link Communications and Applications, 63–21 Integrated Terminal Weather System (ITWS), 63–22 Aviation Weather Products Generator (AWPG), and 64–13 ASR Windshear Processor.

**Products:**

Airborne Windshear Advanced Technology

- *Recommendations* based on study of windshear effects on aircraft performance
- Atmospheric model for lowest 1,000 feet of the atmosphere
- Sensor technology assessments for microwave radar, coherent pulsed light detection and ranging, and passive infrared and sensor integration into flight deck
- Windshear hazard algorithm used with ground–to–air data link to provide information on the flight deck
- Operational requirements for airborne windshear warnings
- Airborne windshear sensor to detect clear air turbulence

Windshear Training Applications for 91/135

- Windshear self–study training aid for general aviation
- Windshear ground school training and simulator aids for air taxi and commuter operators
- Revision to Advisory Circular 00–50A, Windshear

**1994 Accomplishments:**

Airborne Windshear Advanced Technology

- Completed mountain rotor hazard characterization and definition.

Windshear Training Applications for 91/135

- Completed Phase 3 which successfully concludes this research area.

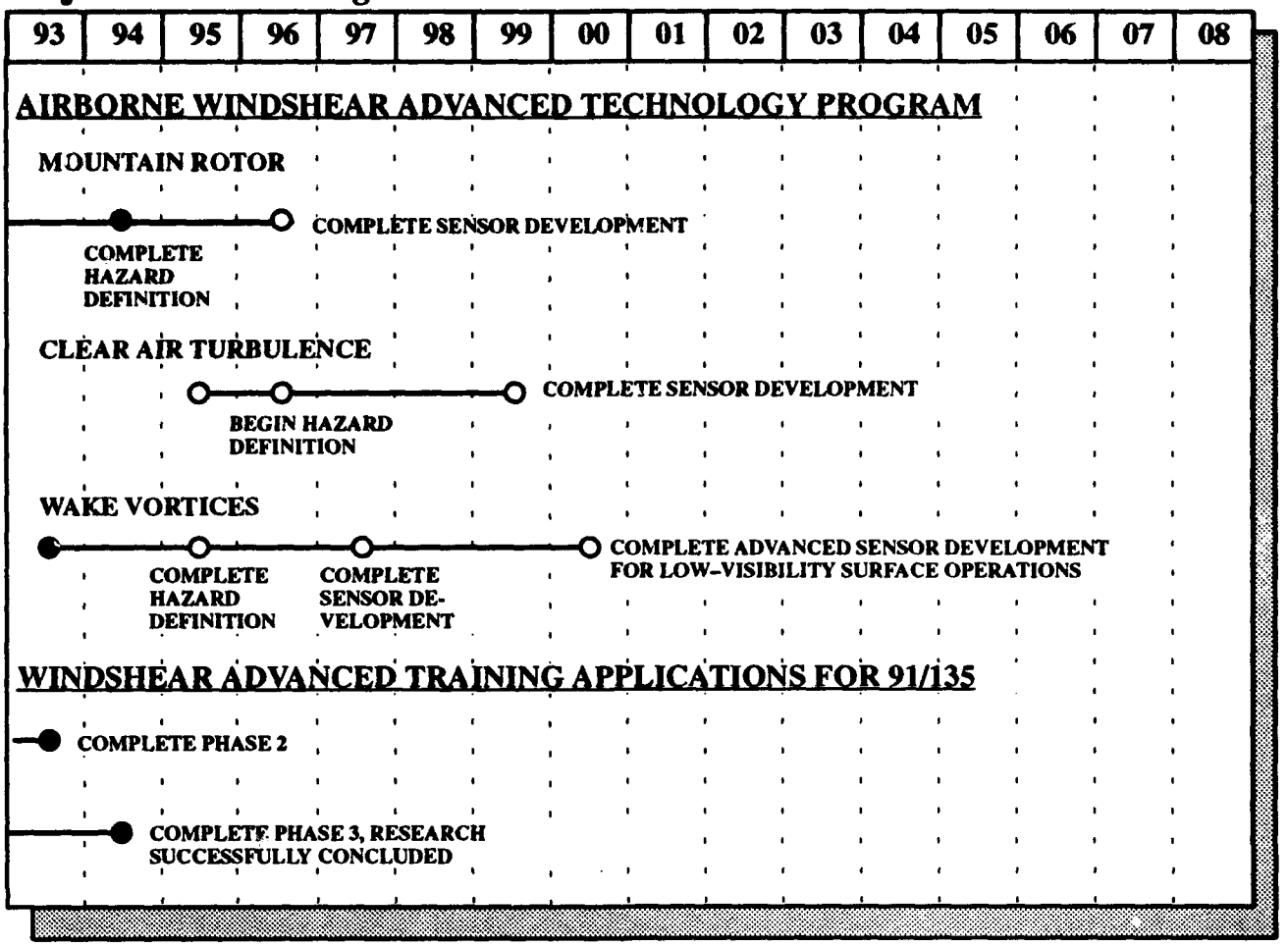
**Planned Activities:**

Airborne Windshear Advanced Technology

Further research in this project will examine three specific clear air phenomena: mountain rotor, clear air turbulence, and wake vortices. For all three areas, a method will be developed to characterize and measure the phenomena. Advanced sensor technology will then be applied to detect and provide a hazard warning. In 1995, mountain rotor research and flight tests will be completed with sensor development expected by 1996. Hazard characterization and definition for wake vortices will continue in 1995 with clear air turbulence efforts beginning in 1996. Flight testing will follow in 1995 for wake vortices and in 1997 for clear air turbulence with sensor development expected in 1997 and 1999, respectively. Following these developments, a final demonstration of sensor capabilities will include a category II low-visibility approach for closely spaced parallel runway operations. Other possible applications are detecting volcanic ash and detecting objects during low-visibility surface operations. The volcanic ash research will run concurrently with clear air turbulence activities. Advanced sensor development will begin for low-visibility surface operations in 1997. Anticipated conclusion for this work will be in 2000.

A key objective throughout this project is integrating the output from airborne and ground–based systems to ensure the detection, warning, and avoidance of hazardous clear air phenomena. This integration work will be accomplished in conjunction with air traffic control during the development cycle for the three major areas.

## Project 042–110: Integrated Airborne Windshear Research



# 5.0 AIRPORT TECHNOLOGY

The FAA is responsible for encouraging and fostering safe and efficient national airport system development. The Airport Technology Research and Development Program assists in developing new and improved standards, criteria, and guidelines to plan, design, construct, operate, and maintain the Nation's airports, heliports, and vertiports.

There are over 17,000 aircraft landing areas in the United States. Aircraft are increasing not only in number, but more importantly, in weight, landing speed, and overall dimensions. Many airport facilities are reaching design life, and the capital costs of airport improvements over the next 10 years are estimated to exceed $40 billion. Research will be an important factor in the efforts to control costs. Both passenger enplanements and aircraft operations are projected to experience strong growth for the foreseeable future, leading to airport activity levels two or more times greater than today. However, there are limited possibilities for expanding existing airports or building new airports. Consequently, maximum benefits must be derived by maintaining and improving existing facilities and by supporting research that can reduce congestion and delays at airports. Research can also provide innovative means for improving safety, increasing capacity, improving airport access and passenger services, assessing Federal investment effectiveness, and supporting U.S.–developed aviation products.

Airport technology research can lead to improved designs, techniques, equipment, and methods to assess system performance that will increase Federal investment effectiveness of the $1.9 billion Airport Improvement Program (AIP). For example: pavement and other facility life–cycle costs can be reduced; capacity can be improved and delays reduced; and both airports and heliports can be better integrated into the National Transportation System.

Pavement research has the potential for very large benefits. Approximately $2 billion is spent on constructing, rehabilitating, and maintaining airport pavements each year, whereas only $2 million is spent on research. Increasing the average life of pavements by as little as 10 percent through research would result in a benefit/cost ratio of 50 to 1 or more. This objective is not unreasonable or unattainable.

The landside portion of airport design and operation is also addressed in this research area. Projects in this area will help ensure that the systems that bring passengers to the aircraft are also able to handle forecasted traffic levels.

## 5.1 Airport Technology Project Descriptions

### 051–110 Airport Planning and Design Technology

**Purpose:** This project will help improve existing (or develop new) design standards pertaining to runways, taxiways, aprons, and gates. It will also develop standards and advisory information to be used in planning and designing airports, terminals, and ground access systems.

Advances in technology have supported major refinements in the air transportation system and made it possible to transport a large number of people (one-half billion passenger enplanements) each year. But ever–increasing travel demand and projected growth in the next 15 years will influence airport design, layout, and configuration, and require improved landside facilities. A major concern facing the U.S. air transportation industry is how to manage increases in air traffic with improved safety, reduced delays, and minimal operational constraints.

As advances in air traffic control and other airport improvements increase airside efficiency and capacity, passenger facility capacity and access to the airport will become a limiting factor with greater interest for communities. Optimum airport utilization will require that there be a smooth and uninterrupted flow of passengers, cargo, and airplanes between the various elements of the airport system.

**Approach:** The goal of this program is to eliminate runway acceptance rate as a limiting factor in maximizing airport capacity. This goal would be achieved by reducing the runway occupancy time as much as practical. It will also require optimizing the geometry of runway and taxiway exits which will allow aircraft to negotiate turns safely at higher speed. Research will also be needed to optimize existing airport facility designs to balance the relationships between access roads for public and private transportation and parking lots. In addition, it is necessary to identify the clearances and design requirements of future aircraft and review the adequacy of current airport designs for those requirements. Also, simplified methods must be developed for determining terminal, curbside, and airside capacities.

**Related Projects:** 021–220 Multiple Runway Procedures Development, 024–110 Aviation System Capacity Planning, 051–120 Airport Pavement Technology, 051–130 Airport Safety Technology, 073–110 NAS Security, and 074–110 Security Systems Integration.

**Products:**

- Technical data to support advisory material, regulations, and guidance used by industry and the FAA
- Computer programs and user guides for use by industry and the FAA airport community
- Design standards for terminals and parallel runway configurations
- Terminal design simulation guidance and models
- Aircraft/terminal compatibility analyses

**1994 Accomplishments:**

- Completed analysis on current airport designs for compatibility with new transport aircraft in concept/design stages.
- Developed airport accessibility index tool.

**Planned Activities:**

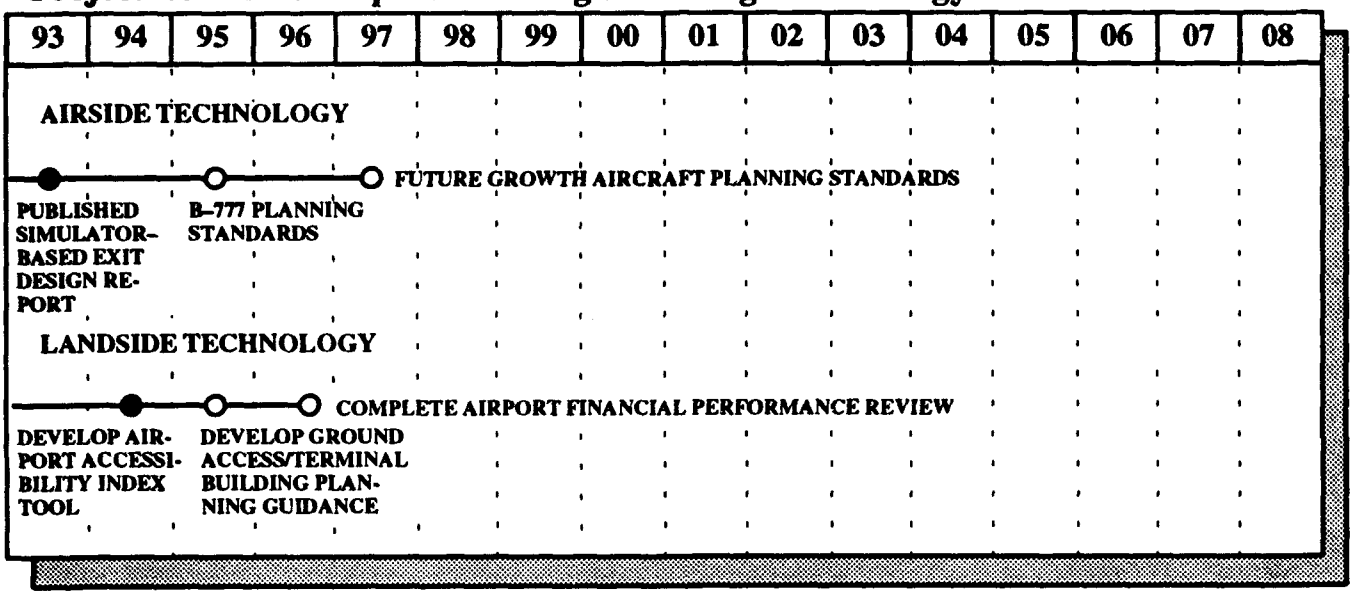
Airside Technology

In 1995, initial taxiway system design and flow rate evaluation for triple and quadruple parallel runways will continue and design standards will be completed. Design advisory circulars will be re-examined periodically to determine how airports should be planned and designed to accommodate new, unique aircraft configurations with larger wingspans. Standards for the Boeing 777 will be completed in 1995 followed by standards for future growth aircraft in 1997.

Landside Technology

In 1995, planning guidance for ground access to airports and for terminal building design will be developed, with an airport financial performance review completed in 1996. These items will efficiently use Airport Improvement Program funds.

## Project 051–110: Airport Planning and Design Technology




## 051–120 Airport Pavement Technology

**Purpose:** The approximately 650 million square yards of pavement at U.S. airports represent a precious national resource. Replacement value is expected to exceed $100 billion, and there are only limited practical possibilities for adding to or replacing major pavement systems. Consequently, maximum benefits must be obtained from the existing facilities.

The Federal Government and the aviation community are spending approximately $2 billion in annual pavement expenditure as well as additional costs of delay resulting from operational interruptions due to construction and maintenance. A significant portion of the $2 billion is spent replacing, repaving, rehabilitating, repairing, and maintaining pavement surfaces. During this decade, an estimated $40.5 billion in Federal and local funds will be required to provide a more efficient and integrated public-use airport system under the FAA's National Plan of Integrated Airport Systems. Of this total, about $17 billion

will be spent on constructing, maintaining, and rehabilitating airport pavements. The majority of this money will be spent at the most heavily used airports carrying the largest aircraft.

The goal of this program area is to reduce the massive costs of pavement expenditure by at least 10 percent by 2010. These savings will be achieved through a systematic research program covering three areas: (1) pavement design and evaluation, (2) materials and construction methods, and (3) repairs and maintenance techniques. Specific projects will be carried out to develop an integrated method for pavement design which will reduce pavement design and construction costs, reduce pavement failures, lower the costs of maintenance, and reduce pavement down–time and aircraft delay costs. A universal pavement design based on layered-elastic theory will also support U.S. aircraft manufacturer efforts to introduce new and heavier aircraft. This goal will be accomplished by providing an internationally accepted basis for evaluating if airports can accommodate new aircraft. Other projects will include developing methods for nighttime and cold weather construction, and improving methods of pavement evaluation and failure prediction to extend pavement life by at least 20 percent.

**Approach:**

Pavement Design and Evaluation

Airport pavement design techniques have evolved from the highway design theory developed in the 1920's and extrapolated in the 1940's and 1950's for application to aviation. While this has worked reasonably well in the past, it will not accommodate the dramatic changes associated with new generation aircraft now on the drawing boards. Research in pavement design and evaluation area will focus on developing a universal pavement design method which can be applied to the design of both flexible and rigid pavements. Efforts will be concentrated first on completing the layered–elastic design method followed by more rigorous design methods such as the finite element analysis to model the material properties accurately. As part of validating the layered–elastic theory, full–scale pavement testing will be required using a facility which can accommodate multiwheel configurations simulating the newer aircraft. The facility should provide aircraft response and pavement performance characteristics accurately. Evaluation of aircraft response and pavement performance will also be initiated at major new airports by installing advanced instrumentation and sensor systems in runways and taxiways. In addition, research will also be conducted to develop design criteria and methods for design, evaluation, performance, and serviceability of pavements at airports in cold regions.

Pavement Materials and Construction

Research efforts in this area will include: developing methods to specify and utilize new or improved materials as substitutes for the conventional materials used for pavement construction; identifying factors affecting the durability of airport pavements and development of criteria for efficient use of devices, construction materials, and construction techniques; performing evaluation of coal–tar mixes; using roller–compacted concrete as a construction technique; and using geotextiles and grid type materials for strengthening airport pavements.

A new program will be initiated for organizing long–term data collection on pavement performance modeled on the Strategic Highway Research Program. This new program will be known as the National Airport Pavement Registry and Demonstration Program and will annually identify significant new airport construction to determine life–cycle costs and other performance factors.

Pavement Maintenance and Repairs

Research efforts in this area will include: determining probable causes of significant distress and life–cycle cost of pavements and developing

criteria and guidance to use seal coating materials effectively for enhancing pavement longevity.

Special life–cycle cost studies on heavy concrete pavements at Dulles and Dallas–Fort Worth airports will be undertaken because these pavements are at the end of their design lives. Pavement sections that show significantly more or less distress than average will be identified and their condition related to the number of stress repetitions, subsurface conditions, or other factors. The results will be used to develop guidelines for concrete pavement average life span, life–cycle costs, and to support developing new design methodologies.

**Related Projects:** 051–110 Airport Planning and Design Technology and 051–130 Airport Safety Technology.

**Products:**

- Technical data for pavement design and design life, evaluation, materials, construction, maintenance, and repair
- Software and user guidelines for pavement design and analysis
- National pavement test capability
- Pavement design tool

**1994 Accomplishments:**

- Completed layered-elastic theory development.
- Completed design specifications for National Pavement Test Machine.

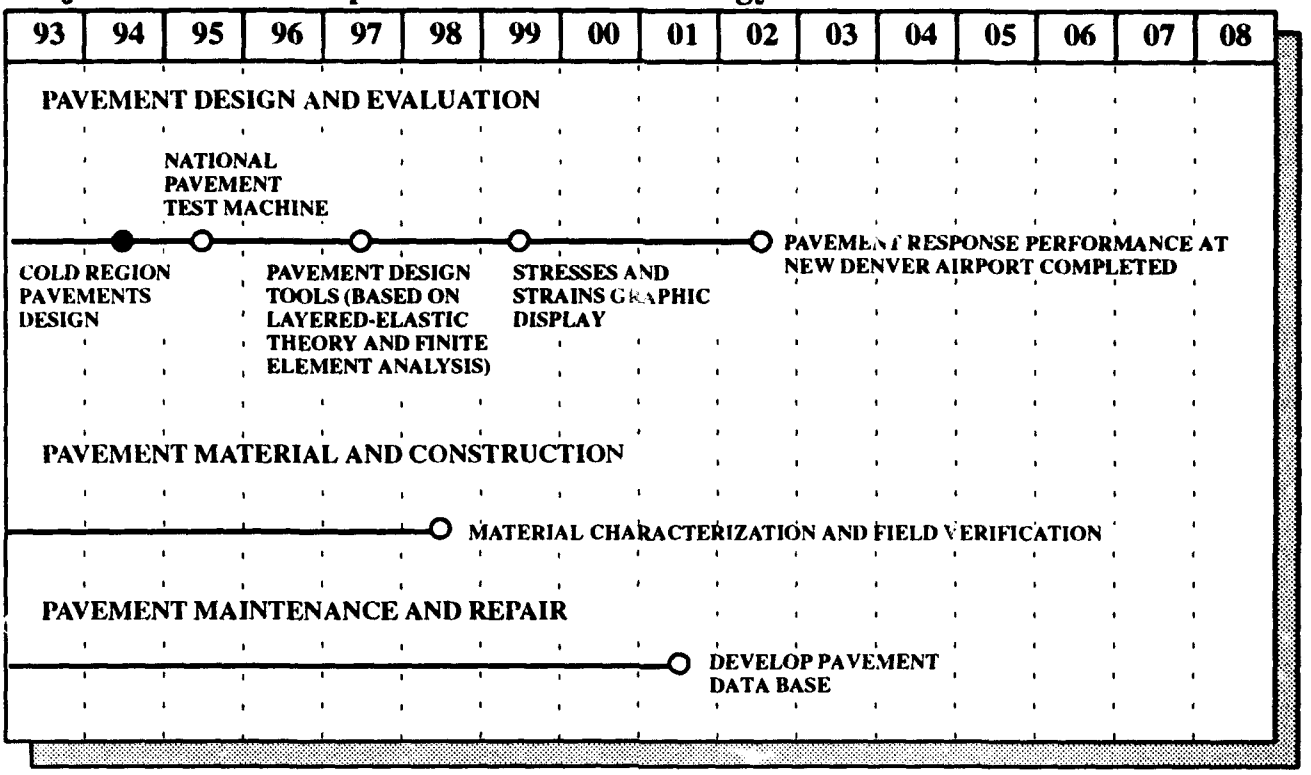
**Planned Activities:** Extensive research is continuing on design and evaluation standards, materials application, construction technology, and pavement maintenance and repair requirements. Major task components include: pavement design and analysis methodology development based on layered-elastic theory; pavement section instrumentation and monitoring at the new Denver airport; cold region pavement design; post–tensioned pavement performance; quality control acceptance criteria; geotextile use; specifications for materials, seal coating and joint sealant criteria; and pavement performance data base development.

In 1995, a 10–year runway data collection effort will continue at the new Denver airport using the newly installed pavement sensors. These sensors will measure the pavement response to repeated heavy aircraft loading. The data collected will be used to validate pavement design theories. This data collection effort will be completed in 2002. Computer software development using the predictive design and analysis methodology will continue in 1995, resulting in a stress/strain graphic display in 1999. New tests for material characterization will be completed in 1998, and controlled experiments under various applied and environmental loading conditions will be formulated to ensure the methodology's accuracy. In addition, studies will be initiated on durability of asphalt mixes and improved shoulder designs.

In 1995, work will continue on collecting and analyzing data that relate pavement performance to FAA design and construction standards. This effort will result in a comprehensive airport pavement data base in 2001. Criteria and methods for design, evaluation, performance, and serviceability of pavements at airports in the cold regions will be completed.

In 1995, studies will be completed on heavy concrete pavement life–cycle costs and the National Airport Pavement Registry and Demonstration Program. In 1995, national pavement test machine development will be completed. Pavement design tools based on layered-elastic analysis and/or finite element analysis will be completed in 1997.

## Project 051–120: Airport Pavement Technology




## 051–130 Airport Safety Technology

**Purpose:** This project will develop new technologies in four research areas: (1) safe and efficient aircraft operations on runway surfaces; (2) new, emerging technologies in lighting, signing, and marking materials for improved visual control systems; (3) new materials, methods, and equipment to improve the capability and cost–effectiveness of airport rescue and firefighting services; and (4) materials, methods, and devices to control birds and wildlife in the airport environment.

**Approach:**

Runway Surface Technology

A critical safety concern at airports is the runway surface condition. Snow, ice, water, and rubber deposits can result in slipperiness, causing aircraft loss of control during braking as well as making surface movements hazardous. In recent years, grooved runways to control surface water have greatly reduced hydroplaning. However, aircraft accidents from overshooting or veering off contaminated runways remain a problem.

During the last 11 years, there have been 130 accidents involving aircraft overruns and veeroffs. The accidents involved runway surfaces which were either dry or covered with water, ice, snow, or slush. The three major aircraft accidents during the last 10 years have focused national attention to the question of runway slipperiness and loss of control during landings and takeoffs. Accidents at Washington National Airport on January 13, 1982, at Boston Logan International

Airport on January 23, 1982, and at John F. Kennedy (JFK) International Airport on February 28, 1984, have resulted in complete loss of aircraft and 80 fatalities. Runway slipperiness and an inadequate "safety area" beyond the end of the runway were identified as factors contributing to these accidents.

The goals of this program area are to eliminate by 2000 runway slipperiness as a cause of accidents and to stop all aircraft within the extent of the runway. To achieve this goal, extensive research, testing, and evaluation will be conducted to develop new techniques, materials, procedures, and equipment to remove ice, snow, and rubber deposits efficiently. Also, research will continue on developing methods to prevent ice and snow accumulation on airport surfaces. In addition, new materials and methods will be investigated to decelerate aircraft safely should there be an overrun.

Visual Guidance

Safe and efficient airport ground operations, especially at night and under low visibility conditions, require that pilots and vehicle operators receive conspicuous and unambiguous information from lights, signs, and other markings. Improvements in these visual aids are one of the key elements in the FAA's Runway Incursion Program.

During the past 15 years, seven air transport surface collision events in the United States have resulted in nine fatalities and substantial property damage. In 1990, a collision at Detroit International Airport between two aircraft killed an additional eight people. These accidents have brought into focus the need for providing visual guidance to aircraft in low visibility conditions.

The goal of this program area is to eliminate by 1997 deficiencies in the visual guidance systems and procedures that may contribute to surface collision accidents. This goal would require research efforts in two general areas: visual guidance "control" technology to develop an automated system for aircraft movement on airport surfaces and developing state–of–the–art light sources and applications. These will include fiber optics, laser sources, and holographic techniques. In conjunction with this effort, technology will be developed to evaluate new visual guidance systems and procedures, particularly during low visibility conditions, on a computer–based simulation system.

Rescue and Firefighting

The analysis of aircraft accidents involving external fuel fires has shown that, although external fire is effectively extinguished, secondary fires within the fuselage are difficult to control with existing equipment and procedures. Large amounts of smoke, toxic gases, and high temperature levels in the passenger cabin can cause delay in evacuation and pose severe safety hazards. The February 1, 1991 accident at the Los Angeles International Airport involving two aircraft clearly demonstrated this concern. The rescue and firefighting personnel were faced with a post–crash fuel spill fire, a rapidly growing interior fire, and a structural fire. A rapid response to the accident site was accomplished, but evacuation was hampered by the thick black smoke that filled the cabin following the accident. Reductions in off–runway response times will be achieved by developing a new truck suspension system that improves traction in soft sand, wet, and uneven ground conditions.

The goal of this program area is to increase passenger survival rate in post–crash fires by providing a safe evacuation route through the aircraft cabin in a timely manner. This goal would require research and testing to develop firefighting systems that can effectively be used to control both external and internal cabin fires. Research will be carried out to reduce vehicle response time during nighttime and in low visibility conditions to develop new training techniques for

rescue and firefighting personnel. Improvements in response times and proper equipment development are needed for operations in poor visibility conditions.

Improvements in soft terrain and off–road firefighting vehicle capabilities will be needed to cope with expanded airport runway configurations into 2000 and beyond. New methods, procedures, and firefighting chemicals will be developed for use with large capacity aircraft, double–decked aircraft, and/or aircraft made from advanced materials.

Chemicals used in firefighting training facilities are raising concerns about environmental damage. Research will investigate methods to maintain a high level of performance for firefighting services, while minimizing air pollution and ground water contamination.

Wildlife

Presence of wildlife at and near airports poses a potential threat to movement of aircraft and other ground vehicles. In spite of various control devices in use to keep birds away, over a thousand incidents of bird strikes are reported every year. Many more incidents are known to occur, but are not reported.

Since 1912, when the first fatal accident of a Wright Flyer was recorded, 104 civil aviation fatalities from bird strikes have been reported in the United States. Worldwide civil aircraft fatalities total approximately 126. Potential for a serious accident continues on an ongoing basis. The cost of bird strike damage has been estimated at $1 billion annually by the Europe Bird Strike Committee.

The goals of this program are to increase airport safety and decrease damage to aircraft by reducing bird strikes. These goals require research efforts in developing effective regional wildlife habitat management to minimize or eliminate sources of bird attraction at airports. Research will also be conducted to identify active and passive harassment techniques that can effectively control the presence of birds and other wildlife at airports. These techniques and methods will assist airport owners and operators in complying with FAA airport certification regulations. Land use siting compatibility guidance will be provided by researching relationships among birds, airports, and landfills.

**Related Projects:** 021–190 Airport Surface Traffic Automation (ASTA), 051–110 Airport Planning and Design Technology, 051–120 Airport Pavement Technology, and 061–110 Aircraft Systems Fire Safety. Capital Investment Plan projects: 62–21 Airport Surface Traffic Automation (ASTA).

**Products:**

- Technical data supporting rules, regulations, and advisory circulars on runway surface maintenance
- Technical data and design criteria for lighting and marking systems for airports, heliports, and vertiports
- Technical data on tests and evaluation of firefighting agents, full–scale systems, and rapid response all terrain firefighting vehicle
- Technical data and advisory circulars on wildlife habitat management, bird harassment techniques, and landfill studies

**1994 Accomplishments:**

- Completed installation standards for a plastic foam arrestor system.
- Completed technical report on runway sand application rates.
- Provided technical data for developing U.S. runway stop–bar standards.

- Published advisory circular on minimum rescue and firefighting capabilities at general aviation (GA) airports.

- Developed specifications for a firefighting penetrating nozzle boom.

- Developed standards for fire extinguishing agents to replace Halon 1211.

- Published third report on wildlife harassment/deterrent techniques for airports.

**Planned Activities:**

Runway Surface Technology

In 1995, standards will be issued on runway sand application rates.

In 1996, research will be completed on microwave debonding of runway ice. Also in 1996, testing will be completed on innovative methods of ice removal, with a final report in 1997 leading to an advisory circular in 1998.

In 1997, a universal performance specification will be completed for removing runway rubber deposits.

In 1997, research will begin on advanced aircraft arresting systems for new–generation transport aircraft. Standards for an advanced aircraft arresting system will be issued in 2005.

Visual Guidance

In 1995, standards will be issued for improved airport pavement markings based on technical research into factors such as durability and visibility under dry or wet conditions. Visual simulator enhancements will be completed for testing new and improved lighting systems under all weather conditions. A study on automatic traffic control logic and procedures will be initiated in 1996. This study will lead to developing design standards for an automated taxiway guidance system in 1998.

In 1996 through 2000, advanced technology lighting sources will be investigated to develop more efficient airport visual guidance systems. The most promising technologies will be integrated into enhanced lighting systems by 2000.

Rescue and Firefighting

In 1995, work will continue on evaluating a penetrator nozzle's ability to suppress aircraft cabin fires. Additionally, a study will continue on identifying the most cost–effective technology to provide enhanced vision and location definition for rescue vehicles responding to emergencies under poor visibility conditions. Also in 1995, work will continue on providing fire truck crews with information for efficient rescue operations following a crash. Efforts will continue on evaluating the rescue firefighting standards against requirements to control and extinguish fires in aircraft containing composite material.

In 1995, an evaluation will be initiated for aircraft rescue and fire fighter training simulators. A study will begin on a generic, full–scale firefighting training facility that meets both environmental concerns and operational requirements. Based on this research, the current training advisory circular will be updated in 1997 for a standardized, generic firefighting training simulator.

In 1995, an evaluation will be initiated on developing post–crash fire protection requirements for advanced double decked aircraft seating up to 1,000 passengers. In 1997, the current fire protection advisory circular will be updated to include the new–generation transport aircraft, such as the Boeing 777. It is expected that the advisory circular will be updated in 2000 to include fire protection for aircraft in the 600–800 passenger capacity and in 2006 to include aircraft up to 1,000 passengers.

In 1996, an advisory circular will be published to cover technologies that deal with firefighting procedures for advanced composite aircraft and structures.

In 1996, an advisory circular will be published to cover technologies that improve response during poor visibility conditions for firefighting vehicles. Also in 1996, research will be conducted to evaluate soil stabilization methods to support airport rescue and firefighting vehicles.

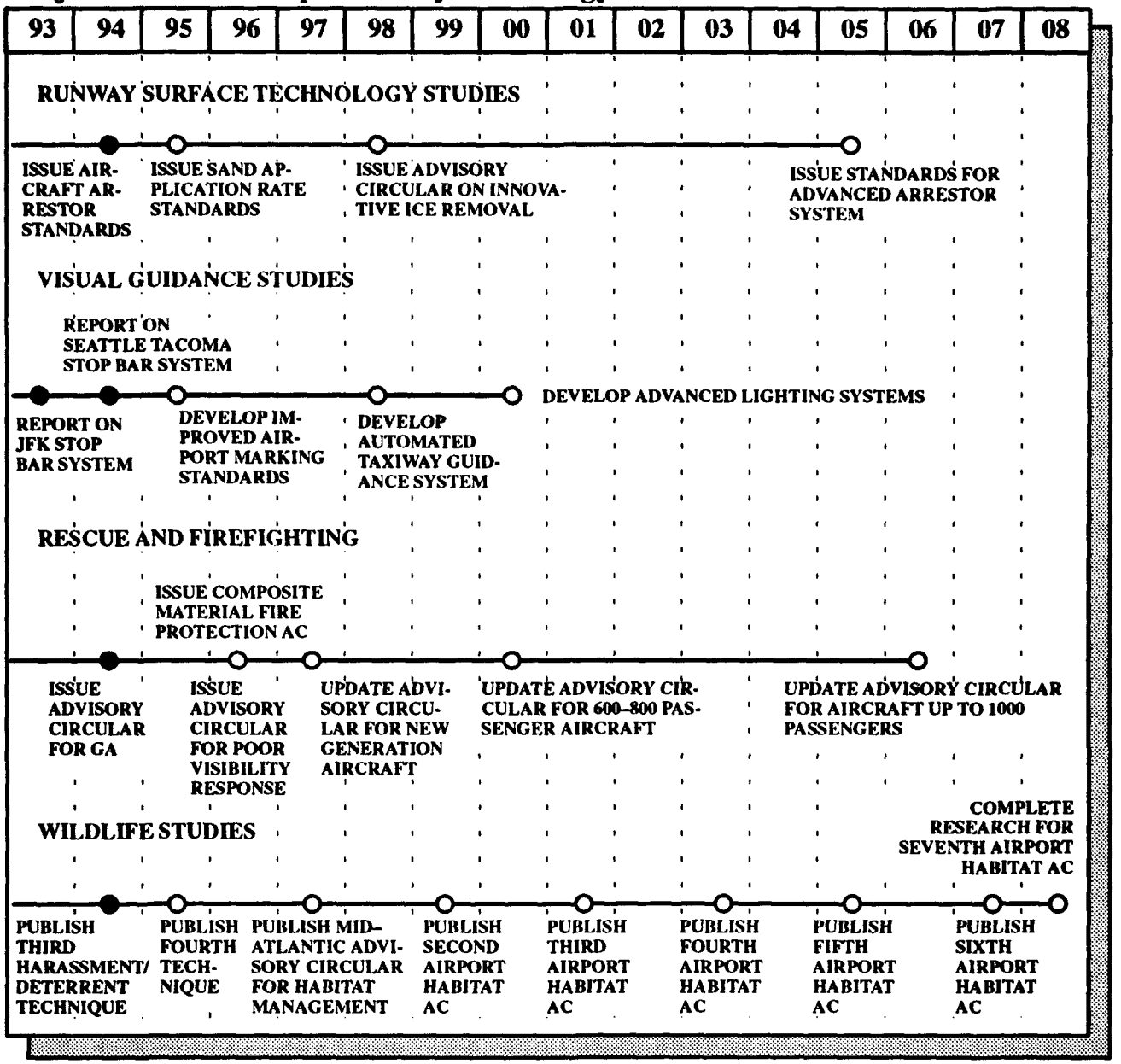
Wildlife

In 1995, the second regional airport habitat management study and research on a fourth wildlife harassment/deterrent technique and landfill studies will continue.

In 1995, the first regional habitat study at Atlantic City will be completed with a final report in 1996, and a Mid–Atlantic U.S. advisory circular in 1997. In 1996, the third regional habitat study will begin and conclude in 2000. Final reports on the fourth and fifth wildlife harassment/deterrent techniques will be finished in 1995 and 1996, respectively. Regional habitat management studies will be initiated and completed at a rate of every 2 years until the 10 regional studies are finished. These regional airport studies will continue through 2008, with advisory circulars published 1 year after final reports.

The primary thrust of the above research efforts is to identify and document the effectiveness and applicability of new wildlife habitat management and harassment/deterrent techniques for use on or near airports to mitigate bird and wildlife hazards. Knowledge of bird relationships to existing and new solid waste facilities will establish a sound scientific basis to evaluate potential bird attraction effects on or near airports.

## Project 051–130: Airport Safety Technology



# 6.0 AIRCRAFT SAFETY TECHNOLOGY

An important element for public confidence in the air transportation system is the aircraft fleet's continued safety record. This thrust area is focused on developing technologies for certification and maintenance regulations that maintain or improve aircraft safety in an evolving, changing, and demanding aviation environment.

Aircraft safety improvements will reduce fatalities and injuries, reduce hull losses, improve aircraft designs, and impact maintenance and inspection procedures. Each project in this thrust area has the potential to provide significant benefits. For example, more efficient nondestructive airframe testing could produce $40 million per year in benefits. A similar improvement in engine maintenance efficiency could achieve $20 million per year in benefits. An additional $30 million per year could accrue from these two projects due to using more effective inspection techniques and avoiding major engine failure incidences.

Research in aircraft fire safety has the potential for accruing large benefits. Statistics show the United States has about 30 to 35 fire fatalities per year in otherwise survivable accidents, and about 135 fatalities worldwide. At an estimated cost of $1.5 million per life, saving 3 people per year would pay for the entire fire safety research, engineering, and development effort.

Over the past 20 years, the aircraft accident fatality rate has been nearly level at just under two deaths per 10 million passengers carried. This statistic is a tribute to aircraft safety provided by the designers, operators, and regulators. Because the civil fleet's size increased over this period, the leveling fatality rate translates into an increase in total fatalities. These statistics indicate that new safety problems have been arising as old ones have been eliminated. Further, some safety problems such as fire and crashworthiness have continued to persist. Other potential problems, such as flight critical software–based digital fly-by-wire flight control systems, have not had sufficient operational exposure.

From 1990 to 2000, the domestic commercial transport fleet is projected to grow from 4,073 to 4,800 aircraft. The air taxi and commuter fleets combined are projected to grow from 1,771 to 2,100 aircraft over the same period. Total commercial operations at controlled domestic airports are expected to increase from 22,800,000 to 29,700,000 over those 10 years. In addition, general aviation and rotorcraft activity is also expected to increase during that time period.

Maintaining the good safety record over the past two decades has required introducing new safety technologies, such as cabin floor emergency escape lighting and seat fire blocking layers. Such enhancements are in addition to scores of pre–existing safety requirements for aircraft. Examples include design requirements for the aircraft structure so occupants can survive rapid decompression at cruise altitudes and demonstrations proving that all cabin passengers can evacuate within 90 seconds for each newly certificated transport category model.

The most important purpose of FAA aircraft safety research is to develop technical requirements for safety improvements needed to maintain or improve the safety level in an evolving aviation environment. Examples of this evolution are manifold and include: the two–pilot flightcrew, the aging aircraft fleet, fly–by–wire aircraft, greater composite material utilization, new terrorist threats, new aircraft fire extinguishing chemicals to replace ozone depleting agents, and electromagnetic susceptibility of sophisticated aircraft digital flight control and avionics systems. Keeping pace with these changes through safety–oriented research is a continuing effort unique to the FAA.

Today's passenger safety depends on fault–free maintenance and operation of the Nation's civil aircraft. Tomorrow's passenger safety depends on steps taken now to ensure future aircraft reliability and their operator's competency. The steps taken today by the FAA for future safety are embodied in the Aircraft Safety Technology Program. This program addresses the many hazards that face all aircraft in flight, as well as 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 their digital flight control and avionics systems and associated imbedded software, are more susceptible to upset from external electromagnetic interference.

This program emphasizes safe aircraft operation throughout all flight regimes including effective ground deicing prior to flight, airworthiness considerations such as reliable and effective structures, propulsion systems, control systems, and electrical systems. Additionally, the aircraft's ability to counter or absorb external hazards found in flight must be considered. External hazards include lightning, high intensity radiated fields, birds, turbulence, windshear, and icing conditions. When human error or systems failures result in an aircraft accident, there are additional design requirements to make the accident more survivable and minimize any post–crash fires. When such fires occur, design considerations include measures both to increase the time available for passenger evacuation and to facilitate their escape. The main hazards the FAA Aircraft Safety Research Program addresses are represented in Figure 6.1.

Fire safety studies will result in specifications for effective fire extinguishing agents to replace currently used ozone destroying agents. They will also lead to developing automated, computer–driven fire management systems that will expedite locating and extinguishing in–flight fires. Additional fire safety enhancements will include developing an onboard water spray fire suppression system and more effective fire retardant materials that further increase the time for passengers to escape from the aircraft cabin.

Similarly, results from current work in crashworthiness will be used in developing guidelines for designing aircraft structures that can absorb severe impact loads and still maintain a habitable environment. Cabin safety improvements will include improved energy–absorbing seat restraint systems and designs for galleys and overhead stowage compartments that reduce their hazard potential in accidents. These improvements, along with strengthened structures around door and window exits, will also enhance emergency evacuations in post–impact situations.

Propulsion system safety research will lead to reductions in the number of lives lost due to turbine engine bird and water ingestion or fragments from uncontained rotor failures that destroy critical systems. This goal will be accomplished by developing specifications for advanced engine ingestion systems and rotor containment systems.

A new fuel safety program is aimed at preventing or diminishing the critical elements involved in forming the deadly mist fireball fuselage chain: spilled fuel, mist formation, and ignition sources.

The flight safety/atmospheric hazards research program will provide state–of–the–art information to address aircraft icing, electromagnetic environment, digital systems validation, and flying qualities, and operations to support regulatory, certification, and flight safety processes.

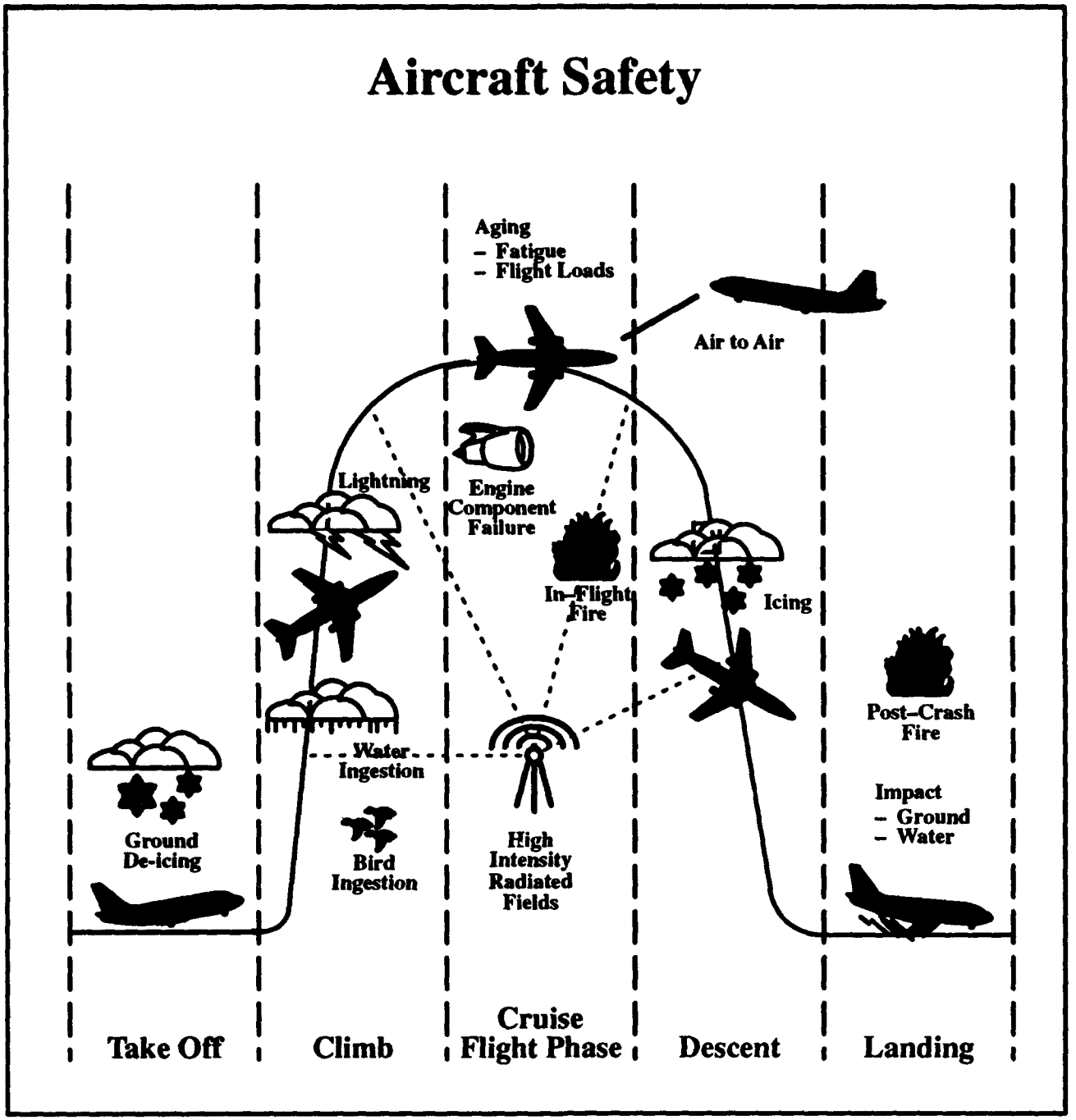



**Figure 6.1 Typical Flight Hazards**

## 6.1 Aircraft Safety Technology Project Descriptions

### 061–110 Aircraft Systems Fire Safety

**Purpose:** This project will minimize fire–related injuries and increase survival rates for aircraft occupants during in–flight and post–crash fires. It will also improve aircraft fire detection and suppression capability, thereby decreasing the potential for igniting aircraft materials and reducing hull losses in the civil aircraft fleet. The fire safety performance requirements involve fire hardening the fuselage structure and interior cabin materials to increase available evacuation time and reduce fire hazards. Research will lead to new systems and procedures to increase fire safety.

**Approach:** Aircraft fire issues are unique when compared to fire safety issues in buildings, residences, and ground transportation. In–flight fires must be reliably detected, suppressed, and contained: allowing adequate time for descents, landing, and passenger evacuation. During an aircraft crash, impact energies, coupled with the aircraft fuel load, result in a high potential for exterior fuel fires and injuries or fatalities. Studies will be conducted to determine airplane design characteristics that have the potential to increase fire safety. Research will be performed on more fundamental aspects, such as material flammability, extinguishment chemistry, fire dynamics, and risk analysis, to develop promising fire safety improvements for future aircraft.

**Related Projects:** 062–110 Aircraft Crashworthiness/Structural Airworthiness and 063–110 Propulsion and Fuel Systems.

**Products:**

- Upgraded aircraft material fire test handbook
- Guidelines for cargo compartment fire protection
- Upgraded fire performance criteria for aircraft cabin materials
- Guidelines for approving halon alternate extinguishing agents
- Design for an optimized onboard cabin water spray system
- Auxiliary fuel tank hazard and protection assessment
- Improved fire hardening for fuselage structure
- Enhanced fire detection, fire management, and decisionmaking for in–flight fires

**1994 Accomplishments:**

- Completed tests on fire–hardening materials and concepts to protect against fuselage fuel fire penetration.
- Optimized performance capabilities for cabin water spray system.
- Determined efficacy of Class E cargo compartment design requirements.
- Completed Aircraft Command in Emergency Situations (ACES) system demonstration tests.

**Planned Activities:** This project will be divided into three major areas: Materials Fire Safety, Fire Management, and Systems.

Materials Fire Safety

In 1995, design guidelines will be developed for hardening aircraft fuselages against penetration by an external fuel fire. Long–range research on advanced cabin materials will continue through 2005. The goal is to create a practically "fireproof" cabin interior that will resist ignition by an external fuel fire.

Efforts to resolve agency certification issues related to material fire test requirements will be supported by continuing to sponsor and conduct the International Working Group on Aircraft Material Fire Tests.

By 1999, a prototype fire–resistant cabin interior will be demonstrated. To reach this goal, material research will be conducted to modify advanced polymers for airplane cabin interior applications. In 1995, development efforts will focus on present–generation cyanate ester derivatives to develop a high–temperature substitute for resins used in cabin sidewalls. Tailored polymers involving highly cross–linked molecular structure will provide new materials that do not support combustion. In 1997, fireproof decorative coatings and high temperature thermoplastics will be developed for cabin interior fabrication. In 1998, fire resistant foam research will provide a replacement for urethane seat cushions. This research will culminate in a fire–resistant cabin. Follow–on research will be conducted to reduce material weight and cost for eventual applications in transport aircraft.

Fire Management

Alternate agents developed by industry to replace Halon 1301 will be tested. In 1995, Halon 1301 replacement guidelines will be developed for cargo holds. Further testing will include powerplant, hand–held extinguisher and lavatory applications for the purpose of developing guidelines for equivalent effectiveness by 1997.

In 1995, this project will design and fabricate a cabin water spray fire suppression system for installation and evaluation in an operational airplane. Flight testing will be completed in 1997. This activity will yield needed data related to aircraft water spray system design, weight, cost, and maintenance.

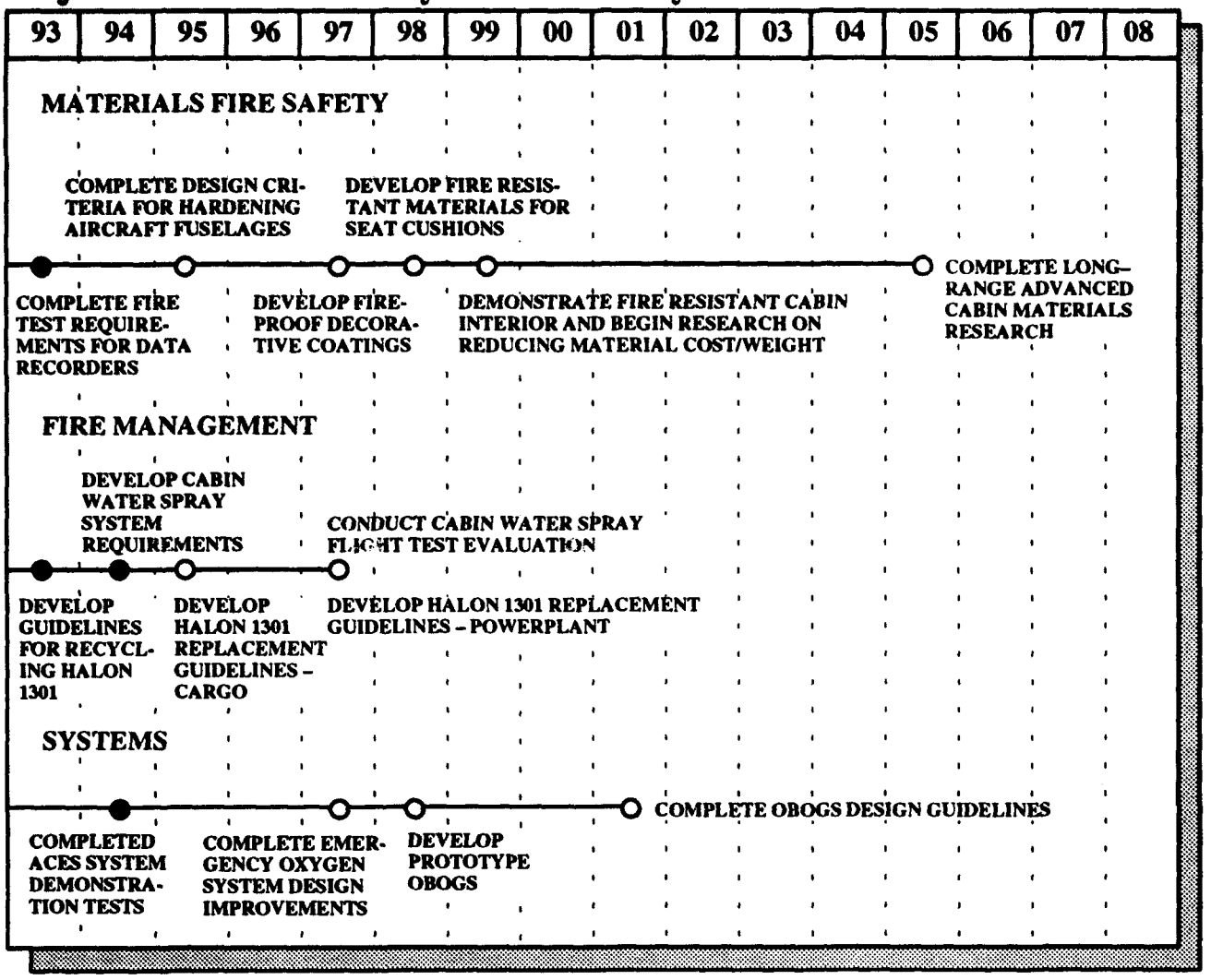
An initiative in 1995 will lead to developing standardized test procedures and criteria for certifying aircraft smoke detector response rates. Certification criteria will be recommended in 1996.

Systems

In 1995, support for National Transportation Safety Board aircraft fire investigations will continue, including participation on accident investigation teams, accident material and fluid chemical analysis, and full–scale fire tests to re–create/analyze accident scenarios.

Prototype development and testing of an onboard oxygen generating system (OBOGS), employing selective absorption membranes, will be conducted in 1995–1997 with prototype delivery in 1998. OBOGS technology, if successful, would virtually eliminate the fire hazards associated with current containers and chemical canisters. In–service performance evaluations will lead to OBOGS design guidelines for industry in 2001.

## Project 061–110: Aircraft Systems Fire Safety




## 062–110 Aircraft Crashworthiness/Structural Airworthiness

**Purpose:** This project will increase protection for both occupants and crew during an accident. Work will be conducted to develop and validate test procedures necessary for generating required research data. These data are needed to support certification standards, performance specifications, advisory circulars, and other regulatory materials necessary to enhance aircraft crashworthiness and occupant safety. The research will focus on advanced composite material structures safety and acquiring the necessary knowledge to support regulations that ensure continued civil fleet airworthiness.

**Approach:** This project establishes a technical data base to generate aircraft crashworthiness and structural airworthiness criteria for both fixed–wing and rotary–wing aircraft. Experimental and analytical research efforts will be developed to create standard guidelines and performance

criteria that ensure continued aircraft structural airworthiness. These efforts will help reduce occupant injuries and fatalities in the crash environment.

Aircraft Crashworthiness

Aircraft crashworthiness includes three areas: airframe structures, cabin interior, and occupant evacuation. The airframe structures area will analyze the crash environment, aircraft fuel systems, and structural components to identify and address structural failures. The cabin interior area will analyze seat/restraint systems, interior furnishing, and human tolerance limits. Occupant evacuation analysis will investigate escape devices, environmental factors, procedure effectiveness, and ditching survival equipment. Analytical modeling will be used in developing structural, occupant, and seat information.

Structural Airworthiness

Structural airworthiness addresses advanced materials research and landing gear systems. It comprises three areas: engineering, operations, and manufacturing/quality assurance. The engineering area will investigate damage tolerance, environment, joints, and other structural or fatigue concerns. The operations area will research issues related to environmental effects on durability, impact damage, nondestructive inspection (NDI), and training/repair procedures. The manufacturing/quality assurance area will analyze and develop standard process characterization procedures, control criteria, and production readiness.

These research efforts will be accomplished in part via the University Grant Program, interagency agreements, memorandums of understanding, Centers of Excellence, and the Small Business Innovation Research Program.

**Related Projects:** 061–110 Aircraft Systems Fire Safety, 063–110 Propulsion and Fuel Systems, 065–110 Aging Aircraft, and 066–110 Aircraft Catastrophic Failure Prevention Research.

**Products:**

- Data base addressing certification criteria for seat/restraint systems
- Technical data packages on crash-resistant fuel system designs
- Data package and analysis of commuter airplanes and rotorcraft exposed to a water impact environment
- Data base characterizing aircraft structural responses when exposed to various impact terrain environments
- Handbook for FAA personnel on new composite technologies and manufacturing/inspection/analysis techniques
- Data package on nondestructive evaluation technologies in advanced composite/metallic structures
- Data package on damage tolerance for structures constructed using advanced materials
- Data base addressing certification criteria for brake wear limits and aircraft stopping distances

**1994 Accomplishments:**

- Completed longitudinal crash testing/analysis on fuselage section with conformable auxiliary fuel tank and overhead bins.
- Completed radial and bias ply aircraft tire comparison.

- Completed feasibility assessment of probabilistic design methodology for composite aircraft structures.

- Completed Aircraft Advanced Materials Research Program Plan.

**Planned Activities:**

Aircraft Crashworthiness

Testing and analysis related to aircraft structures will be completed in 1995 and 1996, respectively. Testing will be completed in 1997 on a commuter aircraft that utilizes composite materials.

In 1995, an auxiliary fuselage fuel tank system analysis will be completed. The test program will be completed for crash resistance of fuel lines and fittings in 1996, empennage and fuel tanks in 1998, and wing tanks in 2002.

In 1995, testing associated with various commuter cabin safety and evacuation issues will continue. Also, seat restraint system testing and improved seat/occupant model analysis will be completed.

Overhead bin testing for various transport category aircraft configuations will continue through 1996. In 1995, work will continue on developing wide–body lower lobe technical data leading to regulatory guidelines in 1997.

Full-scale water impact testing and analysis will be completed for rotorcraft in 1997 and for transport category aircraft in 1999.

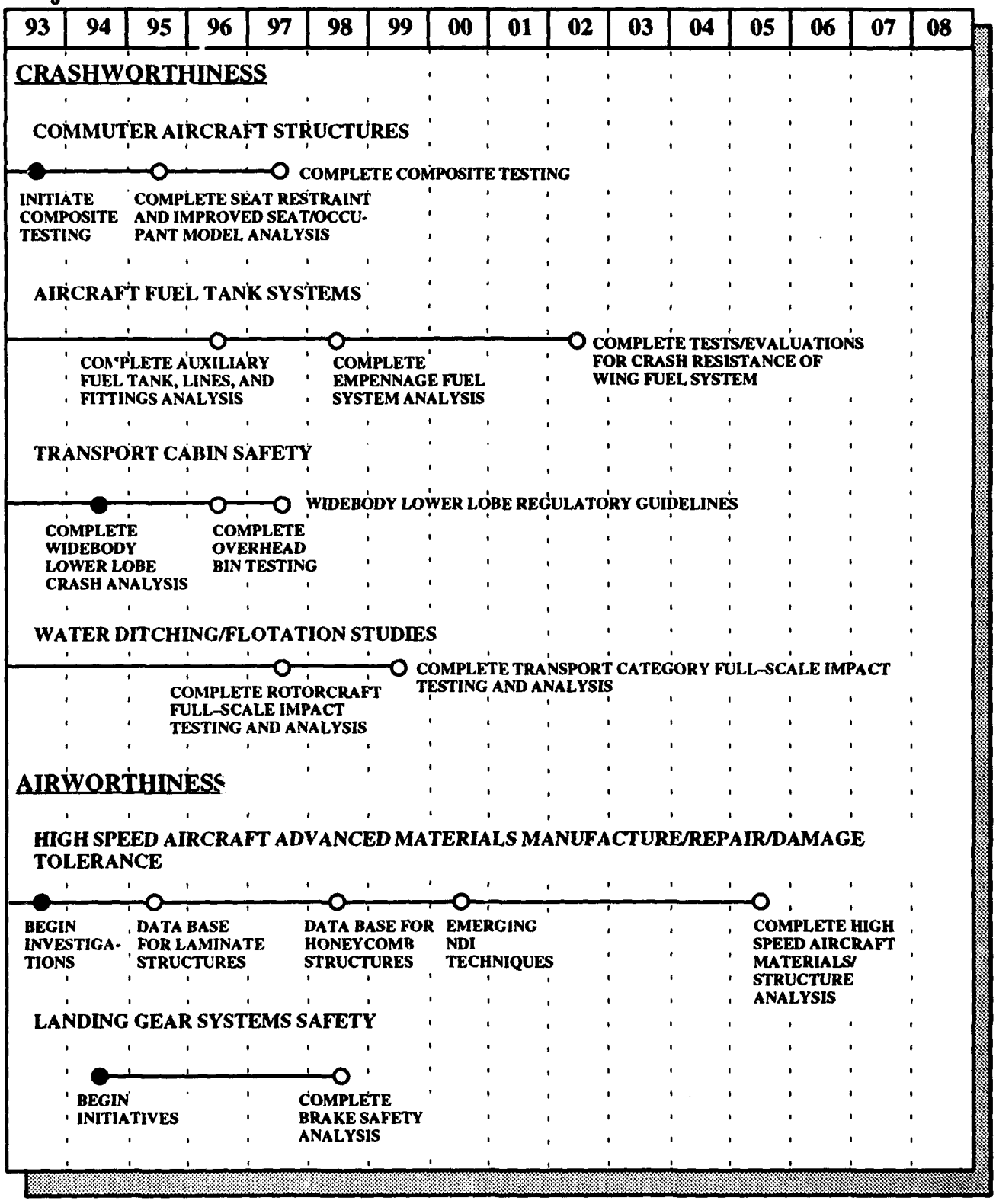
Structural Airworthiness

In 1995, investigations will continue on determining structural design service life variability with advanced materials; addressing advanced NDI technology, including smart structures, for metal/composite interface areas; and developing data to compare bias–ply and radial–ply tires using tire temperature data to validate a tire heating model. Work will also continue on the following: investigating composite material test methods and studying delamination and environmental effects on composite aircraft structure's fatigue/damage tolerance and operational life utilizing probabilistic modeling and testing. A data base addressing laminate structures will be completed in 1995, and one addressing honeycomb structures will be completed in 1998. Development work on emerging NDI techniques will be completed in 2000.

In 1995, several initiatives will continue including the following: evaluating developments/applicability for advanced high speed aircraft design and fabrication technology; updating the FAA's handbook on fiber–reinforced composite manufacturing/repair; identifying and investigating design and manufacturing techniques that optimize damage tolerance for advanced composite/metal aircraft structures; developing data for evaluating bonded advanced material repairs on damage tolerant structures; and addressing anti–skid brake certification tests/procedures, brake wear limits, and aircraft stopping distances.

The investigations for advanced composite/metal aircraft structures, the brake safety issues, and the high–speed civil aircraft research will continue into 1997, 1998, and 2005, respectively.

## Project 062–110: Aircraft Crashworthiness/Structural Airworthiness



## 063–110 Propulsion and Fuel Systems

**Purpose:** This project will increase future engine efficiencies. Superalloys, ceramics, and coatings will permit the engines of the 1990's to operate at much higher temperatures and pressures. Future engine durability is a concern as thermal and mechanical fatigue/fracture problems are likely to become more serious. This project will provide FAA headquarters and regions with the technical data needed to assess current in–service propulsion and fuel system problems. The data are needed to determine if current regulations are adequate. The project will also establish airworthiness criteria and related technical materials to: ensure powerplant safety, reliability, and durability; review changes in aviation fuel specifications/availability; and conduct research necessary to enhance propulsion and fuel system safety.

**Approach:** This project involves developing criteria, guidelines, and data to support improvements in turbine and piston engine certification requirements. The primary research and development areas are engine reliability, engine structural safety, and fuel safety.

Engine Reliability

Analyses in progress will determine if current standards adequately address engine durability problems under extreme operating temperatures and pressures. Advanced engine safety and reliability will be continuously assessed as these engines are developed for future commercial and general aviation aircraft.

An analytical study on the water ingestion process in the combustion section will also be initiated. This study will complement a previous study conducted on the compressor section. In–service operation data will be analyzed to identify potential problems from hail or other foreign object ingestion.

A study will be undertaken to determine if sensing flammable mixtures in powerplant installations is feasible and to develop engine case burnthrough test standards.

Research will be conducted to develop technology and establish a technical data base for engine component production, in–service inspection methods, and material manufacturing processes.

Engine Structural Safety

Work will continue on developing lightweight containment materials and analyzing turbine engine rotor failures. The materials under consideration include composite weaves, ceramics, and advanced metallics. Technology will be developed to predict or diagnose a turbine engine rotor structural failure.

Fuel Safety

The results from a previously completed fuel risk assessment will be used to evaluate promising approaches to improve post–crash fuel safety. A future study includes analyzing the elevated fuel temperature effects associated with high–speed transports. Additionally, an effort will be undertaken to expand the technical knowledge base on the characteristics and properties of various unleaded general aviation fuels currently available. The factors that affect aviation fuel availability will be continuously monitored, and research will be initiated to maintain acceptable safety and reliability levels.

**Related Projects:** 062–110 Aircraft Structural Crashworthiness/Airworthiness, 065–110 Aging Aircraft, and 066–110 Aircraft Catastrophic Failure Prevention Research.

**Products:**

- Data base on in–service experience with turbine engine bird and foreign object ingestion
- Analytical design tools to define turbine engine rotor failure fragmentation patterns and engine performance during excessive rain/hail ingestion
- Design criteria and material specifications for containing turbine engine rotor failures
- Advanced engine material manufacturing processes
- Advanced fire protection criteria and prototype hardware for turbine engine powerplant installations
- Risk assessment and techniques to mitigate post–crash fuel fire hazards
- Propulsion safety assessments of future aviation fuels and engines
- Improved nondestructive inspection standards

**1994 Accomplishments:**

- Completed engine nacelle fire detection system evaluations.
- Developed performance criteria for turbine engine rotor X–ray inspection and onboard failure diagnostic techniques.
- Developed generic analytical model to evaluate turbine engine performance during water ingestion.
- Completed general aviation engine performance ground testing using unleaded fuels with additives.


- Developed generic analytical model to evaluate turbine engine performance during water ingestion.
- Completed general aviation engine performance ground testing using unleaded fuels with additives.


**Planned Activities:**

Engine Reliability

In 1995, fire burnthrough test standards and equipment will be evaluated for power plant installations. Experimental efforts will be completed in 1995 to validate an engine water ingestion analytical model. In 1996, work will begin on expanding the analytical model to include water and hail ingestion with completion in 2001. Current efforts to develop performance data on engine inspection techniques will be completed in 1998. Advanced turbine engine maintenance and repair criteria will be developed by 1998.

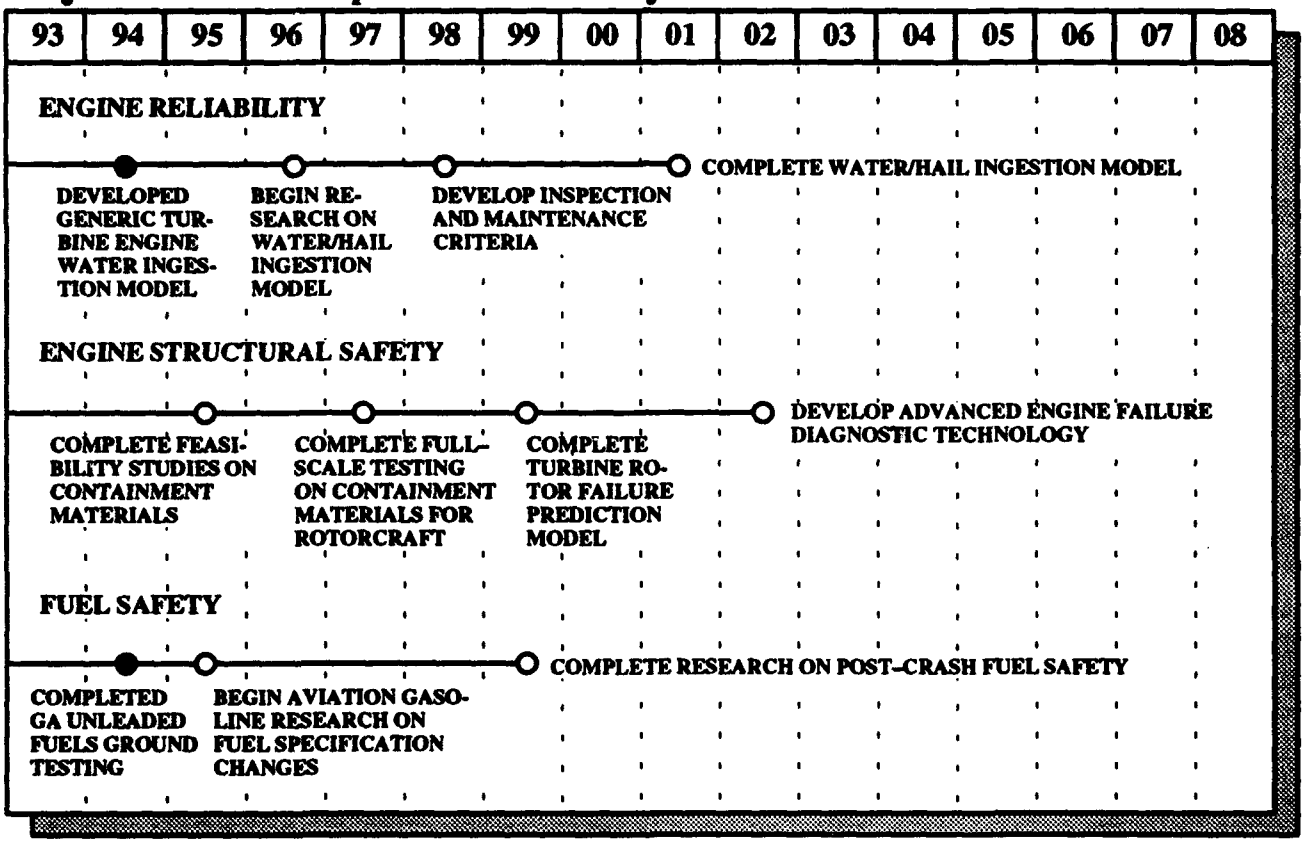
Engine Structural Safety

In–service turbine engine rotor failures will be continuously analyzed and engine failure reports published annually. Feasibility studies to develop and evaluate lightweight containment materials will be completed in 1995, with full–scale testing for rotorcraft applications being completed in 1997. The materials under consideration include composite weaves, ceramics, and advanced metallics. Work on developing advanced engine failure diagnostic technology using artificial intelligence and in–situ engine inspection techniques will be completed in 2002. Analysis in progress will produce an analytical model of rotor failure fragmentation patterns in 1996, with model validation expected in 1999.

Fuel Safety

Promising approaches to improve post–crash fuel safety will be expanded in 1995–1999 to include developing techniques which will prevent the ignition and free flowing of significant quantities of fuel after a crash. The factors that affect aviation fuel availability will be continuously monitored, and the unleaded aviation gasoline test program will be completed in 1996. New research to maintain acceptable propulsion safety and reliability levels as fuel specifications change will be initiated in 1995.

**Project 063–110: Propulsion and Fuel Systems**




## 064–110 Flight Safety/Atmospheric Hazards

**Purpose:** This project will address new technology, design, and operational issues to provide technical data, guidelines, advisory material, and procedures for the regulatory and certification process. This research also has the potential to identify possible safety problem areas before accidents occur.

**Approach:** This project comprises four areas: aircraft icing, electromagnetic environment, digital systems validation, and flying qualities and operations.

Aircraft Icing

The worldwide aircraft atmospheric icing environment will be characterized to include supercooled clouds, snow, ice crystals, freezing precipitation, and mixed conditions from ground level through all flight levels. Efforts will continue on screening and assessing commuter class aircraft with potential susceptibility to icing induced tail plane stalls. In cooperation with the National Aeronautics and Space Administration (NASA) and the Department of Defense (DOD), simulation methodologies and facilities, analytical techniques, and instrumentation calibration standards will be developed for designing and testing ice protection systems. Technologies associated with ground anti/deicing fluids will also be investigated to determine optimal application procedures, holdover–time tables, and associated aerodynamic effects. Additionally, surface ice detector(s) and related technologies assessments and evaluations will be conducted.

Electromagnetic Environment

An electromagnetic environment data base will be developed to address atmospheric electrical hazards. Research will continue to determine the adverse effects from lightning and high intensity radiated fields (HIRF) on all advanced technology airframes and systems. Through cooperative efforts with industry and other governmental agencies, efforts will continue with full–scale testing, data collection and analysis, modeling, and simulation on flight control systems susceptibility to HIRF. The results from these efforts will determine damage/upset levels.

Digital Systems Validation

The digital systems validation area will compare traditional airworthiness/certification techniques with fly–by–wire/fly–by–light (FBW/FBL) concepts. Research will proceed in fault tolerant architecture and electromagnetic effects assessment associated with FBW/FBL and the new power–by–wire (PBW) concepts. This work will be accomplished in coordination with NASA.

Flying Qualities and Operations

The flying qualities area will address certification issues related to improved flight safety assessments for new aircraft that utilize advanced displays, flight management systems, [illegible] dures, and modified operational profiles.

**Related Projects:** 022–140 Vertical Flight Program and 066–110 Aircraft Catastrophic Failure Prevention Research.

**Products:**

- Pilot's Guide to Aircraft Ground Deicing Advisory Circular (AC)
- Report on field measurements for advanced anti/deicing fluid time of effectiveness
- Report on validating analytical technologies, computer codes, and simulation methodologies
- Electromagnetic threat definition, development, and validation
- Lightning AC and user's manual updates
- HIRF AC and user's manual updates
- Digital systems validation handbook update
- Report on flight critical digital systems technology studies for airworthiness certification
- Software development guidelines report and data package

- Provide data to support operational procedures development for advanced rotorcraft/ tiltrotor instrument flight rules (IFR) approaches to heliports

**1994 Accomplishments:**

- Completed research on anti/deicing fluid time of effectiveness for various freezing precipitation conditions.

- Demonstrated HIRF electromagnetic modeling capability.

- Completed joint FAA/NASA flight critical digital systems research on fly–by–light/ power–by–wire aircraft architecture technology.

**Planned Activities:**

Aircraft Icing

In 1995, efforts will continue on developing a prototype device for determining aircraft anti-icing/deicing fluid holdover–time, and advisory material on ground deicing fluids will be published in 1996. The prototype fluid holdover–time device will be completed in 1998.

Anti–icing research in this project will focus on advanced ice protection technologies such as materials and coatings, and low energy anti–icing techniques. In 1995, investigations will continue on commuter-class aircraft susceptibility to ice–induced tail plane stalls and aircraft (rotorcraft and airplane) ice protection. An important product will be advisory material on ice–induced tail plane stalls in 1996. In 1997, rotorcraft analytical codes will be developed for use in a rotorcraft ice detector system planned for 1998. In 1999, a rotorcraft low–power deicing system and aircraft surface icing detectors for localized coverage will be developed. Further research will lead to publishing advisory material for rotorcraft icing certification in 2000, and developing universal coverage surface ice detectors in 2001.

Additionally, newer aircraft such as tiltrotor/ powered–lift, supersonic transport, and the national aerospace plane (NASP) will require innovative ice protection technologies and attendant innovative approaches for certification. This project will conduct research on powered–lift vehicle (PLV) icing systems, leading to a validation report in 2004. In 2006, a PLV icing technical report will be issued based on flight testing.

Electromagnetic Environment

In 1995, a handbook on HIRF will be completed and a new standard for aircraft lightning strike zoning will be developed. The standard will be incorporated into advisory material later in the year. Also in 1995, the users' manual for protecting electrical/electronic equipment against the indirect effects of lightning will be published. Additionally, HIRF workshops, as well as the Fourth International HIRF Conference, will be conducted.

In 1995, work will continue on evaluating innovative approaches to determine aircraft critical flight control/avionic systems susceptibility to manmade and atmospheric interference. In 1996, HIRF systems tests will be completed, and a technical report on full–scale testing model validation will be issued in 1997. Also in 1997, HIRF flight control/avionics protection standards will be published. Subsequent research will address HIRF and lightning issues in advanced aircraft. In 2002, full–scale PLV HIRF and lightning testing will begin. These tests will lead to a technical report on HIRF and lightning in 2004. Further research will be conducted in 2007 for fly–by–light critical function validation.

Digital Systems Validation

In 1995, research will proceed in assessing fault tolerant architecture and electromagnetic effects. Also, the Digital Systems Validation Handbook, Volume III, will be published in 1995, and an assessment on flight critical digital aircraft controls will be completed. Technical information on fly–by–wire (FBW) and fly–by–light (FBL) systems will be compiled for evaluations to develop advisory material on FBL systems in 1998. Additionally, advisory material will be published in 2000 for rotorcraft FBW/FBL systems. An important research component for this project is evaluating aircraft FBW/FBL bus fault tolerances. Advisory material will be published in 1999 on ARINC 429/629 bus fault tolerance and in 2001 on MIL–STD–1553B bus fault/failure modes.

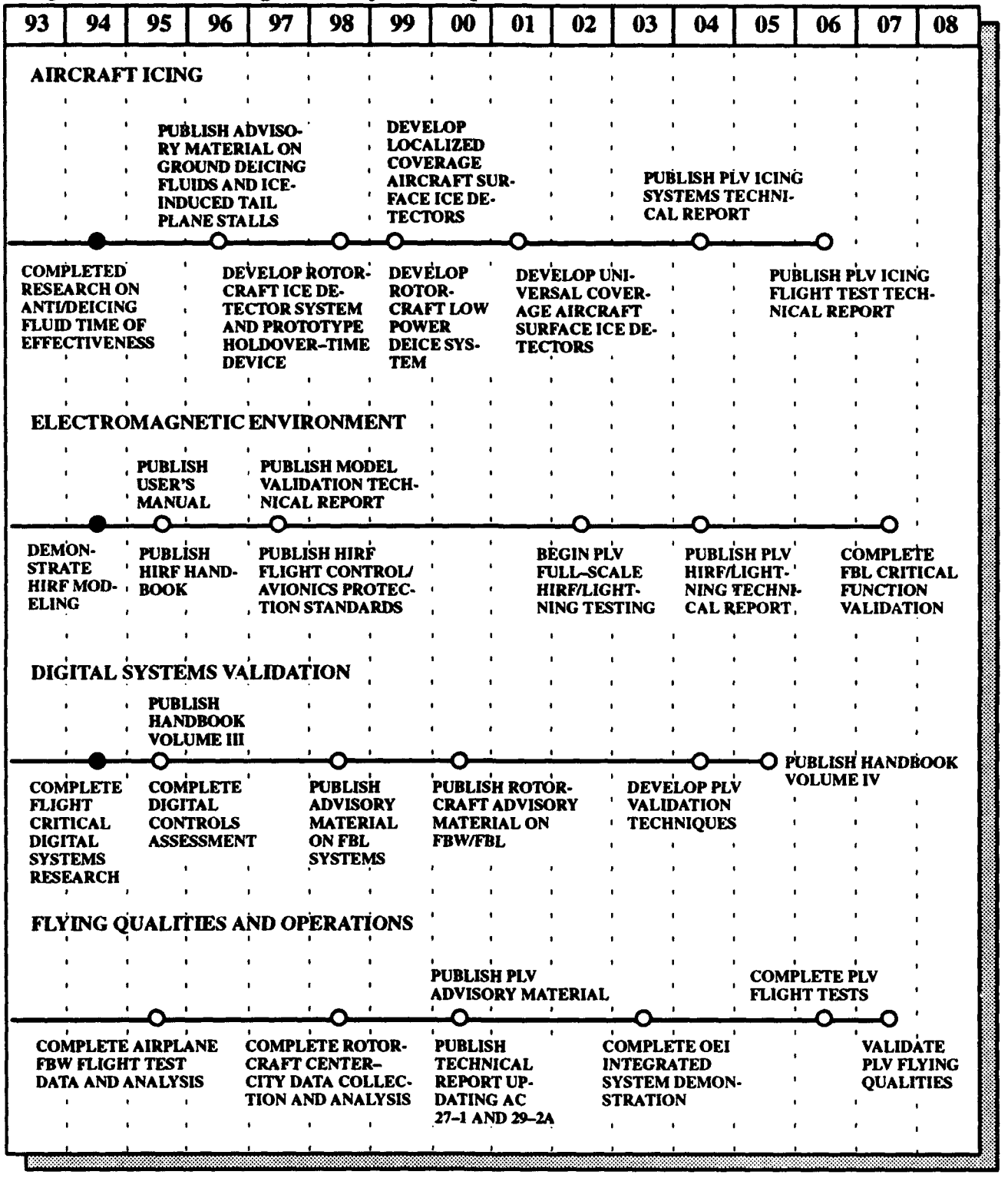
In 2004, validation techniques will be developed for PLV systems, and in 2005, the Digital Systems Validation Handbook, Volume IV, will be published.

Flying Qualities and Operations

In 1995, technical emphasis will concentrate on updating flight test data and analysis of fly–by–wire, automated flight control systems and equipment that improve certification/safety techniques. Both type- and operational-certification issues will be addressed for failed–mode flight conditions as well as normal operations. During 1995, work will also continue to provide solutions and alternatives for improved access and more efficient utilization of center–city heliports by rotorcraft. In 1998, data collection and analysis will be completed on the effect of instrument meteorological conditions on center–city rotorcraft operations.

In 2000, a technical report will be issued to update Advisory Circulars 27–1 and 29–2A. Also, advisory material for PLV flying qualities and operations will be published. In 2003, a one engine inoperative (OEI) integrated systems demonstration will be conducted. In 2006, civil PLV flight tests will be completed for flying quality validation in 2007.

## Project 064–110: Flight Safety/Atmospheric Hazards



## 065–110 Aging Aircraft

**Purpose:** Aging airframe structures have shown increasing susceptibility to widespread fatigue damage and corrosion that could pose a threat to their structural integrity. Instances of structural failures point to the need for increased reliability in inspection methods. Furthermore, the demands on the aviation safety inspectors due to the aging aircraft fleet require automated data tracking improvements. This research effort will develop the means for evaluating and ensuring safety and reducing the risks associated with aging aircraft structures. The three thrust areas of this project are: structural design, maintenance and inspection, and automated methods for surveillance of information relating to the aging aircraft fleet.

The various research activities will also include technology transfer of technical material and knowledge to industry and foreign regulatory agencies.

**Approach:**

Structural Integrity

To address aging aircraft structural design problems, improved methodologies and test data are needed. Models and data will be developed to correlate service experiences with test and analysis results. Design alternatives that delay or eliminate widespread fatigue damage will be identified.

The corrosion effects on fatigue and fracture will be quantified and evaluated. Analytical fracture models resulting from this work will be used as a basis for rulemaking.

Means for evaluating the effect of single and multiple repairs on airframe structural integrity will be developed. This work will benefit independent repair stations and smaller air carriers. Modern flight and ground load data collection systems will be developed, and the structural loading histories will be determined for the current fleet.

Maintenance and Inspection

Improvements in maintenance practices and training, as related to repair and corrosion control, will be developed and offered to heighten awareness of structural degradation modes among the aviation community, particularly the FAA inspectors. A job task analysis will be conducted to identify critical maintenance inspector tasks.

Existing and emerging NDI equipment and methods will be evaluated in relation to their capability to detect structural defects. Prospective technologies are being developed that offer improvements in relation to reliability, ruggedness, automation, human performance, and cost. The most promising technologies will be prototyped for testing, leading to cooperative research and development agreements (CRDA) with industry for technology transfer. Additionally, standards will be developed for inspection equipment and personnel.

Information Systems

In this thrust area, safety analysis and data management systems will be developed. These systems will be designed to audit critical performance indicators, identify safety risks, and maintain information for air crew qualification. These systems will have the capability to interrogate data relating to air operators, aircraft, air agencies, and aircrews.

**Related Projects:** 062–110 Aircraft Crashworthiness/Structural Airworthiness, 063–110 Propulsion and Fuel Systems, 064–110 Flight Safety/Atmospheric Hazards, 066–110 Aircraft Catastrophic Failure Prevention Research, and 085–110 Aircraft Maintenance Human Factors.

**Products:**

- Testing to assess structural fatigue/corrosion effects and to establish proper inspection procedures
- Damage tolerance training material for FAA engineering certification personnel
- Airframe repair design and analysis software
- Corrosion prevention/control design and maintenance handbook
- Analytical models that can be used to minimize airframe structural component susceptibility to multiple–site damage
- Reporting system to monitor the aging fleet and provide a basis for structural life management
- Automation of NDI procedures through robotics
- Data base for flight and ground loads encountered by transport and commuter airplanes that can be used for design and certification
- NDI procedures and equipment design commensurate with inspection work environment
- Automatic training systems for repair/maintenance personnel

**1994 Accomplishments:**

- Developed engine maintenance criteria.
- Completed technology assessment for detecting critical engine component material flaws.
- Completed assessments for inspection technology and automated technology.
- Developed information system architecture prototype.
- Developed minimum and proficiency requirements for inspection work environments and NDI equipment designs.

**Planned Activities:**

Structural Integrity

In 1995, flight and ground load data collection will continue for in–flight structural data collection/analysis programs. The data base and collection/analysis programs will be completed for several specific aircraft models in 1997, and a technical report will be published. Further research on flight and ground loads will continue through 2001 when the flight load program will end.

In 1995, model development will be completed and tests conducted to predict airframe structural component susceptibility to multiple–site damage. In 1996, the multiple–site damage model validation will be completed. Also, a corrosion fatigue model will be developed. In 1997, research will be completed on complex structures repair analysis. Factors affecting fatigue quality and airframe design fracture resistance will be studied to develop design guidelines. The structural performance of bonded composite repairs as candidate strategies will be evaluated for conformance to existing FAA regulations. Failure analysis research will be completed in 2001. In 1995, research will be completed to characterize weld cracking for aircraft engines. This research will be used to develop high temperature crack growth data in 1996. Engine life prediction research will be completed in 1997.

Maintenance and Inspection

In 1996, a corrosion prevention and control handbook will be completed with follow–on fatigue interaction materials studies completed in 1997.

In 1997 and 1999 respectively, corrosion fatigue interaction investigations and related materials laboratory evaluations will be completed. These evaluations will be used to determine if existing regulations need to be modified.

In 1996, maintenance instruction repair procedures for civil aircraft will be upgraded. This upgrade involves developing updated advisory criteria and a companion video. In 1997, a personal computer (PC)–based repair tool addressing aircraft structural modifications will be developed for field implementation. Additionally, specifications will be developed for composite/metal repairs in 1997 with repairs analysis planned for completion in 1999.

In 1996, repair station housing/equipment criteria will be developed for airframe/engine structural repairs. Additionally, development work on engine test cell data correlation will be completed. The test cell data correlation is necessary to eliminate anomalies between individual repair stations.

In 1995, weighted job task definitions will be developed for aviation maintenance technicians, and PC–based NDI training will be developed. This research will lead to developing aviation specialist qualifications/standards in 1996. In 1995, a facility will be established and equipped that can be used for independent, quantitative, and systematic NDI assessments. These assessments are associated with NDI reliability and implementation costs for equipment/procedures suitable for aircraft structures. Portable robotic devices will be installed in the facility to automatically position NDI probes for scanning large aircraft structural areas.

In 1995, a promising inspection technology system will be selected for future field implementation. The selected system will be validated in 1996 and optimized through 1998. For inspection automation, systems will be developed in 1995 and optimized through 1999.

In the engine inspection area, in–service eddy current inspection improvements will be developed in 1995, followed by in–service ultrasonic inspection improvements in 1997. In 1998, fluorescent penetration inspection improvements will be developed.

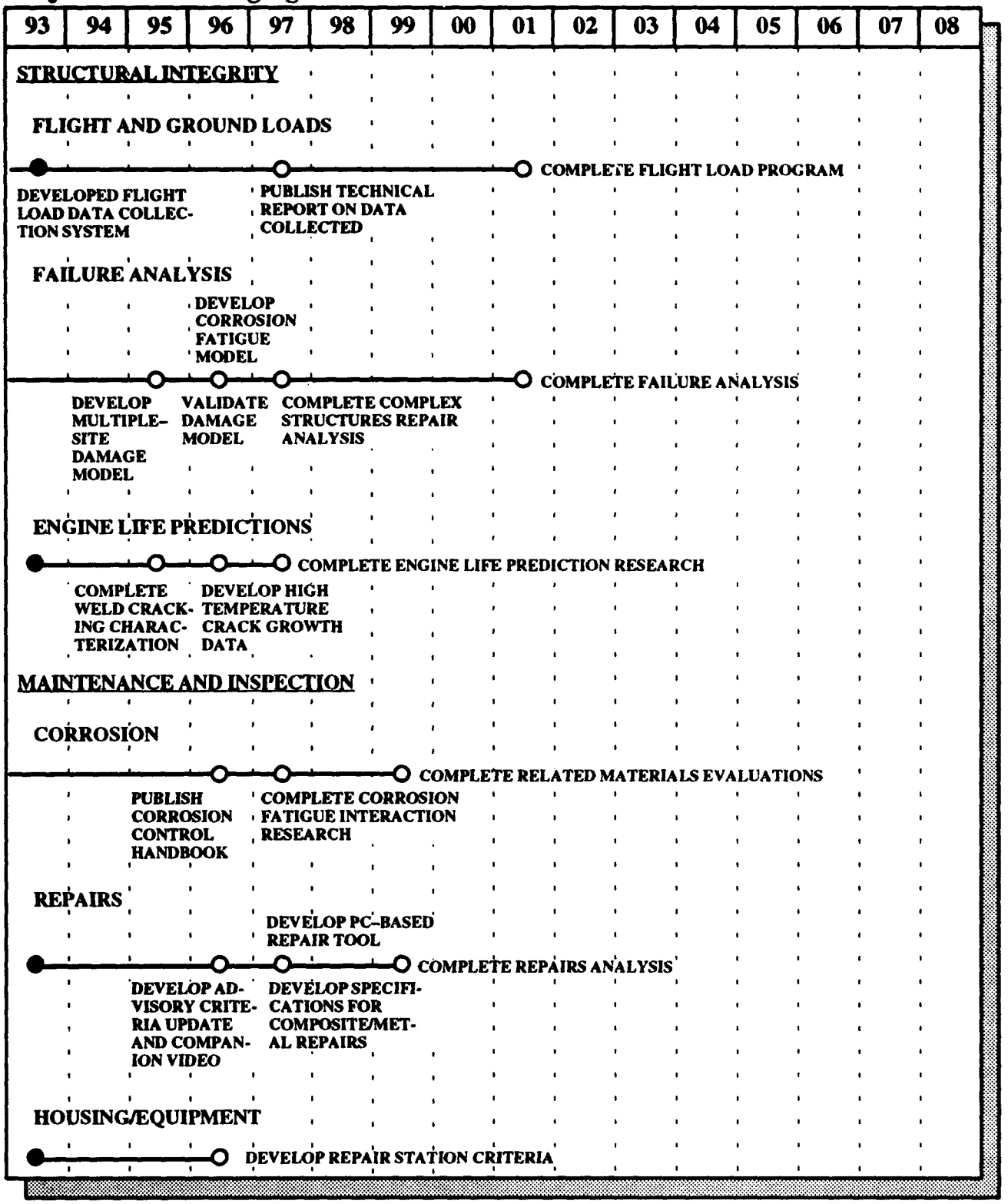
Information Systems

In 1995, a production safety performance analysis system (SPAS) will begin installation in all flight standards field offices. With SPAS, FAA aviation safety inspectors will be able to target their surveillance efforts on certificate holders that pose the greatest risk. This project will support SPAS installations through 1996.

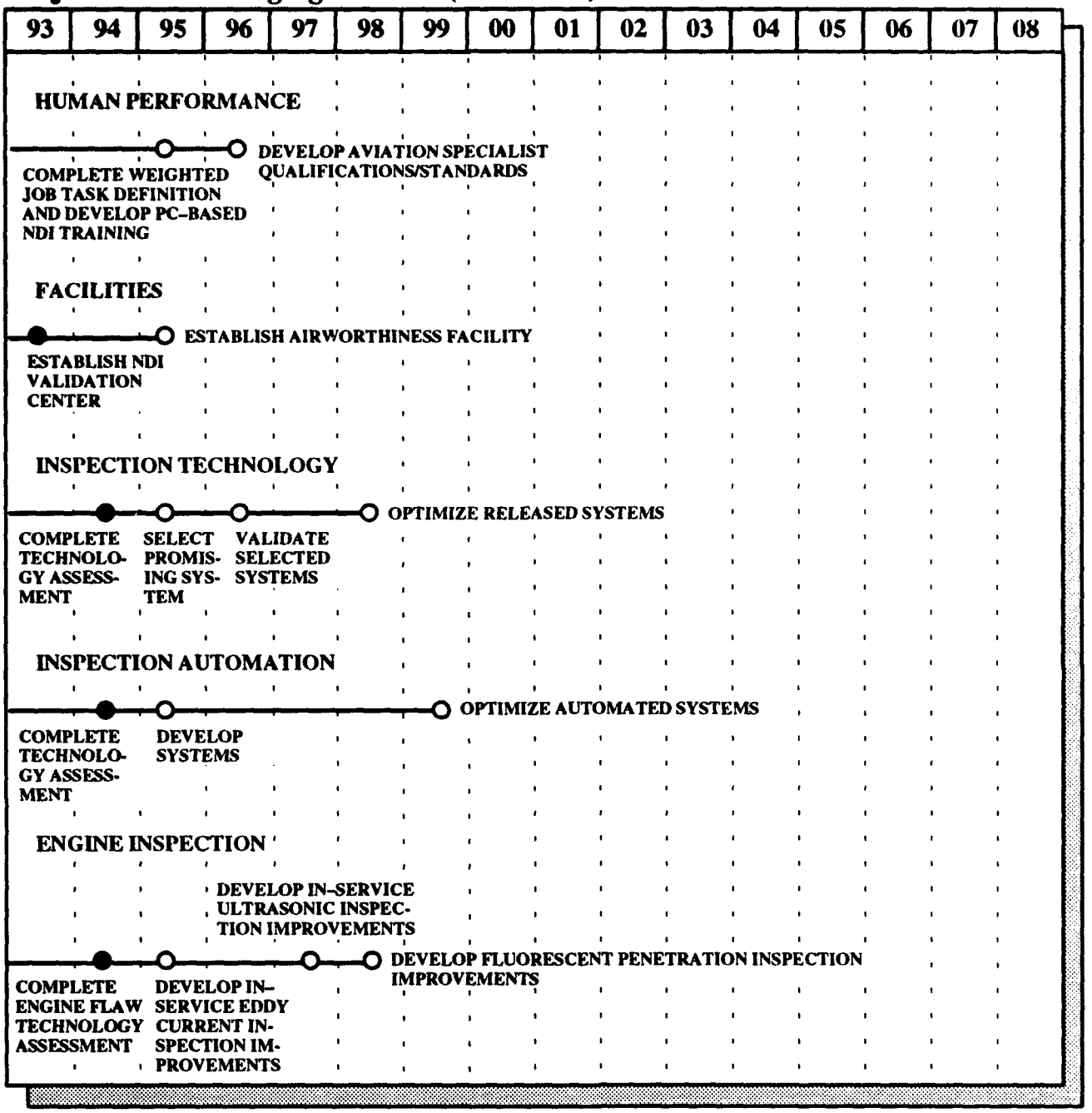
Using SPAS as a model, efforts will begin in 1996 to develop a joint FAA/industry safety analysis system. The concept behind this effort is to share data instead of having both FAA and industry store the same information on duplicate systems. Requirements analysis will be completed in 1997 with a prototype system to follow in 1998. In 1999, efforts will be completed to integrate the FAA and industry safety networks and validate safety indicators.

In 1995, efforts will begin on developing an aviation safety information network utilizing the available FAA infrastructure and commercially available networks. This aviation safety information network will be required to facilitate information transfer between FAA and industry. Requirements definition will be completed in 1995 with a preliminary design review completed in 1996. In 1997, an interim operational system prototype will be developed for evaluation purposes, leading to a fully operational system in 1999.

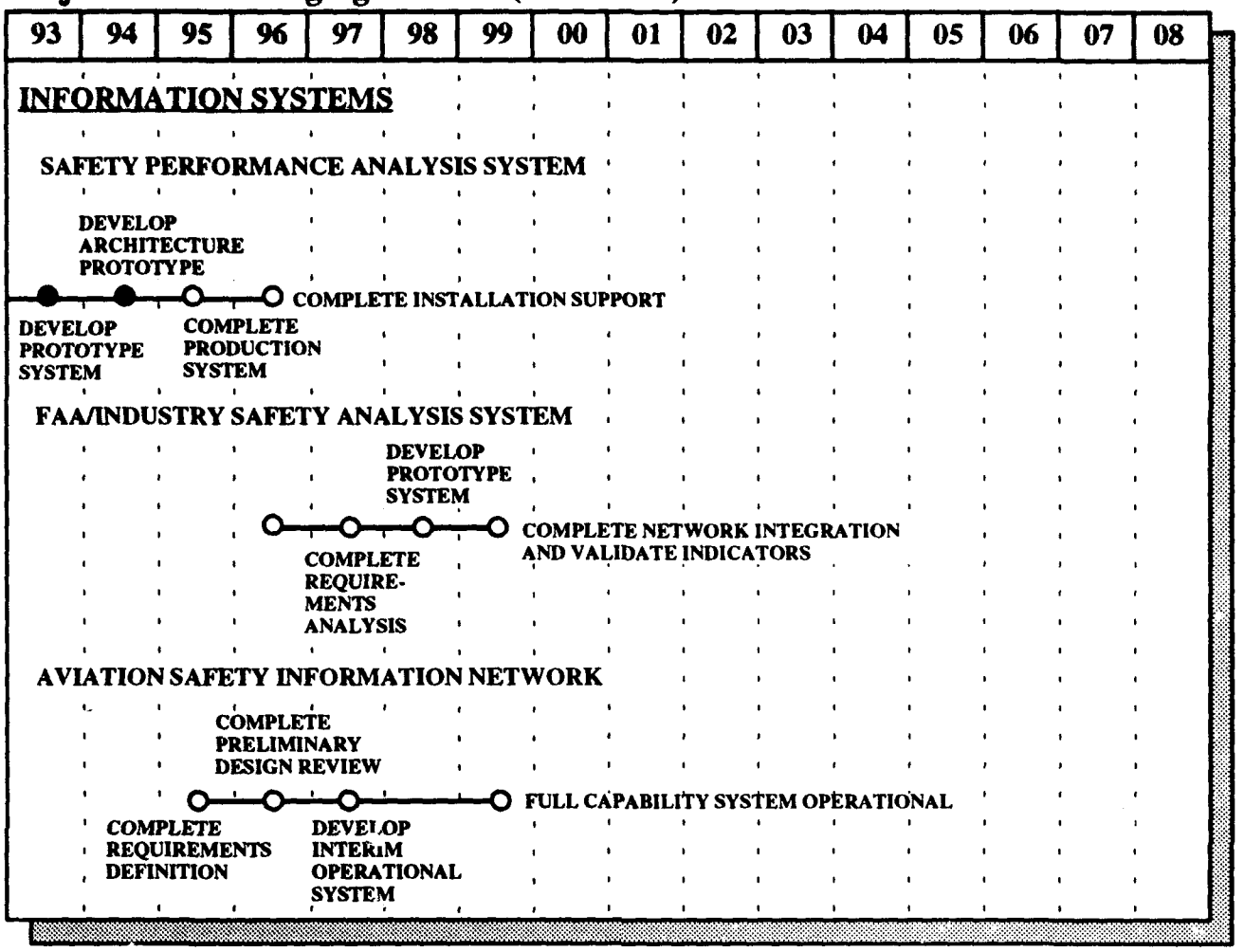
## Project 065–110: Aging Aircraft



## Project 065–110: Aging Aircraft (continued)



## Project 065–110: Aging Aircraft (continued)




## 066–110 Aircraft Catastrophic Failure Prevention Research

**Purpose:** This project will establish and direct a research effort with the objective to identify, reduce, and prevent aircraft system problems that could result in a catastrophic aircraft failure. This failure prevention research will reduce catastrophic accident risks and the number of hull losses, injuries, and fatalities. Information developed from this project will be disseminated to the aircraft industry on a regular basis. This research is required by Title IX of the Omnibus Budget Reconciliation Act of 1990 (Public Law 101–508), "Aircraft Catastrophic Failure Prevention Research Program."

**Approach:** This project will conduct research to develop methodologies that characterize and assess the risks associated with potentially catastrophic aircraft hardware/software problems. Technologies will then be identified to prevent or minimize these hazards. Centers of excellence will be established at universities and/or nonprofit national research laboratories as re-

search focal points. The research will concentrate on three individual technical areas: turbine engine/auxiliary power unit failure hazards prevention, fuselage structural failure prevention, and damaged/failed flight control system airworthiness.

Turbine Engine Failures

A failure in turbine engine and auxiliary power unit (APU) rotating components can be a serious safety hazard to critical aircraft systems because high energy fragments can be released. The traditional approach to minimize these hazards is to isolate individual engines and APU's from other engines and flight critical systems. More effective containment or protective shields are an under-utilized approach due to weight and complexity penalties. This project will develop a high energy fragment containment and/or protective shield material technology. A comprehensive, advanced lightweight material technology state–of–the–art review will be conducted and new material concepts will be developed for absorbing high kinetic energy fragments in the largest turbofan engines. Further efforts will provide a methodology to determine catastrophic failure probability and risk assessment. This methodology will be used to develop an analytical model of liberated fragments from gas turbine engine and APU rotating components. This model will assist in assessing the catastrophic failure risk in current and future designs.

To reduce the occurrence of rotating component failures, advanced computational technology will be used to develop expert/neural network/artificial intelligence systems. These systems will monitor, acquire, and interpret parameters to predict and trend rotor system abnormalities or impending failures. Sensor technology will be developed to measure critical parameters. This capability will be integrated into a total aircraft parameter monitoring system. In addition, research will be applied to advanced critical engine material manufacturing and inspection technologies. A turbine engine titanium consortium has been established to evaluate and improve current state–of–the–art inspection technologies. This consortium includes the FAA, academia, and industry to provide a thorough background in NDI technology.

Structural Failures

Research will be directed toward advanced means to predict and prevent catastrophic structural failures on future commercial transport aircraft. Emphasis will be placed on: forming accurate, quantitative definitions of dangerous aircraft loading conditions; structural failure prevention through improved airframe design and maintenance; and structural failure survivability through an improved understanding of failed airframe loading conditions.

A joint effort with the aircraft hardening project will be undertaken to develop a vulnerability assessment for wide- and narrow-body transport aircraft. Advanced analytical and computational design tools and concepts will be developed and applied to future airframe system designs. Automated maintenance/inspection monitoring devices and artificial intelligence training systems will be developed, tested, and implemented. Interagency agreements will be established for determining composite component structural quality and composite/advanced component inspection and repair procedures.

Flight Control Failures

This project will address specialized technology fields that concentrate on preventing catastrophic flight control failure after an in–flignt accident/incident. Research will assess what failed–mode flight control options are practical for any control failure case to ensure continued safe flight and landing. This project will concentrate on studies that include areas such as: substitute, alternate, and reconfigurable control systems; flying qualities criteria; stability and control; situational awareness; and human factors. A program of modeling analysis simulation and variable stability aircraft flight tests is planned to provide

technology that could be beneficial in failed–mode flight control situations. The proposed approach will test both aerodynamic aspects and aircraft stability/control. This approach will: develop technology to improve aircrew emergency procedures; provide aircrew training that simulates damaged aircraft handling qualities; conduct research on damaged flight control airworthiness issues; and provide a real–time flight control cockpit advisory system.

**Related Projects:** 062–110 Aircraft Crashworthiness/Structural Airworthiness, 063–110 Propulsion and Fuel Systems, 064–110 Flight Safety/Atmospheric Hazards, 065–110 Aging Aircraft, and 075–110 Aircraft Hardening.

**Products:**

- Full–scale prototype aircraft diagnostic system(s)
- Advanced containment material(s) suitable for airframe and/or engine applications
- Advanced airframe and engine structures maintenance/inspection/monitoring/advisory systems
- New NDI inspection technologies for advanced engine and structural materials
- Aircrew emergency procedures and new systems for damaged or failed flight control systems
- Failure modes risk assessment analysis methodology tools
- Computational models of airframe loads during impact or depressurization scenarios
- Quantification and analysis of gust loading conditions on transport aircraft

**1994 Accomplishments:**

While activities leading to future accomplishments were conducted in 1994, no major products/accomplishments were completed.

**Planned Activities:** Failure characterization and risk assessment methodologies will be completed in 1995.

Turbine Engine Failures

In 1995, feasibility and design concepts will be completed. A prototype diagnostic system and advanced containment material concepts will be developed and demonstrated in 1998 for rotorcraft and in 2003 for fixed–wing airplanes.

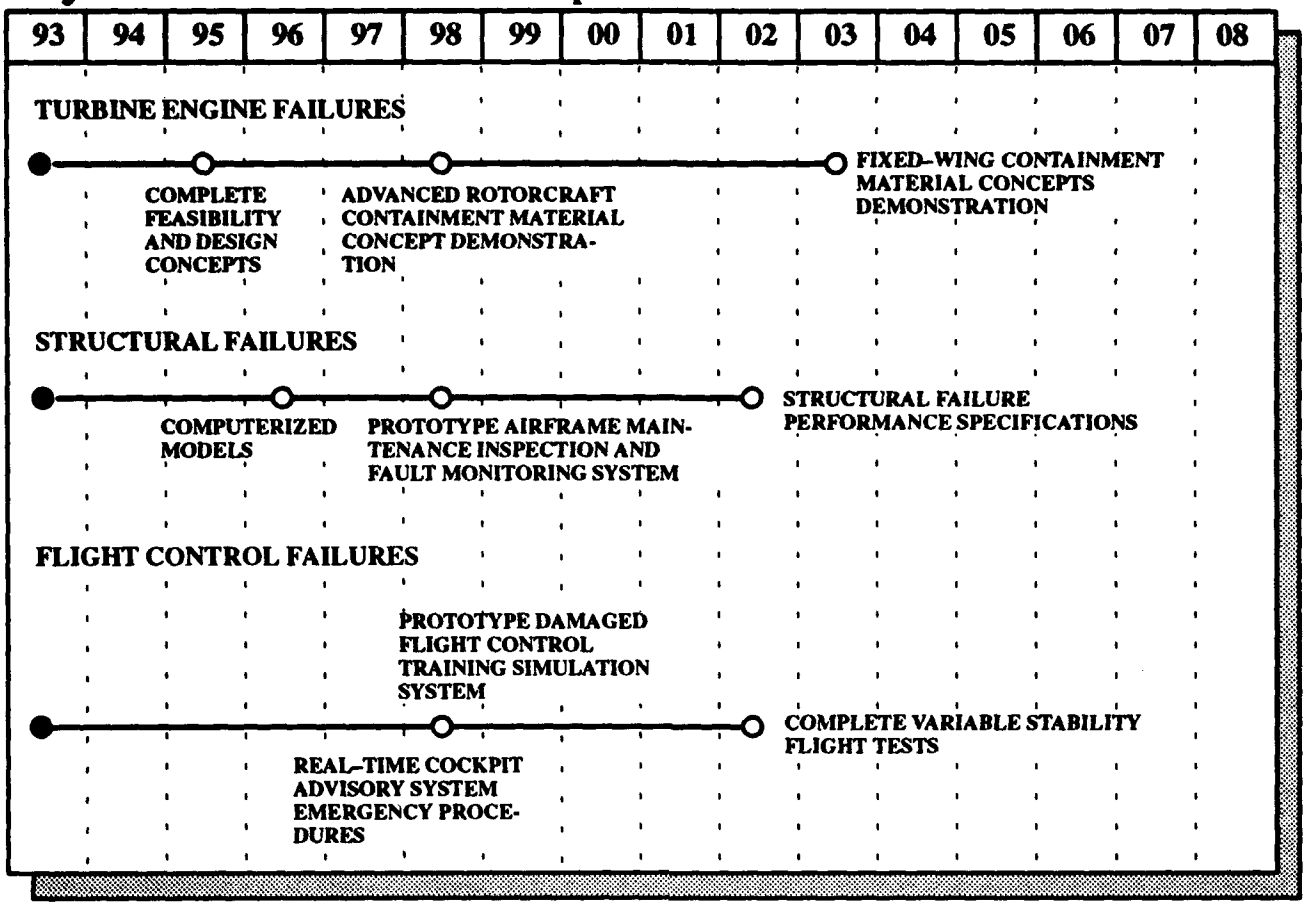
Structural Failures

The risk analyses studies will result in computerized models by 1996. These models will undergo validation from 1996 through 2002. Contemporary and future airframe load testing will begin in 1996 and run through 1998. Structural failure vulnerability reduction through design improvements and new repair and inspection specifications will be ongoing through 2002. A prototype airframe maintenance inspection and fault monitoring/advisory system demonstration will be conducted in 1998.

Flight Control Failures

In 1995, continued research will assess the viability of failed–mode flight control options for emergency operational conditions. A prototype damaged flight control training simulation and aircrew emergency cockpit advisory system will be developed in 1998. Wind tunnel testing on a representative transport aircraft model will be conducted from 1995 through 2002. Variable stability aircraft flight tests are planned from 1996 through 2002 to provide technology which could be beneficial in failed–mode situations.

## Project 066–110: Aircraft Catastrophic Failure Prevention Research



# 7.0 SYSTEM SECURITY TECHNOLOGY

This thrust area is driven by the requirement for a safe and secure aviation system. The direct benefit from an effective security system is preventing fatalities, injuries, and property losses resulting from intentional criminal acts. The indirect benefits include preventing a variety of disruptions to air traffic services and their attendant economic impact. Developing new security technologies is necessary to achieve a high security level without incurring excessive costs or inconvenience to the air transport industry or passengers.

Civil aviation continues to be an attractive target for terrorists or individuals with other criminal motives because it is highly visible. The threat level has evolved from hijacking in the mid–1970's to terrorist activities aimed at disrupting or destroying specific air transportation elements. The tragedy that befell the 270 victims of Pan Am Flight 103 over Lockerbie, Scotland, is one such act. In the United States, the immediate impact from this event was to double airline security costs from $500 million to almost $1 billion per year.

Even a threat on a specific target is sufficient to cause significant disruptions and economic impact. For example, events in the Persian Gulf during the first 3 months of 1991 reduced consumer confidence in the air transport system's security. As a result, scheduled air miles for domestic flights decreased by 5.2 percent, with international flight miles on U.S. carriers decreasing by 16.2 percent. Continued public confidence in the aviation system's security from terrorist threats, in general, and U.S. airports and carriers in particular, is key to the public using these services and the resulting economic benefits.

The Federal Aviation Administration initiatives in system security are designed to provide this confidence and achieve these benefits by developing systems that prevent or deter hijacking and sabotage. An initial thrust area assessment indicates that benefits as high as $40 million per year can be achieved from reduced airport security service costs while providing increased protection. The benefit from avoiding the direct costs of just one major incident would be approximately $150 million for a wide–body aircraft plus $450 million for the lives lost.

Research in security technology is needed to counter threats that are becoming more sophisticated. The spread of international terrorism makes it imperative for the FAA to identify and develop the most effective technologies that can be practically applied in security systems. Those who pose a threat to the traveling public are intelligent, committed, and innovative, striking where the system is most vulnerable. Protection must therefore be comprehensive, addressing all potential vulnerability in the airport and air traffic control facilities, as well as onboard the aircraft.

The Aviation Security Improvement Act of 1990 directs the FAA to:

- Accelerate its system security program over a 36–month period;
- Expand its system security program to address current and future threats; and
- Expand the security initiatives in the aircraft hardening and human factors areas.

The continued emphasis for research in this thrust area has been on developing automated capabilities to prevent introducing explosives onto aircraft.

A broad agency announcement (BAA) and solicitations for proposals have been used to identify and fund over 30 different organizations to conduct security–related Research, Engineering and Development (R,E&D). These contracting mechanisms allow the FAA to identify and exploit innovative concepts and technologies

from both industry and academia. Currently, explosive detection and pattern recognition research is underway.

The FAA's work in aviation security also involves cooperative efforts with many other Government agencies such as the Departments of State, Defense, and Energy; U.S. Customs Service; Bureau of Mines; and intelligence and law enforcement agencies. International working agreements to exchange security R,E&D information are in place with Canada, the United Kingdom, and France.

To support operational security systems deployment, the security R,E&D program includes tasks to devise standard test protocol and performance criteria for testing automated explosives detection systems and for giving advice on credible systems architecture for various detection techniques. Technology assessments will be performed on commercially developed security equipment utilizing the standard test protocol, and a list of approved automated explosives detection technologies will be developed for implementation by air carriers.

The results from the Security R,E&D Program are technologies, specifications, rules, and guidance to be used by airports and air carriers to perform their aviation security functions. The FAA does not, except for human factors and air traffic control (ATC) facility protection, procure the hardware that results from the Security R,E&D Program.

## 7.1 System Security Technology Project Descriptions

### 071–110 Explosives/Weapons Detection

**Purpose:** This project will develop improved systems and operational procedures for detecting explosives/weapons on passengers and in checked and carry–on baggage, air cargo, and mail. These improved, fully automated systems will allow rapid passenger and baggage screening to occur without interrupting passenger or baggage flow. These systems will have high detection/low false–alarm probabilities, thereby increasing airport and air carrier safety.

The current trend in firearm and some grenade manufacturing is toward using nonmetallic components and nonferrous alloys. These weapons may escape detection by current airport metal and weapon detection systems. This project will also develop screening systems based on alternate technologies that are capable of detecting "plastic" and other unconventional weapons.

**Approach:**

Explosives Detection

Current systems are intrusive and labor intensive. Design goals are for systems that are fast and effective and provide a uniform, high performance level through computer assistance. The challenge is to select sensor systems appropriate to the threat and scenario, then integrate them within the constraints of an airport.

The FAA is developing two basic types of explosives detectors. One is designed to collect, analyze, and identify vapors from different explosives, and the other is designed to use electromagnetic energy or nuclear radiation to penetrate and identify bulk explosives based on their elemental or structural composition. Since they are passive devices, vapor detectors are currently the only detectors that can be used for screening passengers. In the near–term, both vapor and bulk prototype detectors will be developed to provide an immediate response to today's terrorist threat. In the long–term, the emphasis will be on identification, feasibility demonstration, and subsequent development of more efficient and effective new technologies.

Development has been completed on several prototype systems for screening checked baggage and cargo has been completed. A vapor portal to screen passengers is in development. Several new chemical detection technologies using chemiluminescence, mass spectrometry, ion mobility spectrometry, surface acoustic wave modulation, and biosensor techniques have been identified and evaluated. Several new technologies have advanced to the prototype stage and a few to the commercial stage. A high resolution X–ray is now in use in foreign countries. A computer tomography (CT) system has collected data at an airport and is being integrated with a pre-object scanner to be the second-generation CT explosive detection system (EDS). Nuclear resonance absorption and pulsed fast neutron system prototypes have been suspended for the near term. Component research on these technologies will continue.

Weapons Detection

Methods to enhance current generation screening system performance are being investigated. Commercial weapons detection devices are being evaluated for deployment in airports and new standards are being developed to ensure that these screening systems continue to be effective. Alternate methods to detect nonmetallic handguns, as well as flammable liquids and liquid explosives, are also being investigated.

Passenger–screening system development based on alternate technology has been initiated.

**Related Projects:** 073–110 NAS Security, 075–110 Aircraft Hardening, and 076–110 Aviation Security Human Factors.

**Products:**

- Feasibility studies
- Prototype hardware
- Project evaluation reports
- Engineering procurement specifications
- Data to support rulemaking

**1994 Accomplishments:**

- Conducted operational prototype tests on the coherent X–ray scattering system, the vapor detection systems for baggage, and the nuclear quadrupole resonance detection system.
- Conducted combined technology tests with enhanced X–ray and vapor technologies for screening checked baggage.
- Completed testing on a linear array millimeter wave passenger screening portal.
- Completed operational testing on dielectic and nuclear magnetic resonance bottle screening systems.

**Planned Activities:**

Explosives Detection

First generation detection systems will continue to be deployed, while new detection systems development, including prototype vapor portals, will continue with operational testing scheduled from 1995 through 1998.

Technology from the nuclear resonance absorption demonstration system will be transferred to industry in 1995. Research will focus on developing nuclear resonance absorption system components such as an accelerator, collector, and detector through 1996. In 1995, testing will be performed on prototype systems for fast neutron spectroscopy/radiography, alternate nuclear systems that can potentially be integrated with multiple technologies, and the nuclear magnetic resonance squid system. Enhanced X–ray systems integration with vapor systems will be initiated for carry–on screening. Additional vapor portal prototypes will be completed, and testing will begin at airports in the United States. Vapor detector prototypes based on surface acoustic wave, frequency modulated infrared, and ion mobility spectroscopy technologies will be completed and undergo evaluation. A cargo container/mail X–ray scanning system laboratory prototype will be initiated with estimated completion in 1998.

In 1996, prototype testing for the pulsed fast neutron system will be completed and a biotechnology vapor detector prototype will be developed for explosives detection. In 1997, a prototype fast neutron system will be completed. An integrated vapor, bulk, and new prototype threat detection system for baggage inspection will be developed in 1998 to replace multiple detection systems in airports.

In 1998, an automatic high–volume passenger scanning portal will be developed to combine explosives and weapons detection systems.

New technologies will be identified and developed based on emerging threats. These will be explored, and those showing promise will be taken to the laboratory and airports for operational testing. Broad agency announcements, the grants program, or similar vehicles will continue to identify innovative approaches to this challenging problem and examine synergistic combinations of the sensor systems identified.

Weapons Detection

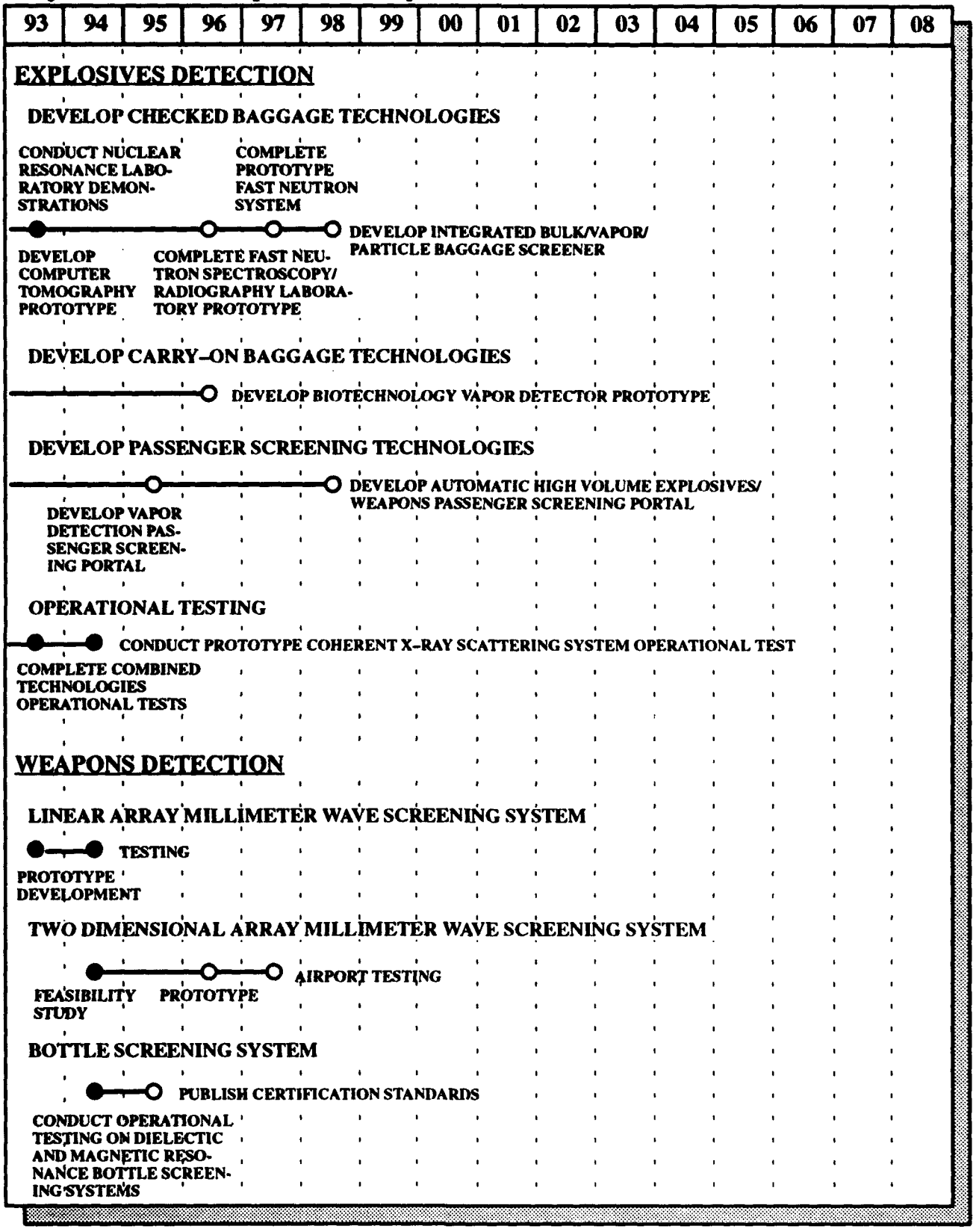
In 1995, lessons learned from the linear array technology will be applied to the two–dimensional array system development. Also in 1995, bottle screening certification standards will be published.

In 1996, a prototype two–dimensional millimeter wave passenger scanner will be evaluated in the laboratory and tested at an airport in 1997.

In 1997, an automatic high–volume passenger scanning portal will be developed to combine explosives and weapons detection systems.

New technologies will be identified and developed based on emerging threats. These will be explored and those showing promise will be taken to the laboratory and airports for operational testing. Broad agency announcements, the grants program, or similar vehicles will continue to identify innovative approaches to this challenging problem and examine synergistic combinations of the sensor systems identified.

## Project 071–110: Explosives/Weapons Detection



## 073–110 NAS Security

**Purpose:** This project will determine the operational effectiveness, impact, and cost for enhanced airport security by using a demonstration airport. Establishing a demonstration airport will provide a test bed for evaluating new security technology and procedures integration into an operational environment.

This project will also evaluate aviation security from a systems approach, determine if current systems integration is adequate, identify alternatives to counter evolving security threats, and identify requirements for research and development. A cost–effective and unobtrusive security system will become an integral part of normal civil aviation operations resulting from the various security research efforts that are currently underway.

**Approach:** Technology and procedures system integration and operational testing will determine whether these technologies and procedures are ready to be implemented in the operational aviation system, or whether further development is needed. New or enhanced training and operational procedures will be validated. Operational test results will be evaluated against threat/risk assessment and requirements definition to determine if the R,E&D products meet the objectives.

Protection for aviation targets has been prioritized based on current and predicted future terrorist threats to airports and operations. The prioritized targets have been correlated with existing FAA regulations and actual airport security plans. Enhanced system design and operational procedures will be developed to counter higher threat levels while maintaining economic viability, responsiveness, and normal passenger flow. The security design and operational procedures will be implemented and evaluated in a test bed environment at Baltimore– Washington International Airport. This test bed will be used to test new technology in an operational environment for performance characteristics and operational procedures through a cooperative research and development agreement with the Maryland Aviation Administration. If successful, equipment tested will be deployed throughout the system as appropriate. Enhanced security for FAA facilities, such as Centers and Terminal Radar Approach Control (TRACON), will be developed based on threat vulnerability assessments. Security enhancements for protecting FAA data and telecommunications will be implemented as required.

This project will interpret and translate threat information into functional security system requirements using accepted analytical methods and tools. Modeling and applied research necessary to define security system parameters and constraints will be conducted. The model will contain information on current and future threats as well as technologies to counter each threat.

A long–range, strategic plan for developing and deploying aviation security system components will be developed to ensure that all components, attributes, and relationships needed to achieve a higher security level are identified and integrated into the system.

Alternative security system design approaches will be evaluated through system cost–effectiveness analyses and tradeoff studies. A feedback mechanism will be established for updating system requirements on a continuing basis as new threat or technology issues are identified through intelligence activities, research developments, and/or operational equipment and procedures testing.

**Related Projects:** 071–110 Explosives/Weapons Detection and 076–110 Aviation Security Human Factors. Capital Investment Plan projects: 56–60 Integrated Security Management Systems (ISMS).

**Products:**

- Airport vulnerability reports based on current and future threat definitions
- Integrated airport security conceptual design
- Upgraded airport security test bed
- Project evaluation reports
- Operational guidelines
- Revised operations concepts and system requirements for an integrated enhanced aviation security system and responses to new threats
- Analytic models for threat/risk assessment
- Long–range, strategic plan for research, engineering, development, and deployment in an integrated aviation security system

**1994 Accomplishments:**

- Completed cost/benefit analysis on bar code technology and profiling alternatives to secure checked baggage to support rulemaking.
- Hosted international task force planning group to identify technologies for countering airline industry threats.
- Developed analytical models for threat/risk assessment.

**Planned Activities:** In 1995, an automated countermeasures data base will be developed to assist in the threat/risk analysis for airports worldwide. Radio frequency technology will be developed to replace bar codes for baggage and passenger tracking.

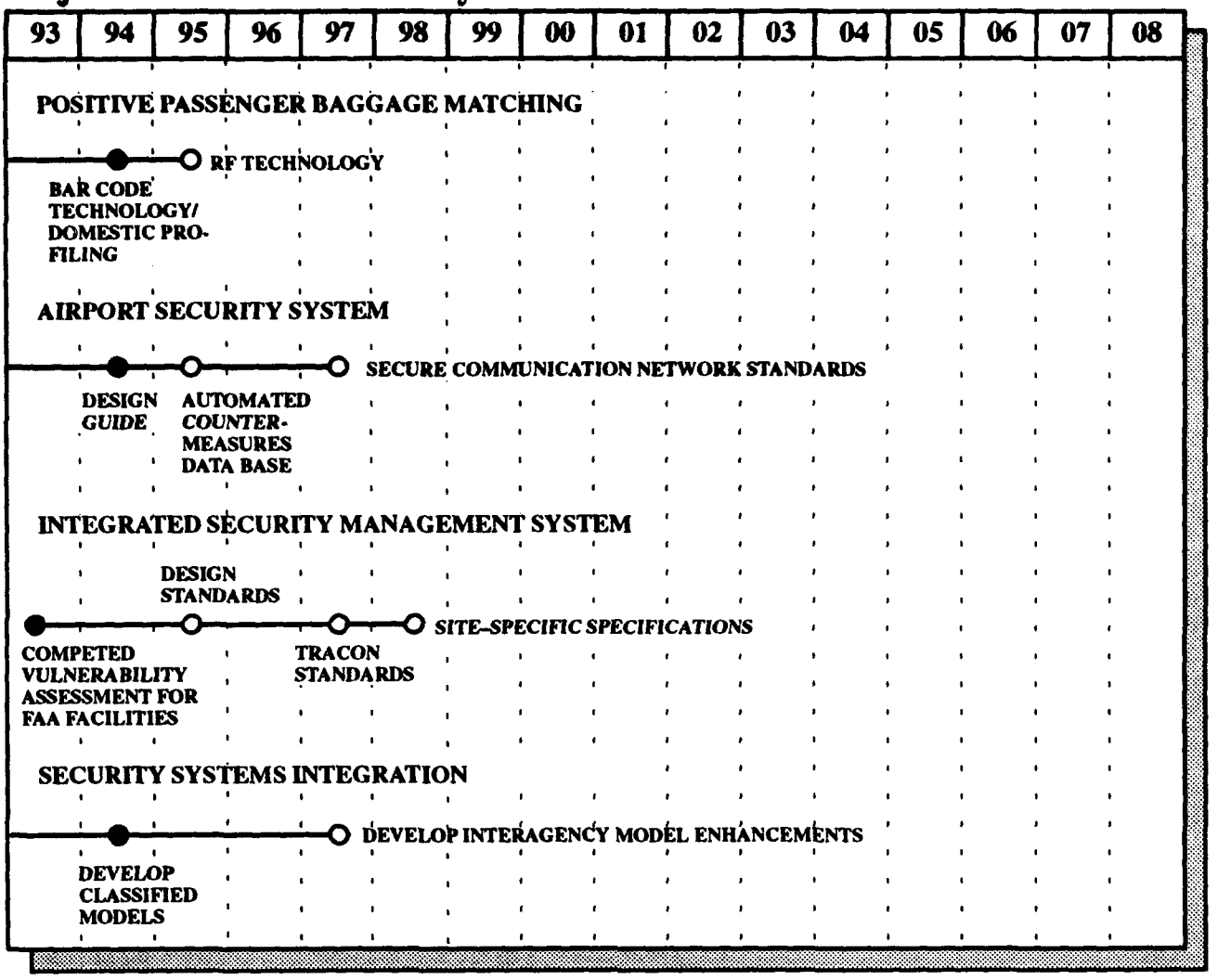
In 1995, design standards will be developed for a prototype ISMS to protect ARTCC's. Standards for TRACON's will be developed in 1997 with site–specific specifications planned for 1996–1998.

In 1996, a telecommunications security order will be issued, followed in 1997 by standards for secure communications networks.

In 1995, threat/risk model work with other Government agencies will continue, and interfaces with other Government agency systems will be expanded. This work will continue through 1997. Sensor integration analytic evaluations will be performed as new technologies emerge.

As new threats emerge, an analysis process and modeling tools will be utilized to evaluate countermeasures and initiate requirements for research and development.

## Project 073–110: NAS Security




## 075–110 Aircraft Hardening

**Purpose:** This project will identify methods to increase aircraft survivability by reducing damage effects caused by small explosive detonation on a commercial airliner. The threat to commercial aircraft and passenger survival due to the in–flight detonation of a small explosive device is significant. Balancing current technology detection capability and aircraft hardening to withstand damage from a detonation in flight will be accelerated as required by the Aviation Security Improvement Act of 1990.

**Approach:** Blast loading parameters caused by various explosive types and quantities will be determined. Models will be developed to predict damage to an aircraft resulting from explosive detonations. Explosives testing will be conducted on aircraft and/or other test devices to

verify models and assess damages using various scenarios. These tests will also be used to help determine aircraft vulnerability and validate blast mitigation/structural hardening techniques. Additionally, testing will be used to evaluate least–risk guidelines. Once failure mechanisms are identified, methods to protect an aircraft against catastrophic structural failure due to an in–flight explosion will be developed.

**Related Projects:** 064–110 Flight Safety/Atmospheric Hazards, 065–110 Aging Aircraft, and 071–110 Explosives/Weapons Detection.

**Products:**

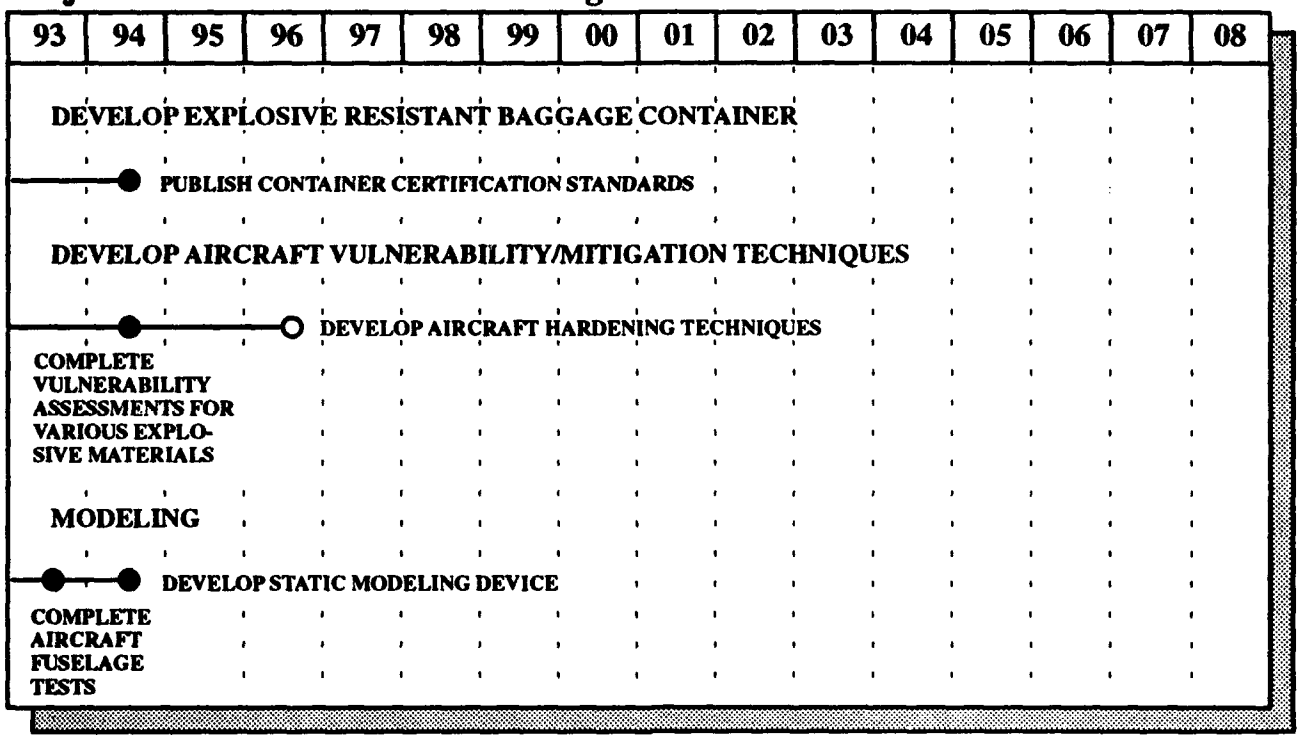
- Project evaluation reports
- Prototype hardware
- Guidelines for blast mitigation/aircraft hardening
- Engineering design specifications for aircraft and support equipment

**1994 Accomplishments:**

- Published container certification standards.
- Developed static test modeling device to replace actual fuselage test sections.
- Completed aircraft vulnerability assessments for various explosive materials.

**Planned Activities:** Development of new explosive resistant hardening techniques will continue through 1995 with recommendations for design specifications in 1996. Identification of methods and techniques to reduce vulnerability to other threats will continue through 1996 as well. These efforts will be coordinated with other R,E&D projects as appropriate.

## Project 075–110: Aircraft Hardening



## 076–110 Aviation Security Human Factors

**Purpose:** This project carries out the mandate of the Aviation Security Improvement Act of 1990, Public Law 101–604. This law's intent is to "maximize human performance" within the aviation security system and "include research and development of both technological improvements and ways to enhance human performance."

**Approach:** This project will develop guidelines, specifications, and certification criteria for human performance within an aviation security system(s). Effective human–machine interface and the human input to decisionmaking will be improved through a focus on selection, training, motivation, and job design. In this way, errors made through inattention, boredom, or inadequate performance standards will be minimized as both system and operator performance is strengthened. The explosives detection systems (EDS) programs will have in–house human factors analyses and recommendations available to them. Additionally, the Engineering, Research and Development Service (ACD) and the Aviation Security Research and Development Service (ACA) will develop and implement a program of joint human factors research. This joint, in–house human factors R,E&D program gives the FAA/Federal Aviation Administration Technical Center (FAATC) the ability to capitalize on generic human factors research which will benefit this project as well as other human factors efforts.

This effort involves collaboration with Government, airlines, security companies, equipment suppliers, and industry. Research is being planned and coordinated in the following areas: security system passenger/baggage screener selection, training, and performance evaluation; adversary identification and counteraction by security personnel and aircrews; FAA workforce training; and human factors aspects of new and emergent EDS and NAS security technologies.

**Related Projects:** 071–110 Explosives/Weapons Detection and 073–110 NAS Security.

**Products:**

- Empirical data and reports for use in rules, standards, certification, and guidelines on airport X–ray screener selection, training, and performance
- Functional requirements specification document for X–ray screener training and assessment equipment
- Report on analyses of commercial off–the–shelf (COTS) X–ray screener training equipment
- Report on cost/benefit analyses on tradeoffs and interactions among human factors, equipment, and environmental variables
- FAA workforce performance improved via the design and delivery of human factors training

**1994 Accomplishments:**

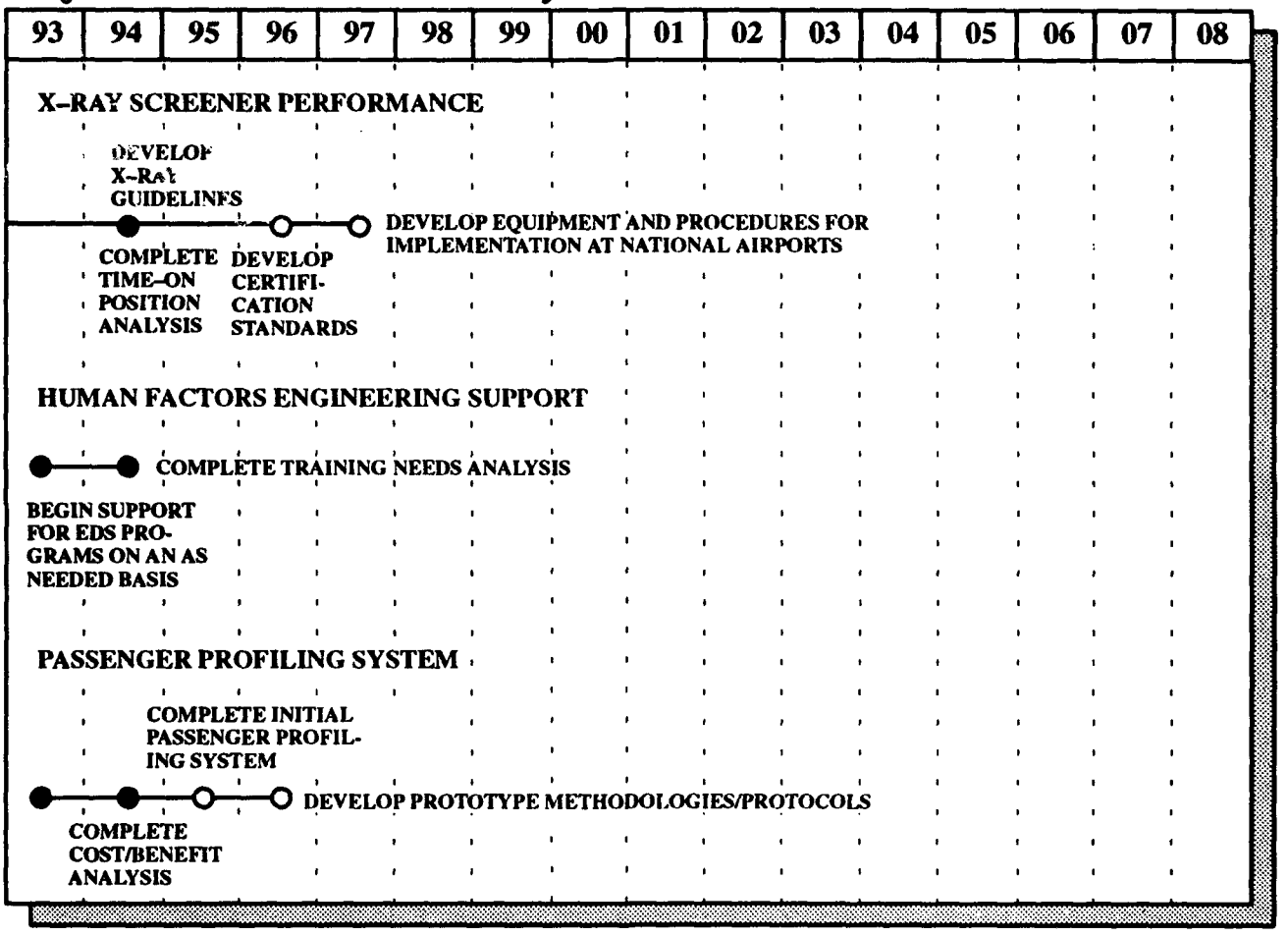
- Completed security workforce training needs analysis.
- Issued X–ray equipment guidelines.
- Completed alternative profiling cost/benefit analysis.

**Planned Activities:** In 1995, an initial domestic passenger profiling system that identifies passengers requiring greater scrutiny will be completed. Prototype methodology and protocols to increase passenger profiling system effectiveness will be developed in 1996.

In 1995–1996, human factors criteria will be established for screener selection standards, training, equipment design, and performance evaluation. These criteria will be followed in 1996 by guidelines for selecting screening personnel using computer–based performance testing. Final certification of SPEARS equipment will also be accomplished in 1996. In 1997, SPEARS analyses, simulation, and engineering efforts will be broadened to support developing SPEARS equipment and related procedures for implementation at national airports.

A key project element is responding to new requirements from sponsor organizations for human factors engineering that supports new technology developments for emerging threats.

## Project 076–110: Aviation Security Human Factors



# 8.0 HUMAN FACTORS AND AVIATION MEDICINE

Human factors–related aviation incidents and accidents have been the subject of increasing public concern. Much of the concern stems from the fact that despite the aerospace industry's success at developing ever more sophisticated and reliable technology, the human error–related incident and accident percentage has remained remarkably constant. However, recent human error analyses suggest that attention should be focused on developing error tolerant systems.

As a result, human factors research programs have received considerable attention over the past several years. In 1988, the United States Congress Office of Technology Assessment published the results from an in–depth investigation in a report titled "Safe Skies for Tomorrow: Aviation Safety in a Competitive Environment" that concluded human factors–related research was not well coordinated among Government agencies and that research funding was inadequate considering the problem's magnitude. In addition, the Air Transport Association of America (ATA) organized a Human Factors Task Force composed of industry and Government representatives, from both the research and operational communities, that offered similar conclusions and proposed developing a national plan to enhance aviation safety through human factors improvements. The ATA task force also made recommendations regarding the national research priorities.

In response to the dramatic increase in public concern, Congress enacted new legislation, the Aviation Safety Research Act of 1988 (Public Law 100–591), that called for the FAA to augment its research efforts in human factors and to coordinate programs with the National Aeronautics and Space Administration's (NASA) efforts. This Act authorized specific areas of aeromedical research and human factors functions to be conducted by the Civil Aeromedical Institute (CAMI).

## The National Plan for Aviation Human Factors

It is generally accepted that many productive research efforts in aviation human factors have been underway for many years at FAA, NASA, the Research and Special Programs Administration's Volpe National Transportation Systems Center, the Department of Defense (DOD), and in academia and industry. However, these efforts have not been well coordinated. It is also widely accepted that funding for human factors research, in general, has not been adequate and has suffered from a noticeable absence in long–term, high–level management support in most Government and industry organizations. Also, it is recognized that human factors efforts must be integrated with system design and development efforts much earlier in the acquisition process.

The response from the human factors community over the years has been to suggest that increased funding would result in performance enhancements in the aviation system. Unfortunately, these requests for additional support have occurred without an overall plan for human factors work, making the commitments for additional support difficult to obtain. Moreover, the products from Government–funded human factors research have not been effectively transferred to the aviation community in the past—a situation that has further hindered additional support development.

Publishing the two–volume National Plan for Aviation Human Factors represents the initial stages in an extensive effort to address these deficiencies. The National Plan proposes a 10–year program that, if properly implemented and adequately supported, will significantly alleviate many operationally significant human performance issues facing the aviation system. The National Plan for Aviation Human Factors contains the detailed scientific and technical agenda that is to be used as a roadmap for project planning, bud-

get requirements, and developing implementation plans.

The National Plan's purpose is to:

- Identify the technical efforts necessary to address the most operationally significant human performance issues in aviation and acquire the necessary resources to fund these efforts.
- Allocate resources efficiently by coordinating research programs at various Government laboratories.
- Communicate research needs to academic and industrial Centers of Excellence.
- Promote the means by which human factors knowledge is transferred to Government and industry.

The National Plan for Aviation Human Factors resulted from an extensive 1–year research and development planning effort. After reviewing both FAA and industry human factors issues in detail, eight areas were selected for organized research planning. These emphasis areas are to:

- Encourage developing principles of human–centered automation and designing advanced technology that will capitalize upon the relative strengths of humans and machines.
- Improve aviation system monitoring capability with an emphasis upon human performance factors.
- Encourage improving basic scientific knowledge and facilitate understanding both positive and negative factors that significantly influence human performance in aviation.
- Develop better techniques for assessing human performance in the aviation system.
- Determine the most effective air/ground information transfer methods for the National Airspace System.
- Encourage developing controls, displays, and workstations for aviation applications that facilitate the interface between humans and machines.
- Develop enhanced training and selection methods for aviation system personnel.
- Develop human factors–oriented validation and certification standards for aviation system hardware and personnel that will enhance both safety and efficiency.

The FAA and NASA have established an executive level coordinating committee chaired by the Director of Aeronautics in the NASA Office of Aeronautics, Exploration, and Technology and by the FAA Associate Administrator for System Engineering and Development. Efforts are also underway to establish similar working relationships with the DOD. The FAA/NASA Executive Coordinating Committee has executed a memorandum of understanding for collaborative research in all aviation human factors areas, and this plan provides the framework for interagency coordination.

The technical agenda was developed with assistance from 50 of the Nation's leading human factors researchers. Scientific Task Planning Groups (STPG) were organized for five primary aviation system environments:

- Aircraft Flight Deck.
- Air Traffic Control.
- Aircraft Maintenance.
- Airway Facilities (AF).

- Flight Deck/Air Traffic Control (ATC) Integration.

The STPG's for these environments, working with requirements, project descriptions, recommendations, and priorities developed by the FAA and industry, completed a comprehensive technical agenda focused on developing operationally useful products.

This national planning document's publication represents an unprecedented effort for the human factors and aviation communities, but it is only the beginning. If adequately implemented and supported, the National Plan for Aviation Human Factors should lead to significant improvements in overall system safety, efficiency, and capacity.

## FAA Involvement in the National Plan for Aviation Human Factors

The technical agenda developed in the National Plan forms the basis for future detailed implementation plans in each participating organization. These plans will involve collaboration among the sponsoring, managing, and performing organizations to specify research priorities, final technical approaches, organizational management plans, anticipated operational impacts, milestones, deliverables, and resources required.

The FAA/NASA Executive Coordinating Committee has created a technical subcommittee to oversee coordination between NASA and FAA research projects to accomplish the plan's objectives. The Research, Engineering and Development (R,E&D) projects articulated in this chapter represent the portion of the National Plan which should be supported by FAA R,E&D funding. Some programs described in the National Plan will be accomplished largely by NASA or other funding sources. Currently a large portion of the National Plan does not have committed funding from any source. The FAA must accomplish its research portion specified in the National Plan to address the critical priorities identified by the FAA's operational community and the entire aviation community.

### Benefits

Each project area in this plan can significantly impact NAS safety, efficiency, and effectiveness. Although benefits quantification in this thrust area is in an embryonic stage, early human factors considerations during the development phase in many research, engineering and development and facilities and equipment projects would produce benefits worth many times the project costs.

While the future system's outline is fairly clear and new technology breakthroughs are always available and welcome, a major design challenge in realizing system improvements centers on the human operator's roles. For example, as new higher automation levels are introduced into the cockpit and in ground systems, the pilot's, controller's, and technician's roles will change dramatically. Human factors research is required to ensure that this transition is effected smoothly and safely. In the cockpit, as on the ground, new technologies will introduce digital and analog signal mixes, graphics displays, procedures that will change the nature of displayed information, and the pilot's and controller's actions/responsibilities.

Testing and evaluating these new concepts, systems, and equipment will require much greater attention to human factors considerations than ever before. Simulation laboratories will need to address the pilot's interaction with the aircraft systems, the controller's interaction with the aircraft systems, the controller's interaction with the air traffic management systems, and the interaction between pilots and controllers. Training facilities and approaches must be developed to handle new, sophisticated equipment and procedures introduction and operation. This research thrust area is directed toward ensuring that this design challenge, effectively integrating the human being and the machine, is addressed so that expected benefits will accrue.

## 8.1 Human Factors and Aviation Medicine Project Descriptions

### 081–110 Flight Deck Human Factors

**Purpose:** This project will improve human performance and reduce the adverse effects of error in the cockpit through improved systems design, procedures, and training. An important element in this research is, when possible, applying existing knowledge of human capabilities and limitations to the flight deck environment. Where existing knowledge is inadequate, this project will develop a better understanding of human performance factors. Statistics show that approximately 65 percent of all fatal civil air transport accidents and a higher proportion of general aviation accidents list human error as a probable cause. Since flightcrew errors contribute to the majority of aircraft accidents, a continuing program directed toward improved flight deck human engineering, flightcrew performance standards, airman selection, and initial and recurrent training can pay for itself many times over by preventing a single accident. New technology developments and better flightcrew performance using existing technology will provide further benefits by increasing operational efficiency.

**Approach:** FAA and NASA share the responsibility for research in this project. Some of the current work is being accomplished under NASA's Aviation Safety/Automation Program, and some work is being accomplished as a collaborative effort. An operating project premise is to be a service–oriented organization that can respond to relatively short–term requirements from sponsor organizations. A long–range goal is to develop the corporate human performance knowledge base needed to support future rulemaking and safety programs scientifically.

Analytical, laboratory, simulation, and field studies will be conducted in the following National Plan for Aviation Human Factors areas: automation, advanced technology, controls and displays, system safety monitoring, human performance, training and selection, and certification and validation standards. Information in data bases will be used to analyze the effects of selected human factor improvement methods, training, individual and operational stressors, and implementing increased automation. Research reports, conferences, recommendations, and direct assistance to the operational organizations will be used to support operational evaluations and develop advisory circulars, technical standard orders, and Federal Aviation Regulations changes. Participation in the Society of Automotive Engineers and other technical committees will assist with developing industry practices and standards.

**Related Projects:** 022–140 Vertical Flight Program, 082–110 Air Traffic Control Human Factors, 084–110 Flight Deck/ATC System Integration, and 086–110 Aeromedical Research.

**Products:**

- Guidelines for the human factors design, evaluation, and certification of advanced technology flight deck displays and control systems
- Research data base integrating information on pilot medical history, age, prior experience, airmanship history, and information on accidents and incidents
- Pilot and flightcrew behavioral coding techniques that can be used to assess flightcrew training program effectiveness
- Guidelines for improved training programs in crew resource management (CRM), and

aeronautical decisionmaking, instrument flight skills, and other critical pilot skills

- Human factors reference materials, checklists, courses, and evaluation procedures for FAA aircraft certification personnel

- Model Advanced Qualification Program (AQP) for FAR Part 135 operators, ab initio training modules, and simulator standards for training/airman certification

**1994 Accomplishments:**

- Published flight deck information management guidelines.

- Published guidelines for electronic and paper chart designs.

- Developed CRM evaluation expert system software and published technical report.

- Completed flight training device efforts in visual scene content requirements, personal computer (PC)–based devices, and automated simulator revalidation.

**Planned Activities:** In 1995, work will continue on developing a model AQP for Federal Aviation Regulations (FAR) Part 135 operators with publication expected in 1996. In 1995, work will continue on research to develop team training guidelines. This research studies the decisionmaking process among dispatchers, air traffic controllers, and pilots when an aircraft needs to divert from its original destination. Research will continue through 1998 when training guidelines will be issued.

In 1995, development work will continue on an automated performance measurement system for evaluating training program effectiveness. A prototype system will be completed in 1997.

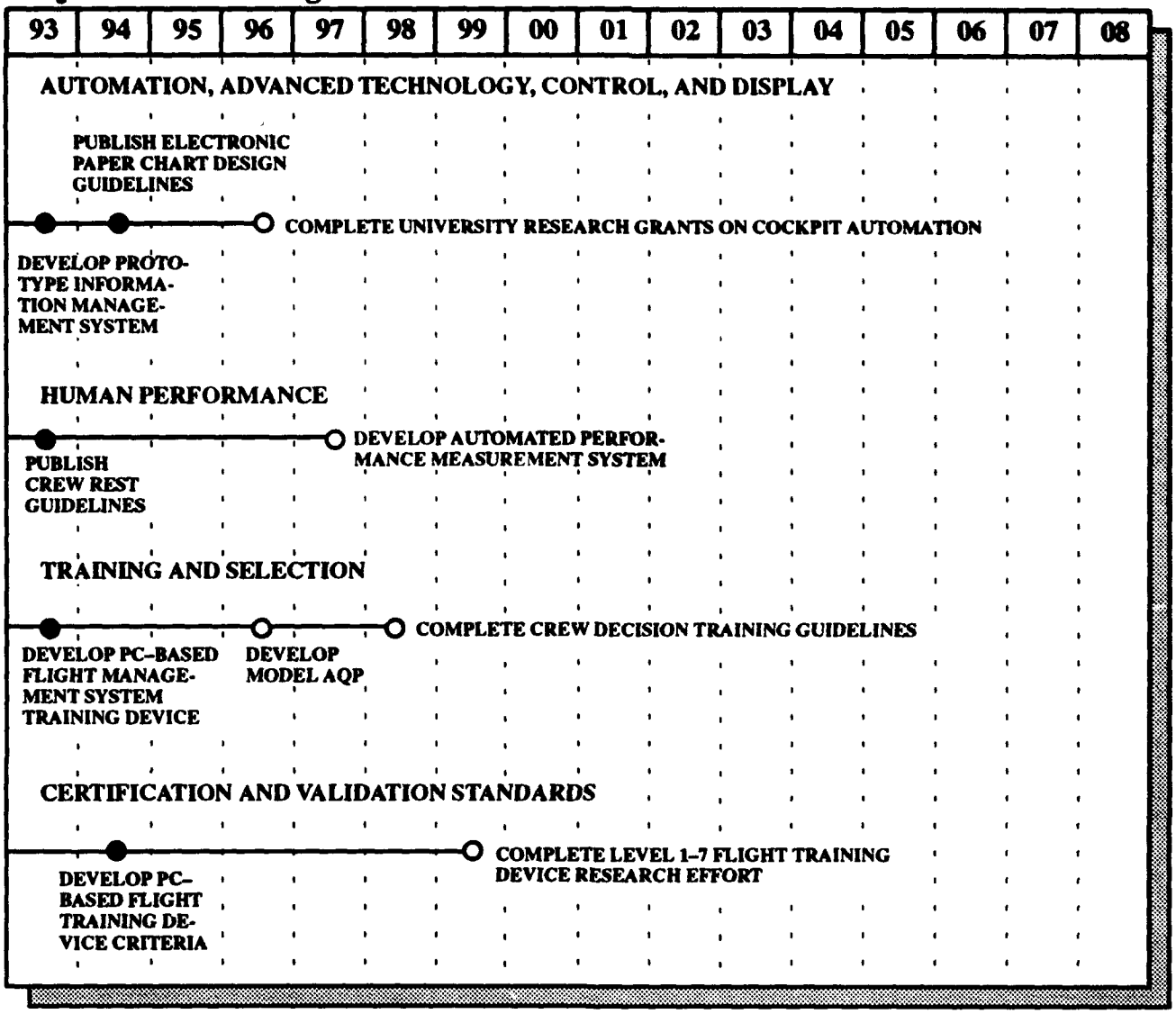
In 1995, a program of research to study specific general aviation pilot performance problems will continue using a dedicated research simulation device.

In 1996, two university research grants will be completed on cockpit automation. These grants will identify safety issues and recommend appropriate automation levels and techniques.

From 1995 to 1999, civil aviator selection techniques and instruments will be developed.

From 1995 through 1999, systematic research efforts will quantify the performance transfer for level 1–7 flight training devices. This research is needed to establish the allowable credit for training and checking tasks when using a flight–training device in place of actual aircraft flight training/testing.

## Project 081–110: Flight Deck Human Factors




## 082–110 Air Traffic Control Human Factors

**Purpose:** This project will determine the effects of automation and work environment on current and next generation air traffic controller's performance, develop improved controller selection and training methods, develop methods to reduce the adverse effects of controller errors, and develop methods and standards for developing and implementing National Airspace System (NAS) systems.

System safety and efficiency will be enhanced by ensuring that automation and other advanced technologies are introduced in a manner that is appropriate, effective, and properly supportive of

the controller with no adverse side effects. Proper attention to human factors in system design and operations will provide a substantial return on investment by allowing the FAA to maintain a high level of safety and system capacity with a minimum work force and training expense.

This project delivers products that address air traffic human factors needs throughout all R,E&D and Capital Investment Plan (CIP) programs.

**Approach:** The FAA has recognized not only the importance of human factors for preventing operational errors, but also the critical relevance of human factors for effectively designing, integrating, and evaluating equipment and procedures for use in air traffic operations. This project addresses the following areas in the National Plan for Aviation Human Factors: Air Traffic Control and Human Performance; Impact of Automation on Controllers and ATC Teams; Selection, Training, and Certification of ATC Personnel; and Safety Monitoring of ATC Activities.

Analysis of surveys, test scores, supervisory rating, error reports, demographic characteristics, task analyses, laboratory and simulation studies, and operational evaluations will be conducted in the following areas: the physical and psychological effects of automation on air traffic controllers; causes and remedies for controller error; information management techniques; human perceptual capabilities and limits; workload management strategies; standards and guidelines for applying human factors engineering; and performance measurement methods and criteria. Data bases and tracking systems will be developed to monitor and evaluate personnel selection, training, and performance. Research data bases will be developed to monitor variations in personnel performance resulting from the introduction of new equipment, illness, drug use, and other job-related stressors.

A tracking system is being developed to relate air traffic controllers' on-the-job performance to FAA selection procedures and training programs. Alternative air traffic control specialist (ATCS) selection and training programs, such as the air traffic control specialist/pretraining screen (ATCS/PTS) and the university/college-based programs, will also be evaluated.

**Related Projects:** 081-110 Flight Deck Human Factors, 084-110 Flight Deck/ATC Integration, and 086-110 Aeromedical Research.

**Products:**

- Human factors requirements guidelines for designing, integrating, and evaluating ATC systems for human operators
- Analysis tools and standards for assessing/predicting controller work activity and performance
- Guidelines and models for optimally allocating operational functions and tasks to controllers and their equipment
- Real-time simulations, computational models, and reference data that support FAA specifications, acquisitions, and tests for improving air traffic control equipment and procedures
- Capability to reconstruct en route operational errors and incidents
- Tools and reference information for improved performance-based controller selection, training, certification, and retention

**1994 Accomplishments:**

- Published technical report on paper flight data strips versus electronic flight data displays.
- Developed controller performance model.
- Developed controller memory enhancement training methods and memory aids.
- Developed methodologies for examining controller visual scanning techniques.
- Validated controller performance measurement approaches.
- Developed situation awareness through re-creation of incidents (SATORI) applications for reconstructing TRACON and en route operational error analysis.

**Planned Activities:** In 1995, research will be conducted to determine how Air Traffic Team Enhancement techniques used by aircrew members are applicable to air traffic control sector teams. Training applications and procedures will be developed for Air Traffic Team Enhancement Program implementation in 1997. Additionally, the program's findings will help to define future products. Also in 1995, a decision support system prototype will be developed for analyzing controller staffing requirements, attrition, and training requirements. The prototype will be evaluated through 1996, leading to future field implementation.

In 1995, a technical report will be completed to determine if oculometric display scanning can be used as an index of controller situation awareness. Such an index could be used to make display configuration comparative evaluations. Additionally, a controller memory handbook update will be published.

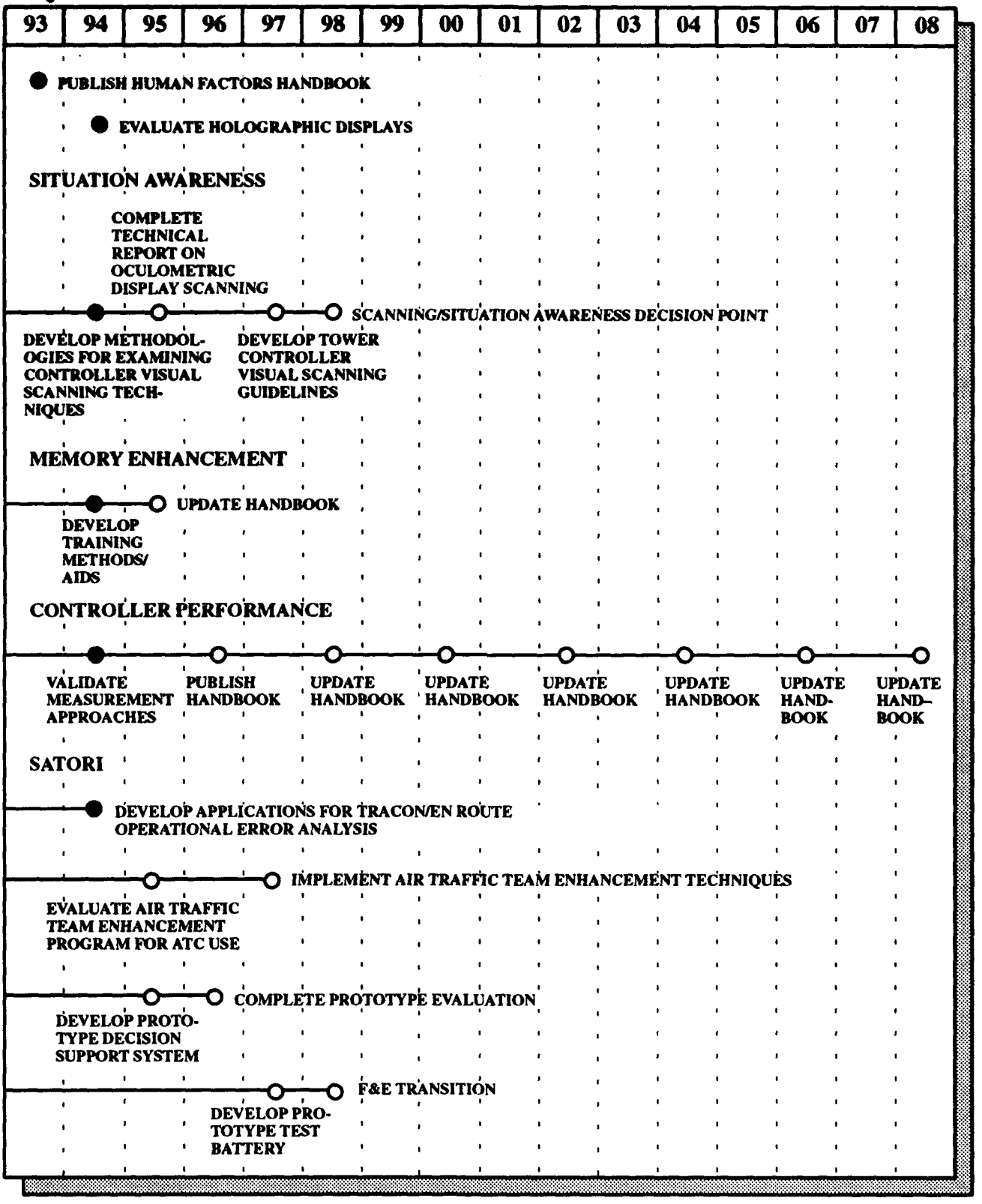
In 1997, guidelines will be implemented to improve tower controller visual scanning techniques to help reduce runway incursion incidents.

In 1996, a handbook will be published containing initial methodological guidelines for measuring controller performance and workload. These guidelines will be delivered to test organizations for evaluating new air traffic control systems such as the Initial Sector Suite System (ISSS). In 1998, and biennially thereafter, the handbook will be updated to incorporate more comprehensive and sensitive measurement techniques.

In 1997, a prototype future automated ATCS selection test battery will be developed. An operational system will be ready for facilities and equipment (F&E) transition in 1998.

In 1998, a decision will be made on the scanning program's direction. One or more research directions will be identified at this point, based on scientific data from previous research. Possible directions will be: stop research in this area; continue research to develop controller scanning training/selection criteria; and/or, continue research to develop a situation awareness index.

## Project 082–110 Air Traffic Control Human Factors



## 083–110 Airway Facilities Human Factors

**Purpose:** The Airway Facilities organization has developed a strategic plan to manage change that is occurring as AF grows into a more system management oriented organization. This plan addresses the vision of the Airway Facilities future organization. The plan also provides the outline for transition to this new operational concept. The AF Human Factors project provides means by which user–system interfaces inherent in the strategic plan can be validated and alternatives for implementation can be addressed.

The purpose of this project is to reduce the impact of change on the organization and to provide the necessary information for implementing the strategic plan. By conducting research in future workforce selection and training; organizational effectiveness; user–centered maintenance automation; and human performance, the AF Human Factors project will provide the input necessary to make informed decisions regarding the best methods to implement the strategic plan and achieve the goals.

**Approach:** Task analyses will be conducted to provide the necessary data for developing knowledge, skills, and abilities, position descriptions, and training criteria for current and future positions in automated systems. These analyses will also be used to develop human to computer/human interfaces for new systems, and for determining where artificial intelligence and expert systems can best be incorporated into the maintenance environment. Simulations will be developed for different work environments to determine the impact of policy and/or procedural changes on work load and staffing. The evolving AF system specialist's role and workload in an automated system will be analyzed and appropriate interfaces developed to take advantage of advanced technology. Expert system and neural network applications as job performance aids will be evaluated. Acceptability of computer synthesized speech in the AF environment will be evaluated.

**Related Projects:** 026–110 Airway Facilities Future Technologies, 082–110 Air Traffic Control Human Factors, and 085–110 Aircraft Maintenance Human Factors. Capital Investment Plan projects: 26–01 Remote Maintenance Monitoring System (RMMS).

**Products:**

- Higher order Airway Facilities task analysis for expert systems applications and training and selection requirements for AF personnel
- Criteria for effectively using intelligent systems in AF maintenance
- Error taxonomy for AF tasks with data base and error recording systems to be used for tracking, quantifying, and mitigating human performance errors
- Human factors design interface specifications for future systems, including workstations, control centers, and job aids
- AF personnel knowledge, skills, and abilities considerations suitable for inclusion in the specifications for new Airway Facilities procurement

**1994 Accomplishments:**

- Developed prototype information system that includes job aid, intelligent tutoring, and electronic documentation.
- Completed current AF organizational structure analysis.
- Completed Human Factors Interface Standards review/revision for maintenance systems acquisitions.

- Developed situation awareness proof–of–concept display for AF applications.

**Planned Activities:** Beginning in 1995, an effort will be initiated to determine how artificial intelligence/expert system technology can best be used to assist Airway Facilities system specialists in their system management and restoration activities. Situation awareness studies will be conducted to investigate the automated control room environments effects on human performance. This research entails developing a situation awareness display prototype for the Maintenance Control Center (MCC) in 1995.

In 1995, data previously collected will be used to develop a prototype error recording and tracking system and to form the baseline for recording and tracking errors made by Airway Facilities system specialists in the future. The data collected by this system will be used to develop methods to remedy the causes of the errors, and to ensure that these errors do not propagate into the future functions and activities. Proof–of–concept operational models will be developed to simulate, test, and evaluate future operational concepts, procedures, and functions defined by AF through the strategic planning process.

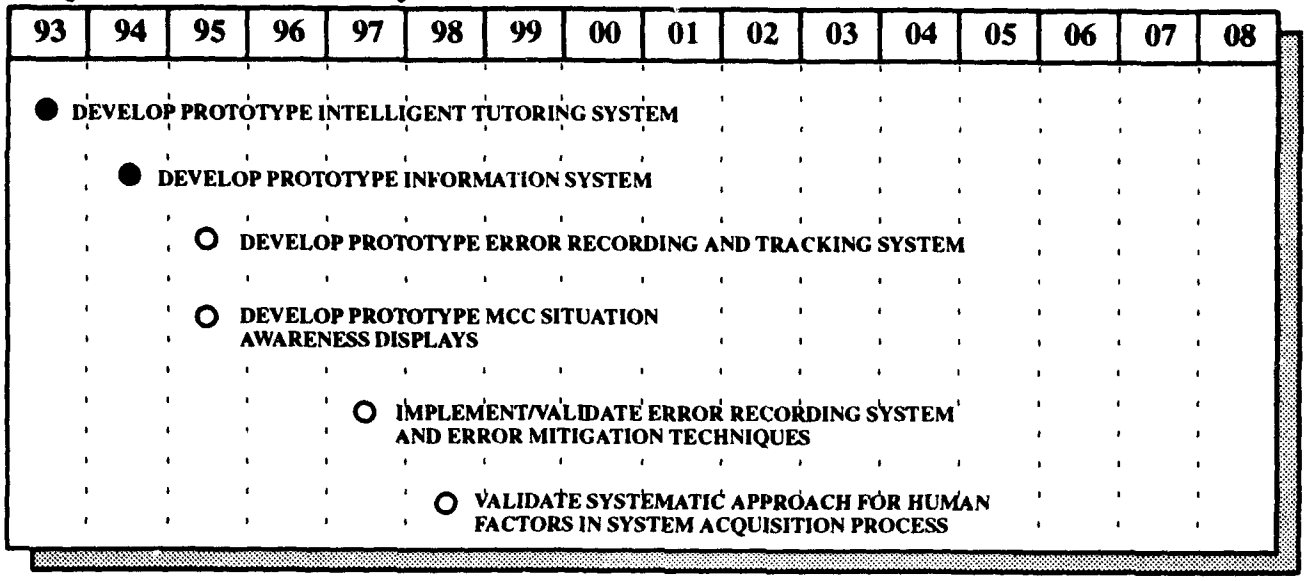
In 1996, the effects of adverse conditions on the performance of the system specialists will be examined. Travel time, bad weather, and facility access conditions will be specifically examined to determine how they impact the performance of AF personnel. A study to determine the effects of satellite–based operational environments on AF personnel will be undertaken. Areas included in this study are system status monitoring and performance management, knowledge required, and operational procedures to support the satellite–based environment.

Results of the research conducted in 1995 and 1996, as well as Airway Facilities' strategic plan, will influence the direction of projects in 1997 and beyond.

In 1997, implementation and validation of error recording system and mitigation techniques will begin. Development of a prototype operations control center environment will include intelligent systems for alarm acknowledgement and resolution, computer–based models and NAS management scenarios, and alternative staffing configurations.

In 1998, validation of the systematic approach for including human factors in the systems acquisition process will be completed. Also in 1998, the impact of the changing AF organization information flow and communications management will be determined.

## Project 083–110: Airway Facilities Human Factors




## 084–110 Flight Deck/ATC System Integration

**Purpose:** This project will ensure new generation aircraft compatibility with the evolving automated NAS and decrease the frequency of flight deck/ATC communications errors through a total system approach. Flight Deck/ ATC Integration raises unique considerations that are distinct from ATC or flight deck issues and will be greatly affected by the technological improvements that are expected to occur simultaneously within the Flight Deck and ATC areas. For example, advanced computer aiding, such as the automated en route air traffic control (AERA), will facilitate controller handling of increased traffic but will also influence flightcrew performance. Data link, and ultimately satellite–based air traffic systems, have the potential to enhance system capacity, but will also influence controller and pilot workload in ways that are not currently understood. NAS safety and efficiency will be enhanced through system–wide analyses that integrate current and emerging airborne and ground subsystems.

**Approach:** This project's objective is to enhance flight deck/ATC information transfer and management; decrease frequencies and consequences of flight deck ATC errors; determine appropriate allocation of authority of functions between flight deck and ATC; and develop the required methods, tools, and guidelines for integration of NAS components into the flight deck ATC environment.

The information transfer area will focus on identifying and resolving issues associated with transferring and managing information exchanged between the flight deck and ATC system. The areas to be studied include ATC clearances, traffic, weather, facility and equipment status, and related information. Both air–to–ground and ground–to–air information and data exchanges are of equal importance. The goal is to reduce the frequency of information transfer errors and minimize their impact when they do occur.

Verbal communications in ATC operations have been identified as causal factors in over 70 percent of operational errors and pilot deviations. Consequently, one of this project's major research areas focuses on developing means to decrease the frequencies/consequences resulting from pilot and controller communication errors. Efforts will be focused on three areas: a pilot/controller communications analysis examining ATC voice tapes; analyses of Aviation Safety Reporting System reports; and a series of laboratory experiments to assess the effectiveness of recommended changes in procedures and/or phraseology.

As the application of intelligent automation increases on the ground as well as the flightdeck, allocating authority between pilots and controllers becomes less well defined. This project will develop a decision support system (DSS) to predict different authority allocations for various TRACON events. The DSS will help the FAA make decisions on future pilot/controller selection, training, and operational authority allocation.

Both FAA and NASA currently operate aging Boeing 727 simulators that represent a diminishing number of obsolete aircraft. Developing and acquiring new simulation capabilities, and enhancing existing capabilities, will be required to assist in transitioning today's NAS to the future advanced automation system. Through a cooperative agreement with NASA, the FAA will jointly purchase a modern, high fidelity Boeing 747–400 research simulator representing aircraft that will be predominant in airline fleets during the next decade. It will be capable of stand–alone use, or can link via satellite to FAA ATC simulation facilities. Simulation studies involving this advanced technology cockpit will eventually be integrated into the National Simulation Capability.

**Related Projects:** 025–110 National Simulation Capability (NSC), 031–110 Aeronautical Data Link Communications and Applications, 081–110 Flight Deck Human Factors, 082–110 Air Traffic Control Human Factors, and 086–110 Aeromedical Research.

**Products:**

- Human factors guidelines needed to set policies for data link architectures and procedures
- Human factors guidelines for developing, testing, and certifying interface designs of various data link applications
- Operational and training recommendations to reduce pilot/controller verbal communication errors
- Revised selection and training criteria to certification and regulatory personnel to ensure available skills are matched with the changing demands on pilots and controllers
- Capability to assess human performance in a highly integrated future automation environment

**1994 Accomplishments:**

- Developed data link functions/services and operational protocols for air carrier and general aviation aircraft.
- Developed flight deck work/risk model to test pilot/controller functional authority and responsibility distribution strategies.

**Planned Activities:** In 1995, the first system integration experiments will begin on the Boeing 747–400 simulator to support the National Plan for Aviation Human Factors and the National Simulation Capability Operating Plan.

As new data link applications emerge, standards and certification guidelines, protocols, and procedures will continually be developed and/or revised. In 1995, this project will identify conditions that have the potential to produce data

link communication errors. Research will then be conducted on developing procedural and design solutions that reduce the likelihood or minimize the effect of those errors. In 1995–1998, standards will be recommended for display content, format, menu design, message displacement, data link function control, and message alerting. In 1997, design and/or procedural solutions will be recommended to compensate for losing party line information if discrete data link replaces open frequency broadcasts. These solutions will ensure that flightcrews maintain situation awareness.

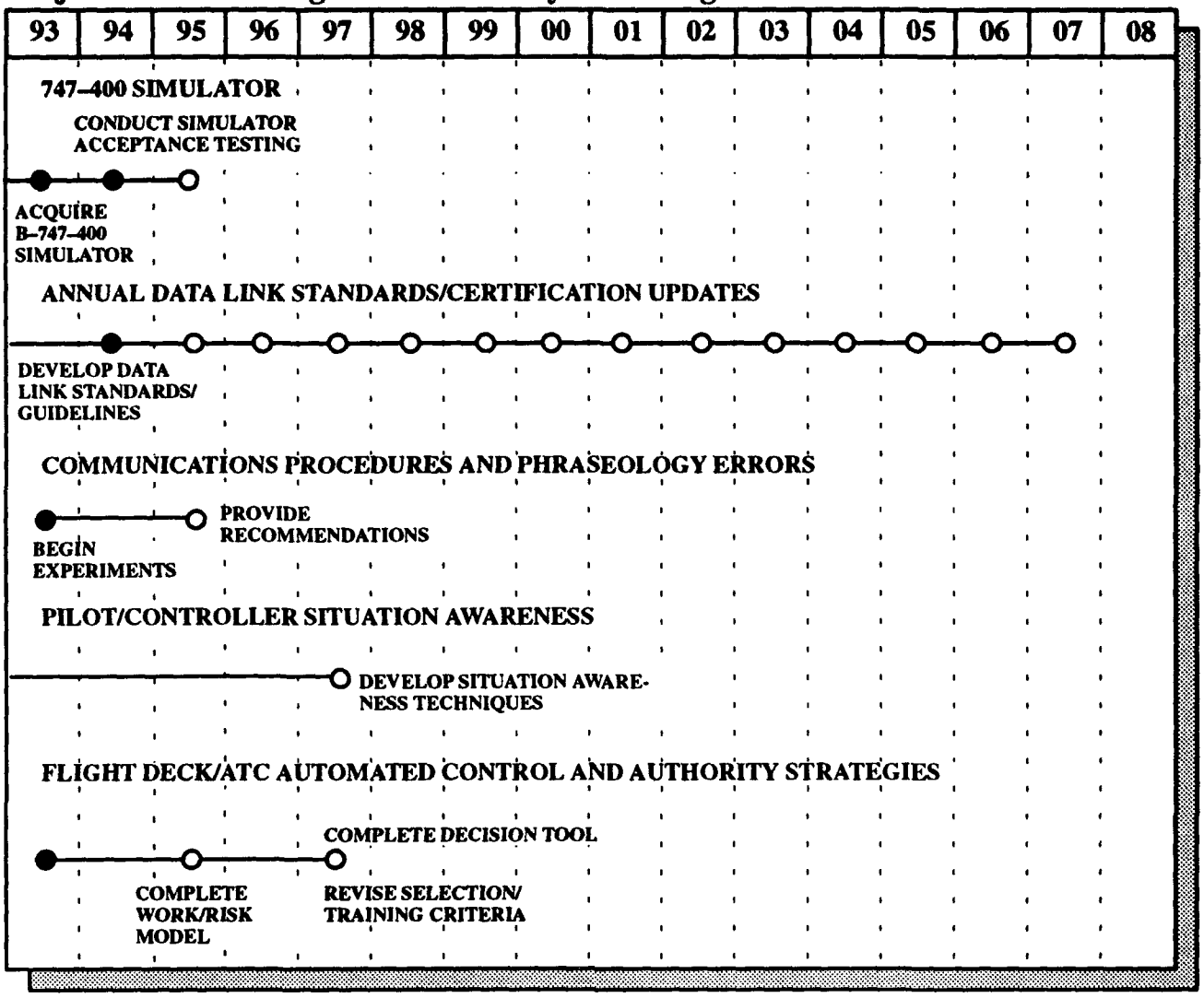
In 1995, a series of laboratory experiments will continue on assessing the effectiveness of recommended changes in pilot/controller communication procedures and phraseology. These recommended changes will be provided to regulatory personnel for implementation in 1996.

In 1995, research will continue on developing compensation techniques to ensure pilot/controller situation awareness. As automation and data link systems come online, techniques must be developed to keep human beings in the decision-making loop. The current line of research is expected to be completed in 1997.

In 1995, research will continue on authority/responsibility allocations between pilots and controllers. One key element of this research is developing a decision tool that aids in predicting shifting allocation of authority between the flight deck and ATC due to intelligent automation. This decision tool will be completed in 1997. In 1995, potential allocation strategies will be defined for distributing automation control decisions between the flight deck and ATC. Revised selection and training criteria will be provided in 1997 to certification and regulatory personnel. This criteria will ensure that available skills are matched with the changing automation demands on pilots and controllers.

It is important to recognize that system integration research will never produce a definitive product which will close out this research domain; rather, it is a continual process that must be applied to every new generation of technologies as they emerge.

## Project 084–110: Flight Deck/ATC System Integration




## 085–110 Aircraft Maintenance Human Factors

**Purpose:** This project will develop and validate training methods to improve aircraft maintenance and inspection personnel performance; develop regulatory support materials to revise Federal Aviation Regulations (FAR) Parts 65 and 147; develop information on advanced technology, techniques, and job performance aids for industry aircraft maintenance personnel and FAA Aviation Safety Inspectors (ASI); and develop information on how workplace environment and organization affect technician performance. A better understanding of these variables will lead to enhanced training methods, improved human engineering of equipment, and improved FAA regulations/oversight. Accidents and incidents in air carrier operations attributable to maintenance and inspection human factors will be reduced as a result of this effort.

Research conducted in this area will ensure that future maintenance technicians will be optimally prepared for their roles. This research will develop guidelines and advisory materials for use by air carrier maintenance organizations concerning work environment factors that influence maintenance personnel performance. Also, information will be developed concerning the effects of advanced technology systems on FAA ASI performance.

**Approach:** This project addresses the following areas of the National Plan for Aviation Human Factors: Personnel and Training Systems, Advanced Technology Systems, and Environmental and Organizational Systems. It is important to remember that as new technology continues to enter the system, human factors research must be performed to ensure that the human/machine interface is optimized. This research will continue into new areas as technology evolves.

This project will conduct research on visual and non–destructive inspection techniques. Laboratory and field research studies will be conducted to determine factors that influence air carrier inspection specialists' performance. Advisory guidance material based on this information will be supplied to air carrier maintenance managers for training, planning, and work assignment purposes.

A major element in this project is researching information needs for FAA field inspectors. The intent is to examine existing processes and develop improved methods for ASI's to access needed information and provide input to national data bases. ASI's have frequent need to access information such as advisory circulars, airworthiness directives, and regulations. Inspectors also need to provide the results of their inspections, so that information is quickly accessible to data base users. Various computer–based technologies will be explored to determine their utility in optimizing inspector performance.

Work environment research has developed knowledge of visual, auditory, thermal, and biomechanical requirements or limitations concerning skilled psychomotor activity in general. Subsequent work will seek to apply this knowledge to specific aircraft maintenance cases. Organizational/management research will examine the influence of management practices, expectations, and norms as well as personnel practices, team operations, and organizational structure on maintenance performance.

**Related Projects:** 065–110 Aging Aircraft.

**Products:**

- Job task and training analyses
- Intelligent tutoring systems
- Supporting data for FAR Parts 65 and 147 revisions
- Human factors guidelines for industry/Government communication, data exchange, and support infrastructure
- Advanced documentation technology to provide rapid access to technical information

**1994 Accomplishments:**

- Completed technical report to support Flight Standards for changes to FAR Part 147.
- Developed visual inspection and NDI guidelines.
- Published first edition of the human factors issues guidebook.
- Completed initial field study for ASI advanced technology applications.

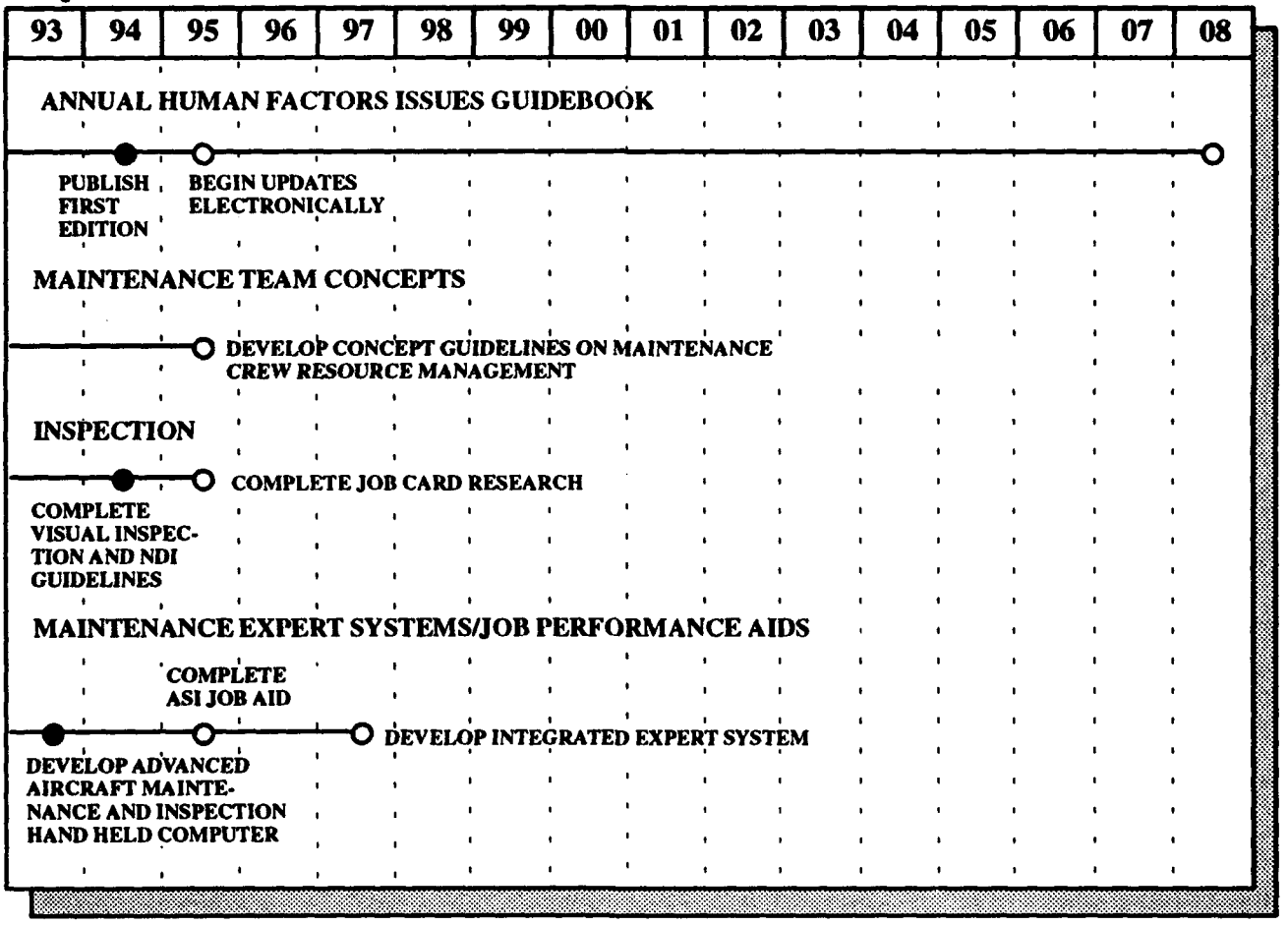
**Planned Activities:** In 1995, updates will be published to the human factors issues guidebook. These updates will be published annually in an electronic format beginning in 1995.

In 1995, guidelines on aircraft maintenance crew resource concepts will be developed to reduce maintenance errors. This research will depend upon NASA participation.

In 1995, work will continue on visual inspection and NDI techniques. This research will involve studying job cards to improve users' comprehension.

In 1995, the ASI job aid development will be completed. In 1997, an expert system will be developed for integrated training/job aiding/information retrieval. This system will use the previously developed ASI job aid as a component.

## Project 085–110: Aircraft Maintenance Human Factors



## 086–110 Aeromedical Research

**Purpose:** This project will assess types of injury and death patterns in civilian flight environments, recommend and develop protective equipment or procedures, and provide guidance to FAA regulatory and medical certification staff. The component tasks of this research will identify human physiological and bioengineering failure modes in uneventful flight and during civil aircraft incidents/accidents while simultaneously assessing counteracting measures. The research will also identify pilot and passenger medical conditions that are incompatible with civilian flight demands. This detailed information will be used to determine if existing equipment and procedures optimally protect the human occupant; to make technical recommendations contributing to improved performance standards; and to support bioengineering, biochemistry, and biomedical aspects of certification actions and rulemaking. Since prioritizing subtasks is directly responsive to Federal Air Surgeon guidance and to unique injury and death characteristics in contemporary accidents, the FAA and National Transportation Safety Board can effect expeditious corrections of unsafe and dangerous conditions.

**Approach:** Tasks in this research area are derived from requirements generated within the FAA by the Aircraft Certification Service, the Flight Standards Service, the Northwest Mountain Region Transport Airplane Directorate, the Southwest Region Rotorcraft Directorate, the Central Region Small Airplane Directorate, and the Offices of Aviation Medicine, Aviation Safety, and Accident Investigation. Organizations outside the FAA generating requirements through FAA channels include the National Transportation Safety Board, the military services, and the Society of Aerospace Engineers. All project activities are coordinated with Government agencies and industrial representatives having related technical interests. The new FAA research process ensures project coordination among the FAA performing organizations, such as the Civil Aeromedical Institute and the Technical Center.

This project broadly encompasses laboratory and field studies on the performance of aircraft passengers, cabin crew, and medically certified airmen. Furthermore, equipment and procedures approved by the FAA and designed to protect personnel in accident situations are evaluated. The studies include evaluating injury mechanisms that might result from system failures or from hazardous conditions such as smoke or toxic gas environments. The studies support rulemaking or certification actions by developing performance standards and evaluating the merits, deficiencies, costs, and benefits of specific safety–related procedures and appliances. The same research generates educational spinoffs that, in cooperation with industry and airspace users, guide the aviation participant in optimal use of the safety equipment or procedure. Protecting humans in decelerative environments, protective breathing equipment, toxicological assessment, cabin evacuation, water survival, and radiation are currently being investigated in the Protection and Survival Track. Sudden and subtle medical incapacitation in pilots, new vision corrective methods by aviation personnel, new antihypertensive treatments for pilots, and onboard emergency medical response capability, represent the current clinical investigations in the Aeromedical Program Support Track.

**Related Projects:** 061–110 Aircraft Systems Fire Safety and 062–110 Aircraft Crashworthiness/Structural Airworthiness.

**Products:**

- 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

- Revised aircrew medical criteria, standards, and assessment procedures

- Identification of medical causative factors in aviation incidents and accidents

- Occupational health assessments for unique populations in the aviation community

**1994 Accomplishments:**

- Developed new techniques to reduce head injury in aircraft crashes.

- Developed new infant/small child flotation device.

- Developed specialized evacuation approval guidelines.

- Completed vision, cardiovascular, and neurological certification standards.

- Completed cabin crew occupational health assessments in cooperation with the National Institute of Occupational Safety and Health (NIOSH).

**Planned Activities:**

Protection and Survival

In 1995, data will be developed to prevent cervical (neck) injuries in crashes. This data will improve compliance with existing crashworthiness regulations and assist the FAA in developing new certification criteria based on technology improvements. Also in 1995, research on protective breathing gear will continue. A key emphasis will be on conducting long–term research to improve high altitude breathing equipment biomedical standards by 1997. In the water survival area, research will continue on developing and applying a new technical standard order for flotation devices. In 1995, work will continue on emergency medical equipment, leading to standardization regulations by 1997.

In 1996, a computer model will be developed to assess emergency evacuation from dual aisle aircraft cabins. This model will serve as a design and regulatory compliance tool. With model validation, it will be possible to eliminate cabin evacuation demonstrations that expose human subjects to dangerous test conditions.

Aeromedical Program Support

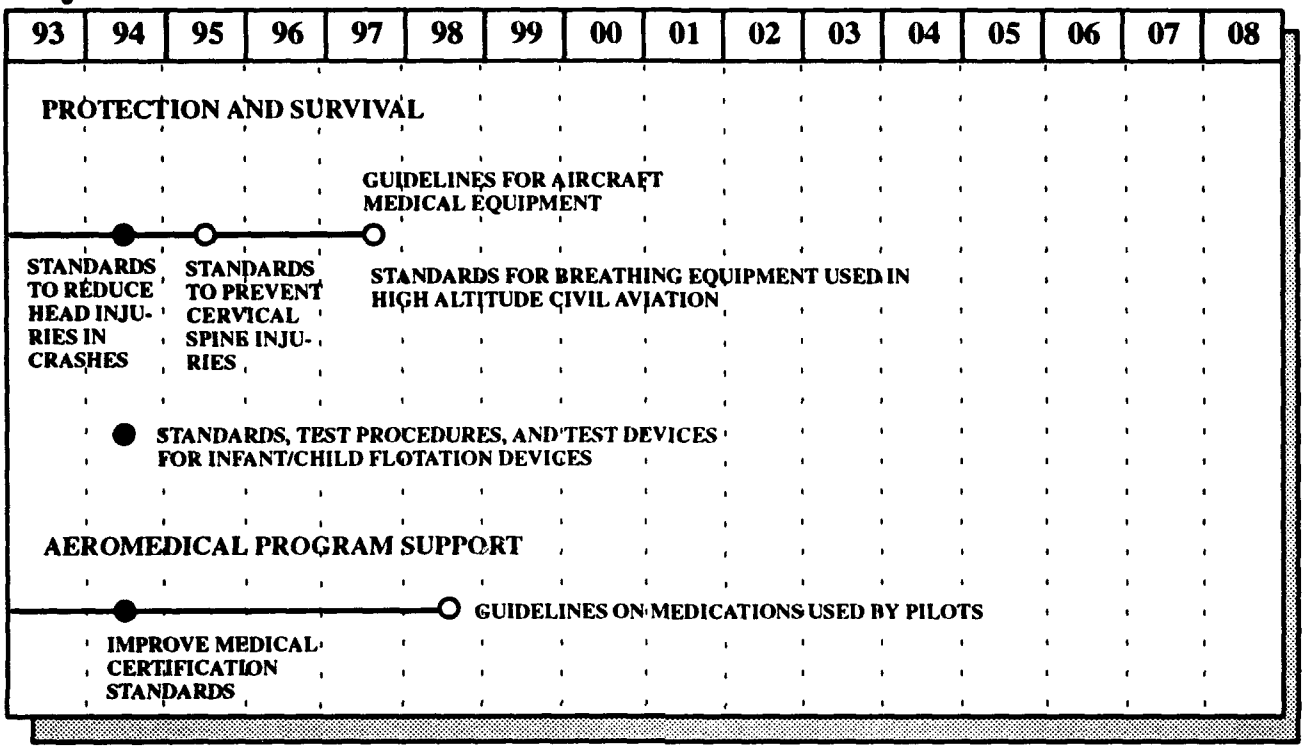
In 1995, field clinical research will be conducted to determine causative human factor elements in aircraft accidents. The FAA Office of Accident Investigation continually requires this data to complete its investigations of complex and diverse aircraft accidents. Joint FAA/NIOSH research into cabin crew occupational health will determine the need for new guidelines to protect aircrew members by 1996.

In 1996, a tool will be developed to permit toxicologists to determine whether alcohol detected in accident victims was ingested or was generated post–mortem. This data will clarify medical and legal uncertainties surrounding the cause of the accident. Long–term research is targeted to develop updated guidance for use of over–the–counter and prescription medications by civil aviation pilots in 1998.

Other long–term research to support the FAA's mission necessitates ad hoc studies on seat and restraint systems; optimizing aircraft exit

configurations; maintaining cabin safety and anthropometry databanks; assessing human factors in aircraft accident causation; performing toxicity studies; profiling chemical abuse in aviation; examining effects of drugs and physiological stressors on performance; evaluating new vision corrective devices, and testing medical equipment in civilian aircraft.

**Project 086–110: Aeromedical Research**




## 087–110 Workforce Performance Optimization

**Purpose:** This project addresses agency–wide performance issues associated with reducing management levels, introducing new technologies into the workplace, and balancing the workforce in terms of ethnicity, age, and gender. Additionally, this project provides a structure for conducting research in managerial innovation and automation that will lead to enhancements in human performance. Research will enable the FAA to make tailored, information–based decisions on these key human factors issues to promote an orderly, efficient, and cost–effective transition to the future workplace. Subtasks are prioritized by operational sponsors within the FAA to ensure maximum responsiveness to meet top priority FAA requirements.

**Approach:** These FAA–wide human factors issues will be addressed under two major research thrust areas. The first research area supports developing programs that improve supervisor/managerial selection, training, and performance. The second area analyzes organizational systems and procedures to identify methods that can enhance individual and team/workgroup performance. Research in this thrust area will also provide

design strategies for an effective, efficient transition to future changes in the workplace. Research conducted under these thrust areas will emphasize field research and experimentation, as opposed to laboratory methods, to ensure optimal transition of knowledge and products to the workplace.

All project activities are coordinated with Government agencies and private sector corporate representatives having related technical interests. Coordination among agency performing organizations and federally funded research centers is continuous. This coordination is a requirement in all FAA R,E&D reviews involving priorities and resource allocation.

Research approaches will consist of: (a) analyzing organizational systems to forecast the impact of new technology on workforce performance; (b) assessing the effectiveness of managerial innovations to determine the impact of innovation on optimizing workforce performance; and (c) evaluating training and personnel programs to establish their cost-effectiveness in achieving workforce performance improvement objectives.

This project's human factors information will be used directly by operational organizations to develop improved policies and procedures for employees to work individually, or as teams, in response to the changing workplace and new requirements. Recommendations for enhancements in selecting, training, and developing supervisory and managerial personnel will provide the basis for an organization that optimizes individual and team performance.

**Related Projects:** This project has potential applications across the entire R,E&D spectrum.

**Products:**

- Methodologies to assess organizational performance baselines for forecasting new technology impacts
- Training requirements forecasts to optimize the operation and maintenance of new workplace technologies
- Assessments and recommendations for managerial innovations to improve workforce performance and safety
- New system cost–effectiveness evaluations designed to enhance workforce performance

**1994 Accomplishments:** Currently covered under other R,E&D Plan initiatives.

**Planned Activities:**

Supervisor/Managerial Selection, Training, and Performance

In 1995, performance criteria will be developed to validate the Air Traffic and Aircraft Certification Services supervisor, manager, and executive identification and development programs (SIDP). The Aircraft Certification Service SIDP will be validated in 1995, with the Air Traffic Service SIDP validation in 1996. Outcomes from the initial selection system validation using new performance criteria will be completed in 1997. Recommendations for an overall model to validate FAA supervisor and managerial selection systems will be completed in 1998, followed in 1999 by generic selection and performance criteria for FAA managers. Specific management selection criteria will be developed in 1999, with executive selection criteria planned for 2002. Task analyses to identify supervisory competencies required beyond 2000 will be completed in 2001. Subsequent research will identify and validate selection and performance criteria for those positions through 2004. Further efforts will be required to ensure that future supervisory selection programs evolve with changes in technology and the agency's organizational structure/ mission.

In 1995, diversity training awareness evaluations will be completed to form recommendations for

improving training methods. These recommendations will help promote progress in developing a workforce that values and uses the unique capabilities of each individual employee. Periodic evaluations will assess progress toward achieving a more effective and diverse workforce. In 1996, research will assess the impact of revisions to the FAA initial supervisor training curricula. In 1997, the CAMI training/tracking data base will migrate to the Computer Resources Nucleus system where it will provide supervisor data to Airway Facilities and Air Traffic Services data bases. The training/tracking data base will evolve to support required research for validating selection, classification, training, and career development systems. This research will lead to recommendations for enhanced management training in 1999 and enhanced executive training in 2001.

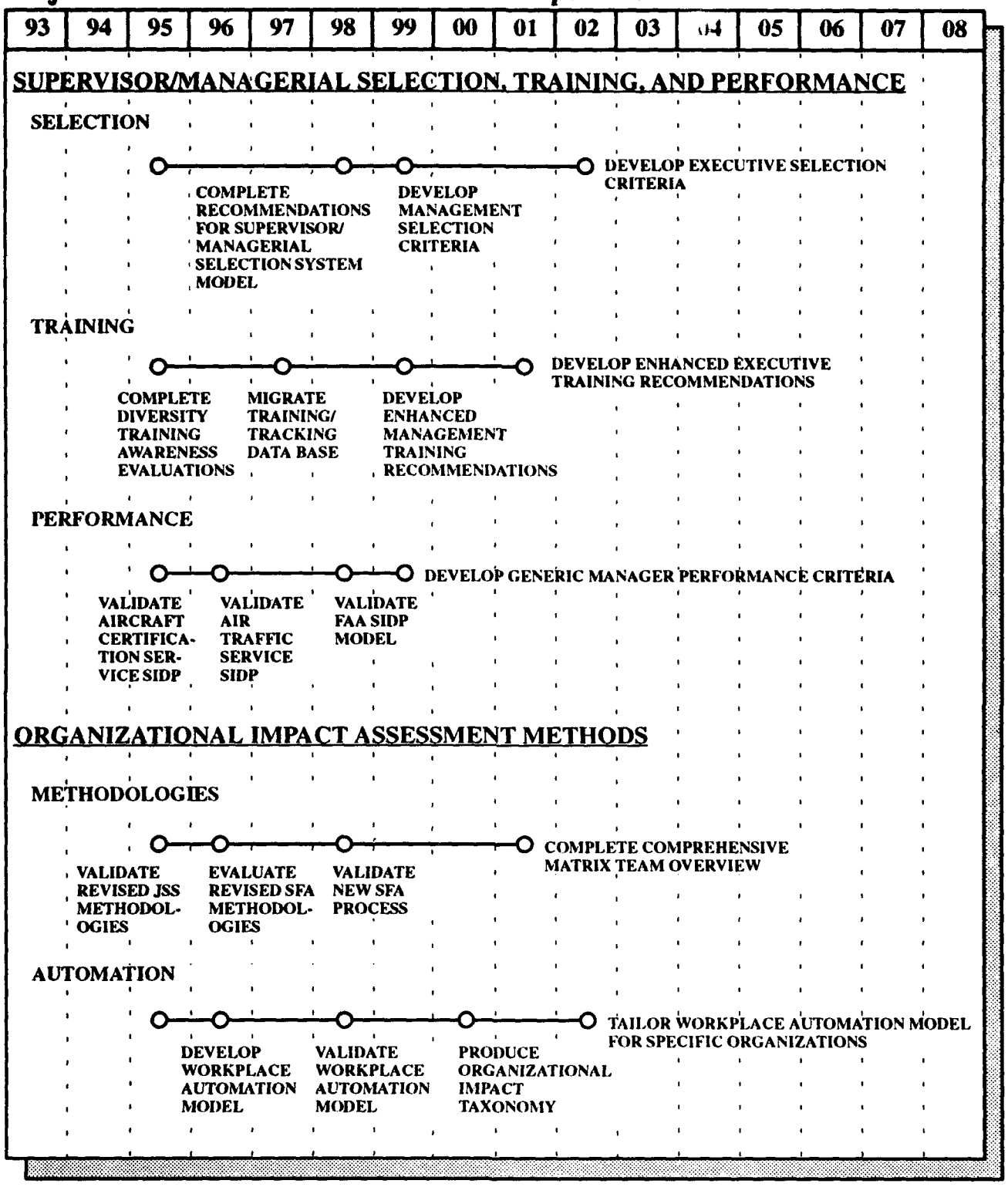
Organizational Impact Assessment Methods

In 1995, new methodologies used in the revised biennial Job Satisfaction Survey (JSS) will be validated and assessed by senior FAA management. The JSS will continue on a biennial basis to explore ways new technical capabilities can enhance survey information value and expand access to results. In 1996, the impact of revised Survey Feedback Action (SFA) methodologies will be evaluated for their utility in enhancing FAA work team effectiveness. In 1998, the new SFA process will be validated.

In 1997, a methodology will be completed for FAA managers to use in assessing the impact of TQM initiatives. This methodology will support information–based management decisions on adopting TQM initiatives affecting customer service satisfaction. By 2001, a comprehensive overview will be provided describing the impact of matrix teams on various types of organizations. Subsequent research will be completed in 2004 to synthesize information about teaming applications and which team models (e.g., Crew Resource Management, matrix, leaderless) best support different mission types.

In 1996, research efforts will develop a dynamic human factors model for introducing workplace automation. In 1998, methodologies will be developed and proven on several office automation projects for the Information Technology Office, and the automation model will be validated. In 2000, research efforts will produce a taxonomy of organizational impact factors affected by automation. This taxonomy will be used to forecast potential barriers to effective automation implementation. In 2002, a methodology will be developed to tailor the generic dynamic human factors model to specific automation applications, such as ATC work stations or AF system management.

## Project 087–110 Workforce Performance Optimization



# 9.0 ENVIRONMENT AND ENERGY

Research, Engineering and Development (R,E&D) projects in this thrust area support national goals to protect the environment, conserve energy, and keep the U.S. air transportation industry strong and competitive. Currently, approximately 2.7 million individuals live within areas considered to be exposed to significant airplane noise (a day–night average sound level of 65 decibels or more) and more than 400 U.S. airports have adopted some type of airport restriction to reduce aircraft noise or mitigate its effects. In some cases these restrictions have little impact on airport capacity, but in others the potential airport capacity has been reduced by as much as 30 percent. While there is an effort underway to ensure an early phaseout of older, noisier aircraft, there will clearly be a demand for even more stringent limitations on aircraft noise. Air pollution from aircraft is also becoming a major concern in airport expansion and proposed new airport construction. New aircraft and new aircraft engine types offer potential relief to the public; however, substantial R,E&D will be required to support future regulations.

The future aviation system will be one that is a "good neighbor" to the people living near airports. The challenges revolve around issues associated with how this good neighbor policy is implemented. While noise and pollution are the primary challenges, other issues associated with the atmospheric effects from new aircraft types, and new or alternative fuels, will require analysis and investigation.

The value gained from projects in this thrust area will derive from reducing both direct and indirect costs associated with meeting the national goals. Discovering ways to build quieter engines that have fewer noxious emissions is the direct approach. The indirect approach is to develop ways to use existing equipment more appropriately. Both approaches are reflected in this thrust area's projects.

A benefits assessment associated with these projects is underway. Noise reduction assessment strategies will be built around meeting local noise restrictions in ways that have less impact on airport capacity and, therefore, on system delays. Finding improvements in the ways to reduce aircraft engine emissions will also yield significant benefits.

The FAA's policy for environment and energy issues is to provide strong leadership in mitigating aviation's adverse impact on the public, consistent with sound energy planning and an effective aviation system. The FAA has adopted the following strategies:

- Lead a cooperative development effort that balances noise reduction with adequate airport capacity.
- Manage FAA activities to minimize adverse environmental consequences and comply with all Federal statutes.
- Develop sound aviation energy plans.
- Stimulate private industry and Government–sponsored research to reduce noise, emissions, and energy consumption by the aviation sector.

The Research, Engineering and Development Plan for the Environment and Energy thrust area responds directly to these strategies, and to the recently passed Aviation Noise and Capacity Act of 1990, and the Clean Air Act Amendments of 1990.

Through joint efforts with industry, the FAA will improve regulatory standards for noise and air pollution. It will also develop better technologies for predicting, measuring, and abating the environmental impact from aircraft emissions. Research will help define global standards for noise and air quality that are now being developed by the International Civil Aviation Organization (ICAO).

The research within this thrust area consists of the following major disciplines:

- Aviation Environmental Analysis
- Aircraft Engine Emissions Reduction and Control
- Aircraft Noise Reduction and Control
- Energy Conservation and Aviation Energy Emergency Contingency Planning

## 9.1 Environment and Energy Project Descriptions

### 091–110 Environment and Energy

**Purpose:** This project will develop various tools and methods that will be used to evaluate the environmental impact from alternative aviation policies and strategies. The focus will be on aviation noise, a major constraint on airway and airport capacity, and air pollution/aircraft emissions in the upper atmosphere, a growing public concern. The project will also ensure FAA compliance with all Federal environmental statutes, such as the Airport Noise and Capacity Act and the Clean Air Act Amendments of 1990.

**Approach:** Environment and Energy R,E&D consists of the following major disciplines: Aviation Environmental Analysis, Aircraft Noise Reduction and Control, Aircraft Engine Emissions Reduction and Control, and FAA Energy Conservation and Aviation Energy Emergency Contingency Planning.

Aviation Environmental Analysis

The Aviation Environmental Analysis and the Aircraft Noise Reduction and Control activities will eliminate many constraints on aviation growth, especially on airport capacity, through technology and expertise aimed at mitigating or controlling aircraft noise. This will include continually updating and improving the integrated noise model (INM), the heliport noise model (HNM), the area equivalent method (AEM), and the nationwide airport noise impact model (NANIM). These noise models are used to predict and assess the impact from FAA policies and Federal actions. Research will be conducted to develop better tools for assessing the costs and benefits associated with noise reduction and control activities.

A cooperative research program with the National Aeronautics and Space Administration (NASA) will investigate human response to noise levels and frequencies as part of a longer range program aimed at developing a better understanding of community response.

Aircraft Noise Reduction and Control

The FAA has entered into a joint research program with NASA's research centers to investigate technology advances in source noise reduction. The research will include engine design parameters, advanced acoustic absorption materials, and active noise control devices. Aircraft technology advances will include high lift devices and methods to reduce airframe–generated noise.

Noise testing will be conducted to simplify existing certification procedures and develop new procedures for future aircraft. Noise requirements for heavy helicopters, tiltrotor aircraft, advanced subsonic transports, high speed civil aircraft, and hypersonic research vehicles will be evaluated in cooperation with industry.

Aircraft Engine Emissions and Control

The FAA will undertake a joint high altitude pollution research (HAPR) program with NASA's research centers to investigate new technologies in jet engine combustor designs that reduce engine emissions, specifically, nitrogen oxide emissions. These emissions generate particular concern due to their potential impact on the upper atmosphere. The results from these investigations will be used in developing future engine emission regulations and international

standards. Studies with NASA will also investigate both current subsonic and high–speed civil transport's (HSCT) effect on the ozone layer and global climate change. These studies are intended to determine the HSCT's future viability and the need for aircraft engine emission standards at cruise altitude conditions.

Energy Conservation and Aviation Energy Emergency Contingency Planning

This project will support achieving a 20 percent energy use reduction or a 20 percent increase in efficiency in FAA buildings by 2000 as compared to fiscal year 1985. It seeks to minimize energy use in Federal facilities to comply with Executive Order 12759. The FAA also will review and evaluate the present Energy Management Reporting System. Based on this review, the system will be upgraded and enhanced, or replaced with another tracking and reporting system. A user's training program will also be developed. The reporting requirement is mandated by Executive Order 12759 and the National Energy Conservation Policy Act, as amended.

The FAA Aviation Energy Emergency Contingency Plan will also be reviewed and updated. An Aviation Energy Statistics/Fuel Survey will be developed, and a method to continually update the data base will be incorporated in the plan. Energy support studies will be conducted as required to support the plan.

**Related Projects:** 021–220 Multiple Runway Procedures Development, 024–110 Aviation System Capacity Planning, and 025–130 Air Traffic Models and Evaluation Tools.

**Products:**

- Mathematical models to compute the impact from aviation noise for both airports and heliports
- Mathematical models to compute aviation contributions to airport and upper atmospheric air pollution
- New, simplified aircraft certification procedures for contemporary airplanes and helicopters that will be used to revise certification regulations
- Handbooks and guidance material for FAA field personnel involved in aircraft certification
- Certification standards for new technology aircraft including propfans, ultra high–bypass engines, and HSCT's that will be used to promulgate new regulations
- Studies to identify feasible technologies leading to potential noise certification standards
- Improved FAA energy contingency plan and computerized reporting system to meet FAA and Department of Energy reporting obligations to Congress
- Revised and updated Advisory Circular AC–36, Aircraft Noise Levels

**1994 Accomplishments:**

- Developed airport air quality assessment tools and procedures.
- Released improved aviation noise prediction computer tools (INM version 4.11 and AEM version 3.0).

**Planned Activities:**

Aviation Environmental Analysis

In 1995, a system of airport noise analysis and impact assessment tools/processes will be developed. These tools and analyses will be used to: identify optimal airport development alternatives, avert public controversy, and accommodate Federal guidelines. This system will be expanded in 1997 to include major air traffic management and airspace improvement projects.

Aircraft Noise Reduction and Control

In 1996, simplified noise certification procedures will be developed for large helicopters. Also, vertical flight noise assessment tools will be completed for use in heliport/vertiport development.

Aircraft Engine Emissions and Control

In 1998, an updated version of the global aircraft emissions forecasting model will be developed to predict the atmospheric effects from subsonic and HSCT emissions on the ozone layer and global climate change.

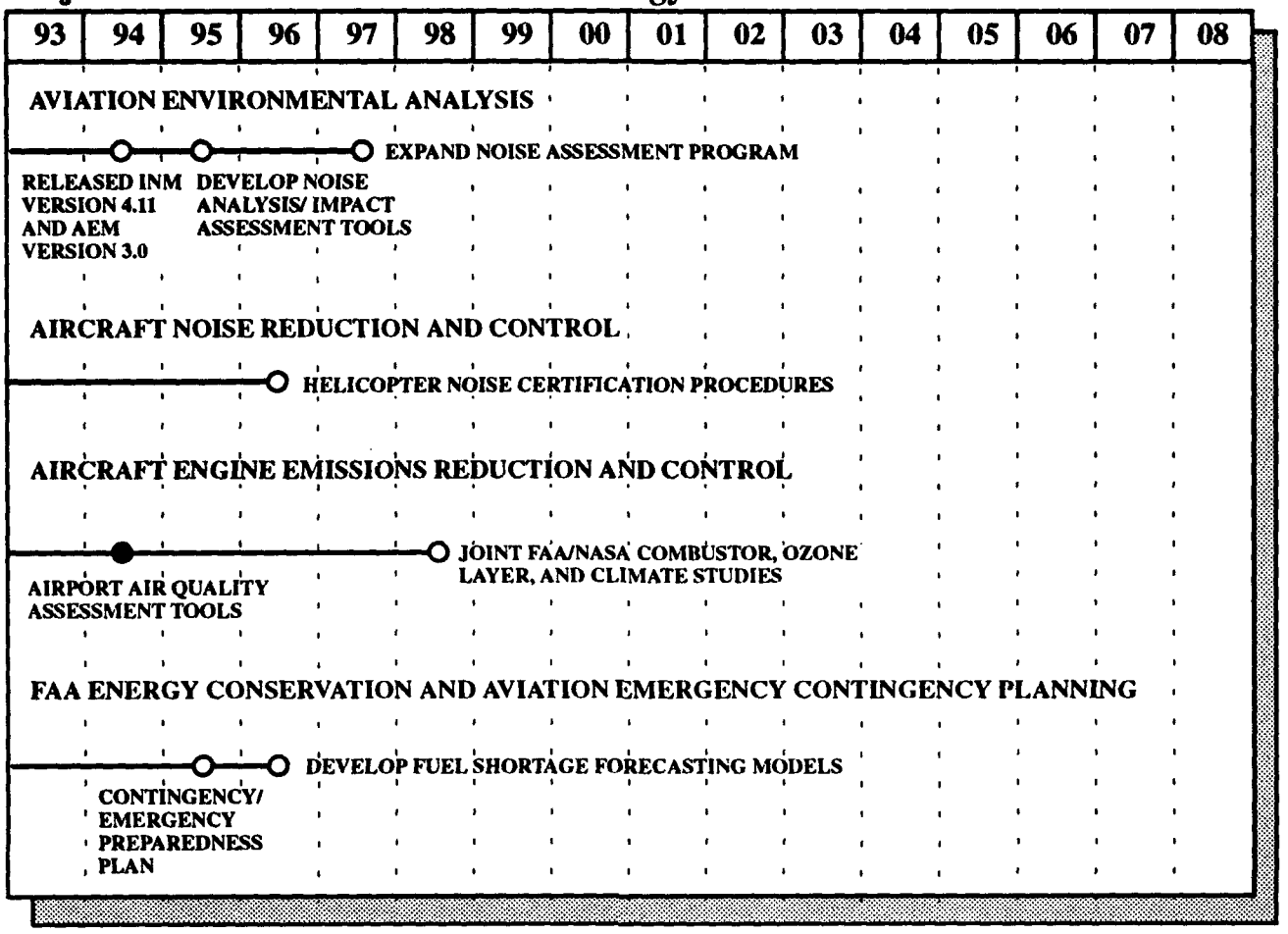
To ensure consistency with known changes in the Clean Air Act, the FAA will update the Federal Aviation Regulations on aircraft emissions. The FAA's data base on emissions characteristics will be expanded by collecting data on new technology and newly certified engines.

Energy Conservation and Aviation Emergency Contingency Planning

In 1995, procedures and a reporting system will be implemented to monitor the FAA's compliance with Executive Order 12759 on energy conservation, planning, and reporting obligations.

In 1996, aviation fuel shortage forecast and assessment models will be developed. These models will support contingency planning and emergency preparedness during a national fuel crisis.

## Project 091–110: Environment and Energy



# APPENDIX A

## Innovative/Cooperative Research

The Federal Aviation Administration's Research, Engineering and Development (R,E&D) program is committed to supporting a technologically advanced future aviation system. The agency's Innovative and Cooperative Research program provides vehicles to test new and innovative ideas to implement the vision while satisfying congressionally mandated research requirements.

The cornerstones of the program are the Aviation Research Grants and the Technology Transfer programs. The Aviation Research Grants Progr .m is integral to the FAA's comprehensive R,E&D Plan. Grants allow the FAA to expand its technology base by accessing the substantial research capabilities of leading colleges, universities, and other research institutions. Grant projects focus on research necessary to the FAA's mission to improve aviation safety, security, capacity, and the environment.

Technology transfer is the process by which knowledge, facilities, or capabilities developed by Federal laboratories or agencies are transferred to the private sector to expand the U.S. technology base and to maximize the return on investment in federally funded R&D. Technology transfer is a critical tool designed to help the private sector meet the challenges of the highly competitive global economic environment. The instrument utilized by the Technology Transfer Program is the Cooperative Research and Development Agreement (CRDA) between Federal agencies and private companies.

In addition, the University Fellowship Program gives students and their professors the opportunity to become involved in a broad spectrum of programs at the Technical Center. This program has led to recruiting highly qualified students for the FAA. The FAA/National Aeronautics and Space Administration (NASA) Cooperative Program allows sharing research that benefits both agencies. The Transportation Research Board is an FAA link to the National Academy of Sciences which sponsors workshops and awards individual fellowships through the Graduate Research Award Program.

Through research grants, cooperative agreements, and small business contracts, the FAA exploits outside expertise and encourages academic, industrial, and other Government agency participation that benefits the R,E&D program.

## 101–110 Transportation Research Board (TRB)

**Purpose:** This program stimulates research concerning the nature and performance of aviation transportation systems, disseminates the information produced by the research, and encourages applying appropriate research findings. This research influences the FAA's future policy direction. The TRB is a National Research Council unit that serves the National Academies of Sciences and Engineering. The products from this research help the public sector focus on technical and management innovations developed by the academic and private sectors to resolve current and future critical issues. The TRB also provides an independent perspective on means that

could be used to improve safety, manage the national aviation system, increase capacity and productivity, and stimulate interest in highly qualified students to pursue careers in aviation.

**Approach:** The FAA determines specific research to be conducted and awards research contracts to the TRB. This program is carried out largely by committees, task forces, and a panel staffed by industry, public officials, and university experts who serve without compensation. The FAA provides one or more analysts to participate on these committees, task forces, and panels. The Board's efforts also include research on aviation's future by conducting an annual Graduate Research Award Program. This program focuses on technical and management innovations for civil aviation facilities in the next century and other special research projects to further the national aviation system's safety and efficiency. Completed products are normally transmitted to the FAA, industry, and general public as an official TRB circular. The Graduate Research Award Program papers are also presented at a special session of the annual TRB meeting.

## 101–120 FAA/NASA Joint University Program

**Purpose:** This program conducts research germane to the entire spectrum of National Airspace System (NAS) activities at recognized American universities in cooperation with NASA. It also assists in educating professional personnel needed to develop and manage the future NAS components. Solutions to large scale systems problems related to the national air transportation system ultimately come only after the technological foundations have been laid through basic research. The Joint University Program has provided an interdisciplinary team approach to research and education in those areas necessary for fundamental advances at the forefront of aviation technology. This program provides results to the FAA from scientific and technology advances through research and development at American colleges and universities. Also, the program is a source of talented engineers and scientists skilled in aviation–related fields.

**Approach:** The FAA/NASA Joint University Program for Air Transportation Research is a coordinated set of three grants sponsored jointly by the FAA and NASA Langley Research Center. Grants are awarded annually to the Massachusetts Institute of Technology, Ohio University, and Princeton University. Principal investigators at each institution prepare an annual research proposal that is based, in part, on suggested topics that are responsive to FAA and NASA long–term needs. The principal investigators are responsible for assembling the research teams, managing the research, and publishing the results. Four technical conferences are held per year at the FAA, NASA, and participating universities. The outcome of the research is published in numerous technical papers and an annual report.

## 101–130 Small Business Innovative Research (SBIR) Program

**Purpose:** This program stimulates technological innovation, uses small business to meet Federal research and development needs, increases private sector commercialization of

innovations derived from Federal research, and encourages participation by small disadvantaged companies in developing technological innovations. The SBIR program is congressionally mandated by the Small Business Research and Development Enhancement Act of 1992 (Public Law (P.L.) 102–504). The program is funded through project funds that reside in other R,E&D programs. By virtue of its FAA–wide scope, the SBIR program benefits the entire program spectrum that makes up the national air transportation system. The budgetary and technical resources can be applied to these programs in a timely and cost–effective manner. By enabling small, high technology corporations to start up and prosper, the SBIR contributes in a larger sense to the domestic economy and technology infrastructure.

**Approach:** Research topics are solicited from the various organizational elements throughout the agency. These topics then appear in an annual solicitation for proposals issued by the Department of Transportation. Individuals who submit the topics evaluate the proposals, and winners are chosen based on evaluations and agency needs. Firms selected to receive an award embark on the following three–phase process: Phase I – conduct feasibility–related experimental or theoretical research for R,E&D efforts up to $75,000; Phase II – perform principal research effort (a performance period of approximately 2 years and funding up to $500,000); and Phase III – perform commercialization of the research conducted under Phases I and II.

## 101–140 FAA/NASA Cooperative Programs

**Purpose:** This program provides a synergistic and cost–effective R,E&D program with NASA in areas of mutual interest. FAA engineering field offices have been established at NASA's Ames and Langley Research Centers to support joint FAA/NASA programs and provide coordination on aviation–related NASA work. The FAA engineering field offices represent a unique resource for the FAA due to their proximity and access to NASA facilities, their knowledge of NASA personnel and ongoing NASA research, and their understanding of FAA needs. Benefits realized when the agencies work together include an enhanced perspective on joint research activities, reduced duplication of similar efforts, and conservation of scarce funds and resources.

**Approach:** Cooperative activities are accomplished via memoranda of agreement (MOA) that incorporate statements of work setting forth specific research thrusts. Joint research activities are performed via memoranda of understanding (MOU) that set forth general areas for cooperative endeavor. Individual research programs are negotiated and undertaken in a manner tailored to meet program–specific objectives, foster cooperative interaction, and share resources and unique facilities. The MOU's address Human Factors, Severe Weather, Cockpit/Air Traffic Control (ATC) Integration, Airworthiness, Environmental Compatibility, and Program Support.

Human Factors research develops technology to reduce the consequences of human error in flight operations. Severe Weather research improves aircraft operational safety during hazardous weather conditions. Cockpit/ATC Integration research improves flight operations safety and efficiency. Airworthiness research pursues technologies that support developing and certifying new aircraft and ensure the continued safe operation of existing aircraft. Environmental Compatibility research reduces or eliminates aircraft noise and emission concerns. Program Support projects individual and joint research activities, shares in using unique facilities, and plans orderly information transfer between the two agencies.

## 101–150 University Fellowship Research Program

**Purpose:** This program expands the education and research activities associated with emerging concepts and technologies related to air traffic control, aviation safety, and security systems. A corollary purpose is to assist in attracting and recruiting qualified graduates to work for the FAA. The University Fellowship Research Program gives well-qualified and highly motivated graduate students an opportunity to conduct thesis research on FAA topics of interest while working with FAA engineers, scientists, and university professors. This program provides technology advancements to enhance the National Airspace System capability and improve aircraft safety and security. Educational opportunities will be provided for talented engineers and scientists with the skills, interests, and abilities necessary to accomplish this work. Opportunities will exist to recruit these and other talented, qualified graduates to work for the FAA.

**Approach:** Participants in the program engage in formal course work at their respective universities and conduct research in FAA laboratories on FAA–directed topics. The program includes expanding universities education and research activities in areas related to air traffic control systems and aircraft safety. Companion education and training activities are included to develop and enhance existing capabilities within the FAA.

## 101–160 Technology Transfer Program

**Purpose:** This program promotes technology sharing among Government, industry, and academia, and it transfers FAA R,E&D results into the mainstream of the United States economy. Technology transfer refers to the process by which existing knowledge, facilities or capabilities developed under Federal funding are used to fulfill public or private domestic needs. The United States is facing increasing challenges to its worldwide technical and economic primacy. A major problem in meeting these challenges is the extremely small return on the $60 billion annual Federal research and development (R&D) investment. The central obstacle to increasing this return has been identified by Congress as the Federal Government's inability to transfer a significant portion of federally funded R&D results into the private sector for commercialization. Several key pieces of legislation have been enacted to overcome this obstacle.

The Stevenson–Wydler Technology Innovation Act of 1980 (Public Law 96–480) mandated that all Federal laboratories assume technology transfer as a primary mission area. It provided the legal foundation for a technology transfer infrastructure within the Federal laboratory system and established an Office of Research and Technology Applications at every Federal R&D activity.

The Technology Transfer Act of 1986 (Public Law 99–502) established the formal tools and mechanisms to accomplish technology transfer and mandated the following elements: (1) establish cooperative research and development agreements (CRDA) between Federal and non-Federal parties; (2) establish the Federal Laboratory Consortium, an affiliation of Government laboratories to support the technology transfer mission; and (3) provide a cash incentive program to promote and encourage individual participation in meaningful technology transfer projects through awards and royalty sharing.

Executive Order 12591 of April 10, 1987, directed all Federal laboratories to establish Technology Transfer Programs. In response to

the laws and the Executive Order, the FAA developed Technology Transfer Order 9550.6 of October 30, 1989, which promulgates the FAA's Technology Transfer Program.

**Approach:** The FAA Technology Transfer Program goals are to: increase the return on the Federal R&D investment, increase the Nation's base for technical knowledge and experience, translate technical developments into private sector applications, reward technical creativity, and comply with the letter and the spirit of Federal technology transfer legislation.

## 101–170 Independent Research and Development (IR&D) Program

**Purpose:** This program encourages contractors to perform independent research and development on topics relevant to the FAA's long–term interests. This activity is a joint Government/industry program legislated by Public Law 102–190.

The Government recognizes IR&D as a necessary cost of doing business in a high technology environment and provides for cost recovery in the Federal Acquisition Regulations (FAR). Major contractors doing IR&D projects are requested to provide the FAA with information describing these projects. Descriptions are also submitted to the Defense Technical Information Center (DTIC) on a yearly basis in the prescribed format.

New IR&D legislation no longer requires yearly on–site review evaluations, but encourages IR&D technical interchange meetings. These meetings are arranged by mutual agreement between the contractor and Government to review and discuss a focused set of technology and/or product development projects. The purpose of these meetings is to: promote face–to–face detailed technical interaction between the contractors and the Government; provide opportunities for Government presentations on relevant technical needs and activities; and provide opportunities for Government participants to visit the contractor's facilities and operations.

The IR&D program's benefits are:

- Access to industry views about technical and business directions for the future.
- A broader range of technical options in an R&D project's early phases.
- An available pool of qualified contractors who can respond competently and competitively to Government requirements.
- Spreading the risk and cost of encouraging new ideas and concepts.
- An enhanced capability for continuous innovation to meet technical challenges for the future.

**Approach:** The Office of Research and Technology Applications has access to the DTIC proprietary IR&D data base. During the year, customized data base searches are performed for the R,E&D services. Upon request, the IR&D program office will arrange technical interchange group meetings to explore any company's IR&D projects. Further contacts may then be made with the principal investigators to monitor the research results and their potential use to the FAA.

## 101–180 Aviation Research Grant Program

**Purpose:** This program provides the FAA with the ability to access and influence directly the considerable resources existing at American colleges, universities, and nonprofit institutions to perform long–term research in aviation–related technical areas. This capability is accomplished by awarding grants for aviation research and establishing Air Transportation Research Centers of Excellence. Two pieces of legislation, the FAA R,E&D Reauthorization Act Title IX, Public Law 101–508, and the Aviation Security Improvement Act, Public Law 101–604, were enacted and contain provisions authorizing the FAA to issue research grants. Public Law 101–508 establishes three separate programs: the Aviation Research Grants Program, the Catastrophic Failure Prevention Research Grant Program, and the Air Transportation Research Centers of Excellence Program. Public Law 101–604 authorizes establishing the Aviation Security Research Grants Program.

Collectively, the legislation directs that:

- The FAA be given the authority to award single and multiyear research grants to colleges, universities, and nonprofit institutions.
- The FAA be authorized to establish Centers of Excellence for research into aviation–related areas of unique interest to the FAA.
- Research areas shall cover, at a minimum, ATC automation, aviation artificial intelligence applications, aviation control simulation and training technologies, human factors, airport and airspace planning and design, airport capacity enhancement, aviation security, and aircraft safety.
- At least 3 percent of the total FAA R,E&D budget be devoted to fund the research grant program.
- The FAA shall contribute to creating a talented pool of technical professionals trained in the sciences, engineering, and mathematics, and mechanics related to aeronautics and aviation.

**Approach:** Program execution rests on a set of established internal and external procedures that are updated continuously. A process for advertising, soliciting, and evaluating program proposals was developed and initiated. This process, together with a companion process for awarding, administering, and closing out grants, is detailed in FAA Directive 9550.7, Aviation Research Grants. Computer data bases have been established to ensure that eligible institutions are notified of the program and that proposals and grant awards are properly tracked. A network of capable proposal technical evaluators and grant technical monitors has been put in place.

Fifty grant awards have been made during initial program operation. These grants are funded via individual program sponsorship. A Center of Excellence in Computational Modeling in Aircraft Structures was started in 1993 at Rutgers/Georgia Tech. Procedures for identifying and initiating follow–on Centers of Excellence have been defined and are about to enter the agency coordination process.

## 101–190 Innovation Development and Engineering Applications (IDEA) Program

**Purpose:** This program will provide the FAA with a formal structure to ensure that novel ideas for innovative R,E&D projects, proposed by FAA employees or the private sector, will be evaluated and, if feasible, sponsored. The FAA IDEA program is designed to expedite and facilitate technological innovation. This will be accomplished by sponsoring innovative applied research and engineering development projects, both in the FAA and the private sector, through a variety of implementation vehicles. This thrust area is expected to promote: an innovative R,E&D environment, new technology applications to FAA programs, an increase in FAA patents and licenses, increased access to private sector expertise, increased technology transfer, increased employee satisfaction, and total quality management implementation.

**Approach:** The approach to this program is to establish a focal point within the Office of Research and Technology Applications, ACL–1, that will have discretionary R,E&D funds available. This focal point will act as a catalyst to accomplish research on innovative ideas from within and outside the FAA. The IDEA program will utilize various vehicles such as grants, CRDA's, broad agency announcements, task–order contracts, employee exchange, total quality management, and employee temporary assignments to aid in timely implementation of these innovative ideas.

The criteria used to evaluate potential innovative research projects will include, but are not limited to:

- Projects that represent ideas or technologies that are promising and should be pursued but are outside the charter of the originating organization.
- Projects that are outside the stated responsibilities of a researcher's position description but seem promising and should be pursued for the FAA's benefit.
- Projects that are not feasible for an organization to pursue because of constraints imposed by time, current project workloads, limited manpower, financial resources, risk factors, or other such limitations.

An ad hoc "council of peers" consisting of experts in various technology areas will be recruited by the program and will serve in a consulting capacity to provide expert advice on proposed projects relating to technologies in their area of expertise. Based on the council's findings, a determination will be made on individual projects.

# APPENDIX B

## Research, Engineering and Development (R,E&D) Management, Plan, Control, and Support

A process was initiated in 1990 to provide more in–depth analysis and control for R,E&D activities. The process emphasizes developing a systems engineering approach to define, implement, and manage the research required for National Airspace System (NAS) development. This process' maintenance and enhancement is critical to the R,E&D program efficiency and effectiveness. Supporting the R,E&D infrastructure contributes to virtually every project within the R,E&D environment.

The R,E&D infrastructure provides the vehicle to ensure that the total R,E&D program is conducted as a cohesive, integrated entity and permits evaluating progress across the thrust areas. This is critical due to the integrated nature, both technical and fiscal, of the individual R,E&D projects with each other, with the future aviation system, and with the Aviation System Capital Investment Plan.

R,E&D resources are required for the following efforts:

Research, Engineering and Development Plan

The Aviation Safety Research Act of 1988 mandates that the FAA develop, maintain, and publish the FAA's R,E&D Plan. The Plan describes the R,E&D process, the relationships with other R,E&D organizations, the National Airspace System and its evolution, and the FAA's R,E&D program.

R,E&D Management, Plan, and Control

The R,E&D management and control process and automated support system will be maintained, refined, and further integrated into the R,E&D planning and budgetary processes. Specific products will include publishing the annual R,E&D Plan, associated report to Congress on R,E&D accomplishments from the previous year, technical/engineering schedule support for the R,E&D program, and the annual R,E&D conference.

R,E&D Advisory Committee

The committee will provide the agency with reports, advice, and recommendations regarding the needs, objective, plans, approaches, contents, and accomplishments with respect to the aviation research program. The committee considers aviation research needs to support the FAA mission and addresses such areas as airport capacity, system safety, aircraft safety, aeromedical research, aviation security, and future ATC technology.

R,E&D Program Support

Provides for in–house support for system engineering and development, international requirements, and NAS program analysis activities.

Technical Laboratory Facility

The FAA Technical Center operates and maintains laboratory facilities to perform test, evaluation, and integration efforts. Funding is required for maintenance, software licensing fees, support costs, and other costs associated with operating the technical laboratories.

System Analysis and Evaluation

This project encompasses system planning, capacity, delay, and performance analyses in the R,E&D program. NAS–related issues will be analyzed, and cost/benefit studies or other studies to support system investment, planning, engineering, development, and operation will be performed. Major products include cost/benefit assessments to make prudent R,E&D program investments; management tools; methods and strategies for R,E&D cost containment; and effective delivery of R,E&D benefits. Analyses will be conducted to review major R,E&D initiatives and impacts on systemwide performance and to improve air traffic management.

# APPENDIX C

## List of Acronyms and Abbreviations

**A**

| | |
|---|---|
| AAS | Advanced Automation System |
| AC | Advisory Circular |
| ACA | Aviation Security Research and Development Service |
| ACARS | ARINC Communications Addressing and Reporting System |
| ACD | Engineering, Research and Development Service |
| ACE | Aviation Capacity Enhancement |
| ACES | Aircraft Command in Emergency Situations |
| ACL | The FAA's Office of Research and Technology Applications |
| ADR | Automated Demand Resolution |
| ADS | Automatic Dependent Surveillance |
| AEM | Area Equivalent Method |
| AERA | Automated En Route Air Traffic Control |
| AEX | Automatic Execution Function |
| AF | Airway Facility |
| A/G | Air/Ground |
| AGFS | Aviation Gridded Forecast System |
| AIP | Airport Improvement Program |
| AMASS | Airport Movement Area Safety System |
| AMSS | Aeronautical Mobile Satellite Services |
| AOC | Airline Operation Control |
| AOR | The FAA's Operations Research Service |
| APU | Auxiliary Power Unit |
| AQP | Advanced Qualification Program |
| ARINC | Aeronautical Radio, Incorporated |
| ARTCC | Air Route Traffic Control Center |
| ARTS | Automated Radar Terminal System |
| ASD | Aircraft Situation Display |
| ASDE | Airport Surface Detection Equipment |
| ASI | Aviation Safety Inspector |
| ASR | Airport Surveillance Radar |
| ASTA | Airport Surface Traffic Automation |

| | |
|---|---|
| ATA | Air Transport Association of America |
| ATC | Air Traffic Control |
| ATCBI | Air Traffic Control Beacon Interrogator |
| ATCS | Air Traffic Control Specialist |
| ATCSCC | Air Traffic Control System Command Center |
| ATCT | Air Traffic Control Tower |
| ATIS | Automated Terminal Information Service |
| ATM | Air Traffic Management |
| ATMS | Advanced Traffic Management System |
| ATN | Aeronautical Telecommunications Network |
| AWDL | Aviation Weather Development Laboratory |
| AWOS | Automated Weather Observing System |
| AWPG | Aviation Weather Products Generator |

**B**

| | |
|---|---|
| BAA | Broad Agency Announcement |

**C**

| | |
|---|---|
| CAA | Civil Aeronautics Administration |
| CAMI | Civil Aeromedical Institute |
| CASA | Controller Automation Spacing Aid |
| CAT | Category |
| CDTI | Cockpit Display of Surface Traffic Information |
| CIP | Capital Investment Plan |
| C/N/S | Communications, Navigation, and Surveillance |
| CONDAT | Conterminous United States Data Model |
| COTS | Commercial off–the–shelf |
| CRDA | Cooperative Research and Development Agreement or Converging Runway Display Aid |
| CRM | Cockpit Resource Management |
| CSD | Critical Sector Detector |
| C/SOIT | Communications/Surveillance Operational Implementation Team |
| CT | Computer Tomography |
| CTAS | Center–TRACON Automation System |
| CTR | Civil Tiltrotor |

**D**

| | |
|---|---|
| DA | Descent Advisor |

| | |
|---|---|
| DARPS | Dynamic Aircraft Route Planning Study |
| DASI | Digital Altimeter Setting Indicator |
| DDAS | Daily Decision Analysis System |
| DEMVAL | Demonstration/Validation |
| DGPS | Differential corrected Global Positioning System |
| DME | Distance Measuring Equipment |
| DOD | U.S. Department of Defense |
| DOT | U.S. Department of Transportation |
| DOTS | Dynamic Ocean Track System |
| DSS | Decision Support System |
| DSUA | Dynamic Special Use Airspace |
| DTIC | Defense Technical Information Center |

## E

| | |
|---|---|
| EDP | Expedite Departure Path |
| EDPRT | Expert Diagnostic, Predictive, and Resolution Tools |
| EDS | Explosives Detection System |
| EFF | Experimental Forecast Facility |
| ETMS | Enhanced Traffic Management System |

## F

| | |
|---|---|
| F&E | Facilities and Equipment |
| FAA | Federal Aviation Administration |
| FAATC | Federal Aviation Administration Technical Center |
| FANS | Future Air Navigation System |
| FAR | Federal Aviation Regulations |
| FAST | Final Approach Spacing Tool |
| FBL | Fly–By–Light |
| FBW | Fly–By–Wire |
| FDIO | Flight Data Input/Output |
| FLOWSIM | Flow Simulation Model |
| FMA | Final Monitor Aid |
| FMS | Flight Management System |
| FRP | Federal Radionavigation Plan |
| FTMI | Flight Operations and Air Traffic Management Integration |

## G

| | |
|---|---|
| GA | General Aviation |
| GDP | Gross Domestic Product |
| GLONASS | Global Orbiting Navigation Satellite System |
| GNSS | Global Navigation Satellite System |
| GPS | Global Positioning System |

## H

| | |
|---|---|
| HAPR | High Altitude Pollution Research |
| HARS | High Altitude Route System |
| HF | High Frequency |
| HIRF | High Intensity Radiated Fields |
| HNM | Heliport Noise Model |
| HSCT | High Speed Civil Transport |

## I

| | |
|---|---|
| I–Lab | Integration and Interaction Laboratory |
| ICAO | International Civil Aviation Organization |
| IDEA | Innovation Development and Engineering Applications |
| IFR | Instrument Flight Rules |
| IMC | Instrument Meteorological Conditions |
| INM | Integrated Noise Model |
| IR&D | Independent Research and Development |
| ISMS | Integrated Security Management System |
| ISSS | Initial Sector Suite System |
| ITS | Intelligent Tutoring System |
| ITWS | Integrated Terminal Weather System |

## J

| | |
|---|---|
| JFK | ICAO designator for John F. Kennedy International Airport |
| JSS | Job Satisfaction Survey |

## L

| | |
|---|---|
| LIP | Limited Installation Program |
| LLWAS | Low–Level Windshear Alert System |
| Loran | Long–Range Navigation |

## M

| | |
|---|---|
| MA | Monitor Alert Function |
| MASPS | Minimum Avionic System Performance Standards |
| MCC | Maintenance Control Center |
| MDCRS | Meteorological Data Collection and Reporting System |
| MLS | Microwave Landing System |
| MOA | Memorandum of Agreement |
| Mode S | Mode Select Discrete Addressable Secondary Radar System with Data Link |
| MOPS | Minimum Operational Performance Standards |
| MOU | Memorandum of Understanding |

## N

| | |
|---|---|
| NANIM | Nationwide Airport Noise Impact Model |
| NAS | National Airspace System |
| NASA | National Aeronautics and Space Administration |
| NASP | National Aerospace Plane |
| NASPAC | National Airspace System Performance Analysis Capability |
| NASSIM | NAS Simulation |
| NAWPG | National Aviation Weather Products Generator |
| NDB | *Nondirectional* Radio Beacons |
| NDI | Nondestructive Inspection |
| NIOSH | National Institute of Occupational Safety and Health |
| NOAA | National Oceanic and Atmospheric Administration |
| NOTAM | Notice to Airmen |
| NSC | National Simulation Capability |
| N–SDAT | National Airspace Sector Design Analysis Tool |
| NTP | National Transportation Policy |
| NWS | National Weather Service |

## O

| | |
|---|---|
| OAS | Oceanic Automation System |
| OBOGS | On–Board Oxygen Generating System |
| ODAPS | Oceanic Display and Planning System |
| ODF | Oceanic Development Facility |
| OEI | One Engine Inoperative |
| OPTIFLOW | Optimized Flow Planning |
| OR | Operations Research |

| | |
|---|---|
| ORD | Operational Readiness Date |
| OT&E | Operational Test and Evaluation |
| OTFP | Operational Traffic Flow Planning |

**P**

| | |
|---|---|
| PADS | Planned Arrival and Departure System |
| PBW | Power–By–Wire |
| PC | Personal computer |
| P.L. | Public Law |
| PLV | Powered–lift Vehicle |
| PRM | Precision Runway Monitor |
| PTS | Pre–Training Screen |

**R**

| | |
|---|---|
| R&D | Research and Development |
| RAWPG | Regional Aviation Weather Products Generator |
| R,E&D | Research, Engineering and Development |
| RF | Radio Frequency |
| RFP | Request for Proposal |
| RMMS | Remote Maintenance Monitoring System |
| RMP | Rotorcraft Master Plan |
| RNP | Required Navigation Performance |
| RSLS | Runway Status Light System |
| RTCA | Radio Technical Commission for Aeronautics |
| RVR | Runway Visual Range |

**S**

| | |
|---|---|
| SARP's | Standards and Recommended Practices |
| SATCOM | Satellite Communications |
| SATORI | Situational Awareness Through Re–creation of Incidents |
| SBIR | Small Business Innovation Research |
| SDAT | Sector Design and Analysis Tool |
| SE | Strategy Evaluation |
| SFA | Survey Feedback Action |
| SIDP | Supervisory Identification Development Program |
| SIMMOD | A trademark name for the FAA's Airport and Airspace Simulation Model |
| SMARTFLO | Knowledge–based Flow Planning |

| | |
|---|---|
| SORS | Seats or Restraint System |
| SPAS | Safety Performance Analysis System |
| SPEARS | Screener Performance Evaluation And Reporting System |
| SSR | Secondary Surveillance Radar |
| STPG | Scientific Task Planning Group |

## T

| | |
|---|---|
| TACAN | Tactical Air Navigation |
| TASS | Terminal Area Surveillance System |
| TATCA | Terminal ATC Automation |
| TCAS | Traffic Alert and Collision Avoidance System |
| TCCC | Tower Control Computer Complex |
| TDWR | Terminal Doppler Weather Radar |
| TERPS | Terminal Instrument Procedures |
| TFM | Traffic Flow Management |
| TIDS | Tower Integrated Display System |
| TMA | Traffic Management Advisor |
| TMS | Traffic Management System |
| TMU | Traffic Management Unit |
| TNA | Thermal Neutron Analysis |
| TQM | Total Quality Management |
| TRACON | Terminal Radar Approach Control |
| TRB | Transportation Research Board |
| T–SDAT | Terminal Airspace Sector Design Analysis Tool |
| TSR | Terminal Surveillance Radar |

## U

| | |
|---|---|
| U.S. | United States |
| USWRP | United States Weather Research Program |

## V

| | |
|---|---|
| VERTAPS | Vertical Flight Terminal Area Procedure Development Plan |
| VertOps | Vertical Flight Operations and Certification program |
| VF | Vertical Flight |
| VFR | Visual Flight Rules |
| VHF | Very High Frequency |
| VMC | Visual Meteorological Conditions |

| | |
|---|---|
| VNTSC | Volpe National Transportation Systems Center |
| VOR | VHF Omnidirectional Range |
| VORTAC | Collocated VOR and TACAN |
| | |
| 2D | 2–Dimensional |
| 3D | 3–Dimensional |
| 4D | 4–Dimensional |

# APPENDIX D

## Alphabetical Index of R,E&D Projects

# APPENDIX E

## Project Changes Since The 1991 R,E&D Plan

Projects that have been completed, renamed, combined, or withdrawn since the 1991 R,E&D Plan publication are listed by chapters.

| PROJECT NUMBER | PROJECT TITLE | LAST ACTIVITY |
|---|---|---|
| | **Capacity and Air Traffic Management Technology** | |
| 021–110 | Advanced Traffic Management System sections pertaining to Dynamic Ocean Track System (DOTS) | Combined With Project 021–140 1992 |
| 021–140 | Oceanic ATC Automation to Oceanic Air Traffic Automation | Name Change 1992 |
| 021–150 | ATC Applications of Automatic Dependent Surveillance (ADS) | Combined With Project 021–140 1992 |
| 021–160 | ATC Automation Bridge | Terminated in 1993 |
| 021–170 | Advanced Automated En Route ATC (AERA) Concepts | Withdrawn in 1992 |
| 021–200 | Surface Movement Safety and Guidance | Combined With Project 021–190 1992 |
| 021–210 | Tower Interim Display System to Tower Integrated Display System | Name Change 1992 |
| 021–220 | Airport Capacity Improvements to Multiple Runway Procedures Development | Name Change 1993 |
| 021–230 | Wake–Vortex Avoidance/Advisory System to Wake–Vortex Separation Standards Reduction | Name Change 1992 |
| 025–110 | National Simulation Laboratory (NSL) to National Simulation Capability (NSC) | Name Change 1992 |

| PROJECT NUMBER | PROJECT TITLE | LAST ACTIVITY |
|---|---|---|
| 026–110 | Airway Facilities Future Technologies | Combined With 026–120 and 026–130 1994 |
| 026–120 | Diagnostic Tools and Future Technology to Airway Facilities<br>Diagnostic Tools and Future Technology | Name Change 1993<br>Combined With 026–110 1994 |
| 026–130 | Functional Models and Evaluation Tools to Airway Facilities<br>Functional Models and Evaluation Tools | Name Change 1993<br>Combined With 026–110 1994 |
| | **Communications, Navigation, and Surveillance** | |
| 033–120 | Mode S Sensor Data Link Enhancement | Withdrawn in 1993 |
| | **Weather** | |
| | **Airport Technology** | |
| 051–140 | Demonstrations and Concepts Evaluation | Terminated in 1993 |
| | **Aircraft Safety Technology** | |
| 064–110 | Flight Safety/Atmospheric Hazards Research to Flight Safety/ Atmospheric Hazards | Name Change 1992 |
| 064–120 | International Aircraft Operator Information System | Terminated in 1993 |
| | **System Security Technology** | |
| 072–110 | Weapons Detection | Combined with project 071–110 1994 |
| 073–110 | Airport Security to NAS Security | Name Change 1994 |

| PROJECT NUMBER | PROJECT TITLE | LAST ACTIVITY |
|---|---|---|
| 074–110 | Security Systems Integration | Combined with project 071–110 1994 |
| | **Human Factors and Aviation Medicine** | |
| 083–110 | Airway Facilities Maintenance Human Factors to Airway Facilities Human Factors | Name Change 1992 |
| 087–110 | Workforce Performance Optimization | New Project 1994 |
| | **Environment and Energy** | |

**For information on the subjects discussed in this document, contact the Manager, NAS Planning Division, APM-300, NAS Program Management Service, Federal Aviation Administration, 800 Independence Avenue, Washington, D.C. 20591.**

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