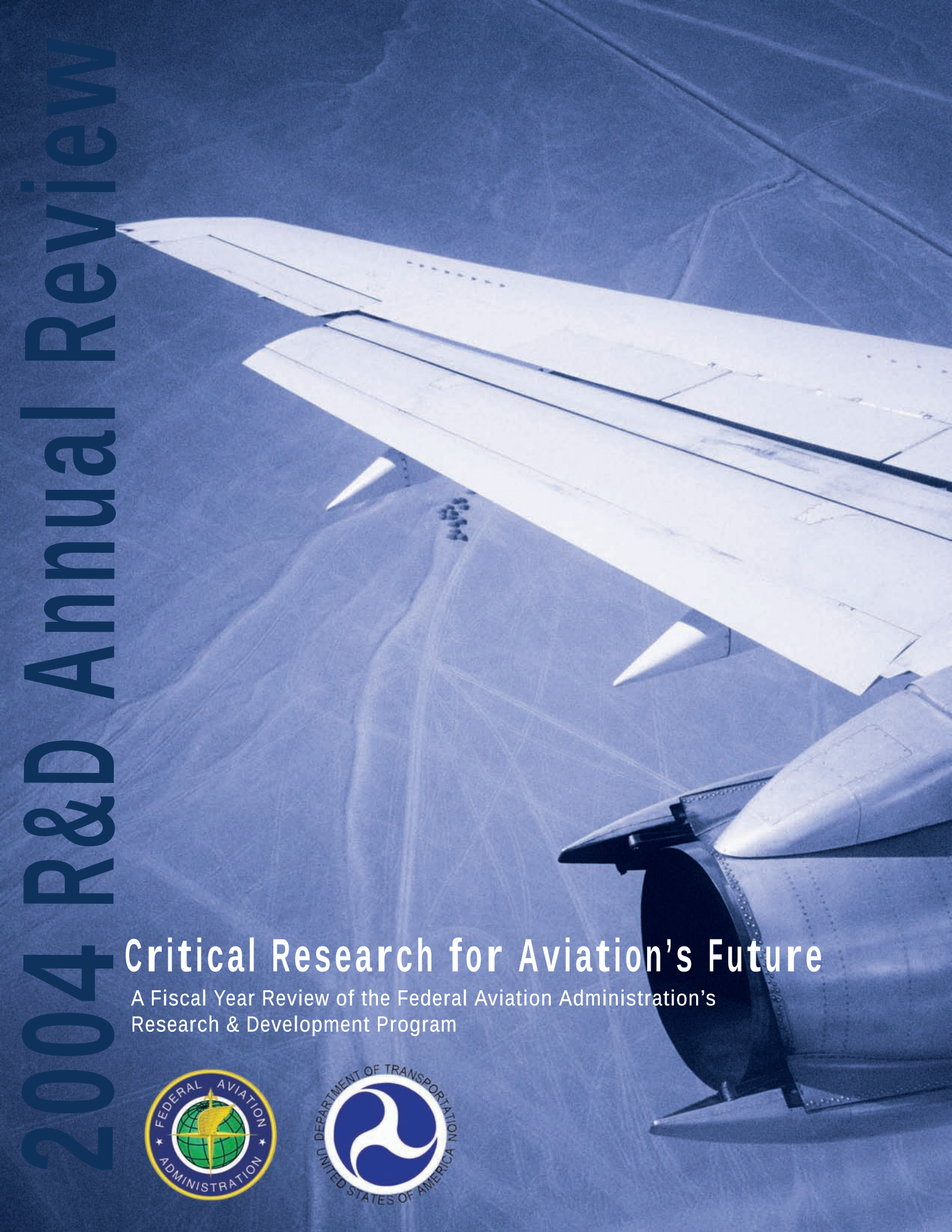


2004 R&D Annual Review

Critical Research for Aviation's Future

A Fiscal Year Review of the Federal Aviation Administration's Research & Development Program

2004 R&D Annual Review

contents:

A Message

From the Administrator

"The support, diligence, and committed service of the FAA researchers and scientists have generated innovations that continue to improve upon a safe, secure, efficient, and environmentally-sound global aerospace system."

Every day, the aviation community faces a number of challenges that range from ensuring the health and safety of passengers and crew to protecting the environment, increasing capacity and efficiency, and creating an aviation system that is performance-based and human-centered. As the Federal Aviation Administration's approximately 38,000 controllers and maintenance specialists work to keep the system operating safely, they do so with the confidence that the FAA's researchers are working in the background to develop the next generation of technologies and procedures that will help them keep the system safe and efficient.

FAA researchers, scientists, and engineers have generated the tools and technologies that continue to improve the global aerospace system. Their cutting-edge research is reducing the rate of commercial accident and building an air traffic control system capable of efficiently meeting future demand. Drawing upon their work, and the work of their domestic and international research partners, the aviation community will meet future challenges and surpass the remarkable success it has achieved to date.

The FAA is able to achieve its goals through the dedicated work of research and development (R&D) organization and the impact of that research on the aerospace community. Some of the activities supported by the R&D program include:

- Licensing, regulation, certification, and standards development;
- Modernization, operation, and maintenance of the national airspace system;
- Aerospace policy formulation, planning, and analysis;
- Effective response to incidents, special situations, and emerging issues; and
- Guidance, coordination, and collaboration across the global aerospace transportation community.

The Fiscal Year (FY) 2004 *R&D Annual Review* highlights another successful year. This Review addresses some of their ongoing work in support of the FAA's strategic goals and mission as described in the Agency's *Flight Plan 2005-2009*. For additional information on our research and development program, please see the *2005 National Aviation Research Plan*, where you will find R&D budget information, research partners, past accomplishments, expected results, and a description of every R&D project over the five years.

Marion C. Blakey
FAA Administrator

Aeromedical Research

Prevent adverse health impact to passengers, flight crew, and ground personnel.

Evacuation into Water

Certification procedures for transport airplanes require the manufacturer to demonstrate that all passengers can evacuate onto land within 90 seconds. These requirements do not specify how passengers must evacuate the aircraft into life rafts or into the water. Instead, certification criteria for ditching have generally been demonstrated through a flotation-time analysis for each new airplane type. Differences in the proposed design and operation of very large transport airplanes, such as the Airbus 380, may be very different from the historically assumed passenger flow rates into water. In FY 2004, cabin safety researchers at the Civil Aerospace Medical Institute conducted a series of tests to evaluate the rate at which passengers evacuate into water from simulated Type A (42 inches wide) and Type 1 (24 inches wide) exits. The tests evaluated exit heights of 9 inches, 2 feet, 4 feet, and 6 feet above water level in tests that required the subjects to use either their flotation seat cushions or life preservers inflated prior to or after water entry. Results indicated that passengers exit the aircraft into the water more slowly as exit heights above the water increased. The researchers also found that evacuation rates for subjects using flotation seat cushions were slower than evacuations with subjects wearing life vests. Researchers presented these findings at the 2004 Annual Scientific Meeting of the Aerospace Medical Association and the 4th Triennial International Aircraft Fire and Cabin Safety Research Conference.

Center of Excellence for Airliner Cabin Environment

The FAA recently established the Air Transportation Center of Excellence for Airliner Cabin Environment Research. This Center, led by Auburn University, includes Purdue University, Harvard University, Boise State University, Kansas State University, the University of California at Berkeley, and the University of Medicine and Dentistry of New Jersey. The consortium will research cabin air quality and assess chemical and biological threats. The FAA will contribute at least $1 million to the center in FY 2005 and then $500,000 both the second and third year. The universities and the private sector partners will provide matching funds.

Enhanced Cocaine Analysis

The National Transportation Safety Board routinely submits pilot and flight crew specimens from fatal aviation accident to FAA's Civil Aerospace Medical Institute for toxicological analysis. During these evaluations, a search is always made for drugs such as cocaine, one of the most widely abused illicit drugs in America. Because of its direct absorption into the blood stream from the lungs, smoked crack cocaine is a particularly dangerous form of narcotic. Also, the reaction of cocaine with alcohol in the body produces a longer lasting and more toxic effect. Demonstrating the presence or absence of cocaine-related molecules in postmortem fluids and/or tissues may help determine the cause of impairment and/or death in pilots. Such evidence can have serious legal consequences. Aeromedical researchers have developed a method for simultaneously determining the presence of cocaine, cocaine metabolites, methyl esters (a unique by-product of cocaine smoking), coca-ethylene (a molecule formed by the concurrent use of cocaine and ethanol), and other related metabolites. In FY 2004, researchers applied the methodology to five aviation pilot/crew fatality cases and concluded that it was simple, robust, and accurate. The new process will simplify postmortem analysis from multiple, cumbersome tests, to a single, highly accurate test that can provide detailed information on the source of the cocaine and its metabolites.

Anti-Hypertensive Medication Analytical Specificity

Pilots being treated with anti-hypertensive medications can be medically certified to fly civilian aircraft if they can successfully control their high blood pressure with diet, weight control, and/or medications. In fact, approximately 8 percent of active pilots are considered "hypertensive with medication." Beta-blockers are one type of FAA-acceptable antihypertensive medication that is frequently prescribed to pilots. Examples of beta-blockers include atenolol, metoprolol, and propranolol. Over the 10-year period, 1993-2002, researchers detected beta-blockers in the postmortem samples of 50 pilots involved in fatal accidents. They found atenolol in 24 pilots, metoprolol in 19 pilots, and propranolol in 7 pilots. Although the initial analysis of some of these cases suggested the presence of both atenolol and metoprolol, researchers could find no medical history supporting the simultaneous use of both of these drugs. Because it is unusual for patients to take more than one beta-blocker simultaneously (whether per prescription or on their own volition), researchers undertook further examination of these cases to verify the initial analysis. New testing techniques now make it possible to identify definitively each beta-blocker without the uncertainty previously associated with atenolol and metoprolol interference. These improved research methods have significantly enhanced the FAA's and the scientific community's ability to define specific medications and conditions that may be associated with an aircraft accident fatality.

Vision Threat Safety Standard

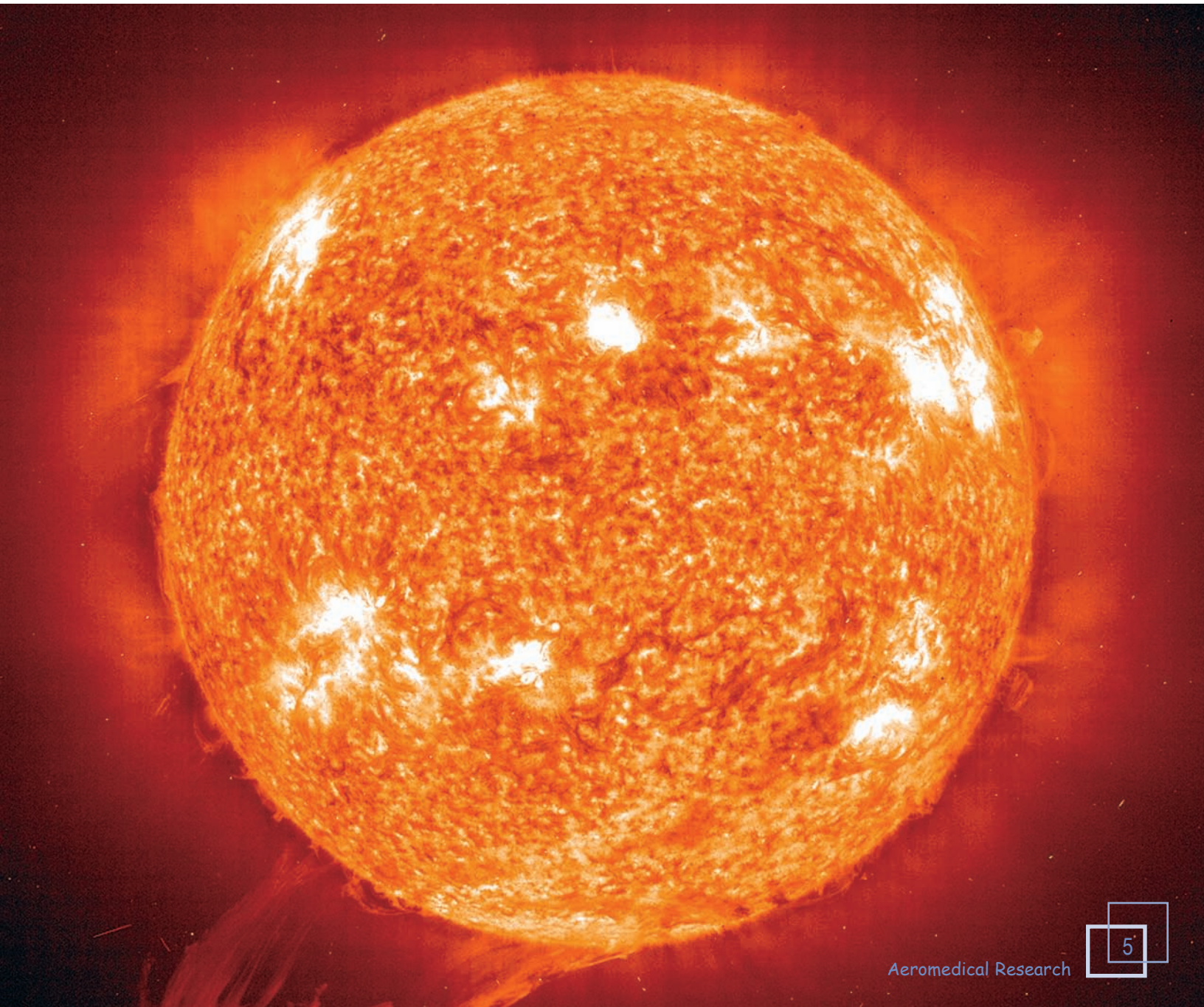
The Vision Research Team at the FAA's Civil Aerospace Medical Institute collaborated with national agencies and international organizations to help develop standards and draft vision guidance materials for aviation personnel. Research activities included assisting the Society of Automotive Engineers (SAE) in the development of Control Measures for Laser Safety in the Navigable Airspace and the development of the American National Standards Institutes' outdoor laser safety standard. Team members also assisted the International Civil Aviation Organization's (ICAO) Laser Emitters & Flight Safety Study Group with development of a manual on laser emitters and flight safety. ICAO contracting states will use this document to guide establishment of outdoor laser safety programs to improve aviation safety.

Head-Impact Criteria Component Tester (HCT)

Current rules and guidelines for the certification of aircraft passenger seats can require full scale testing of certain, relatively minor, design or materials changes. The FAA has initiated a program to improve and simplify the methods used to test and certify aircraft seats that have been manufactured with these minimal design changes. The FAA's aeromedical research program conducted a test program that compared data from a proposed head-impact criteria component tester, developed by the National Institute for Aviation Research at Wichita State University, with the results of testing done on a dynamic sled track. The head-impact component tester was designed to simulate the motion and forces that result from occupant head impact on an aircraft structure or seat back. To complete the evaluation of the test equipment, the Civil Aerospace Medical Institute's Biodynamic Research Team worked with university researchers conducting 11 sled tests and six component tests. Researchers are compiling the results of these tests, which will be used to support timely policy making decisions.

Civilian Aircrew Exposure to Radiation

In evaluating the health aspects of airline crew exposure to galactic radiation (which originates from sources beyond or solar system and from the sun), risk estimates are normally based on occupational exposure. This is important because air crews spend most of their time on the ground. Based on an analysis of 6,737 flights from three U.S. airlines, researchers assessed the risk of cancer from of ionizing radiation exposure from all natural sources received annually by pilots, both on and off the job. Ionizing radiation is any form of radiation that has enough energy to knock electrons out of atoms or molecules, creating ions. This can cause changes in the chemical balance of cells, which can cause cell damage. The results of this study indicated that pilot concerns about cancer caused by occupational exposure may be unjustified. For 65 percent of the flight profiles in this study, the estimated annual dose of ionizing radiation received by the pilots was less than the annual does to residents of an Environmental Protection Agency (EPA) Region (for example, EPA Region 8, which includes Utah, Wyoming, Colorado, Montana, and North and South Dakota). Researchers found that, although airlines pilots as a group are at an increased risk of developing cancer, perhaps other environmental factors are involved.



Human Factors

Ensure technologies and procedures are human performance-based and human-centered.

Night Vision Imaging System Lighting Compatibility Assessment

Aircraft cockpit lighting can interfere with the proper operation of night vision goggles (NVGs). Military researchers determine whether lighting system is NVG compatible by comparing NVG-aided visual acuity both with and without the cockpit lighting activated. Because this military procedure requires expensive illumination sources and radiometric measurement equipment that can cost in excess of $100,000, the FAA and U.S. Air Force have collaboratively started to develop an inexpensive alternative way to assess NVG cockpit lighting compatibility. During the first phase of this project, researchers successfully demonstrated an assessment method that uses inexpensive illuminators and illuminance meters. A second study compared results from the alternative method with data based on the military's classic visual acuity-based method. The research team instructed trained subjects in the specific methods of making lighting compatibility assessments using visual acuity and using the illuminance meter. Using both methods, each subject determined what acuity pattern they could resolve when viewing through the NVGs. The results indicate the alternative method can provide a definitive method of accepting or rejecting an NVG cockpit lighting system. A concurrent visual inspection method is still required, however, to ensure that objectionable reflections are minimized or eliminated.

Aircraft Certification Job Aid for Flight Deck Human Factors

Aircraft certification assures new aircraft designs will be safe for current and future pilots. Although studies have shown that design-induced human performance errors have contributed to many aviation incidents and accidents, only a few methods have been available to help certification personnel predict the future occurrence of such errors based on analysis of the flight deck design. The FAA's Aircraft Certification Job Aid, a computerized decision-support tool, is now helping aircraft certification personnel ensure aircraft flight deck technologies are user friendly. Funded by the FAA, Research Integrations, Inc., is developing the tool, which currently focuses on air transport category aircraft. In 2004, researchers added an advanced search function to allow keyword searches of all Part 25 regulatory and guidance information, as well as all the summaries of human factors information that address the design of flight deck displays, controls, and systems. These additions greatly enhance the speed with which certification personnel can access the extensive human factors information found in this decision support tool. Researchers also reviewed FAA regulatory information and other human factors literature for human factors systems-related information to update the databases. They developed a hierarchy of human factors considerations pertinent to the design and certification of flight deck systems and expanded the three databases to address systems-related human factors. A limited number of certification personnel continue to use the fielded version of the job aid, providing researchers important feedback for future tool enhancements.

Electronic Flight Bags (EFBs)

In 2003, the FAA issued a streamlined field approval process for EFBs in Advisory Circular (AC) 120-76A. Although the AC addresses human factors considerations, it does not specify a procedure for doing human factors evaluation. To aid FAA Aircraft Certification Specialists in conducting structured and comprehensive EFB usability evaluations in the field, aviation human-factors experts evaluated vendor supplied EFBs through co-discovery with a "think-aloud" protocol. This FY 2004 evaluation consisted of task-based exploration and a tool-based review using two different paper assessment tools. Researchers discovered that the language used in the assessment tools is especially important for evaluating EFB usability. The tools need to be understood by a wide range of users, only some of whom may have a human factors background. In addition, having an observer dedicated to the task of keeping detailed notes about the evaluation enhanced the quality of the evaluation significantly. Results from several evaluations have yielded tools and procedures that show great promise for evaluating EFBs. Some manufacturers are beginning to test these tools and are considering how to fit the tools into existing design and development processes. Using the evolving tools and methods could provide a relatively inexpensive way to find human factors problems with the EFBs early in the development process.

Simulator Fidelity Requirements

FAA-funded research is underway at the Volpe National Transportation Systems Center to optimize the affordability and effectiveness of regulatory flight simulator qualification standards for pilot training and evaluation equipment. In 2004, researchers compared and consolidated earlier studies that used different types of statistical analyses, summarized relevant findings based on a literature review for a simulator qualification review, expanded the simulator motion electronic database to almost 600 titles, and suggested directions for future research to improve the guidelines. They developed a systematic approach to aid the interpretation of past studies and influence the design of future studies. They also briefed airline training centers on their findings, generating interest from several airlines for participation in a planned study on the effect of platform motion on initial pilot training. This and future motion simulation requirements research continues the FAA's effort to improve qualification standards by providing a sound scientific basis for decisions.

The Threat and Error Management Model (TEM)

Researchers at the University of Texas, under a grant from the FAA, are investigating the relationships between operational complexity, flight crew performance, and flight crew error during normal flight operations. They have developed the TEM as the framework for two proactive data collection programs: the Line Operations Safety Audit (LOSA) and the Aviation Safety Action Program (ASAP). LOSA captures data from the observer's perspective, and ASAP documents the crew's perspective. By combining data from these complementary approaches, researchers expect to gain a more complete picture of system safety.

During 2004, FAA researchers expanded their collaboration on ASAP from working with a single airline to partnering with three airlines. They began the ASAP Data Sharing Project, a demonstration project in which airlines share ASAP data that do not identify the source of origin. All participating airlines use common software developed by the researchers specifically for the project. The research staff also created a LOSA archive containing more than 3,000 jump seat observations, 11,000 threats, and 7,000 errors to enable industry-wide analyses of safety vulnerabilities and strengths. Detailed phase-of-flight narratives documenting threat and error type, crew action, and outcome supplement the archive's quantitative data. Researchers have begun data analysis and will report their results in safety digests, at industry meetings, and on-line. An international study group is now investigating the feasibility of adapting the LOSA methodology to the air traffic control environment.

Development of a Web-Based Surveillance and Auditing Tool (WebSAT)

FAA and Clemson University researchers are now working with FedEx to develop a web-based tool that will identify potential inspection and maintenance problem areas and devise strategies to minimize them. To standardize collection, data must be tied to the measurement of recognized variables in maintenance processes and must impose reliable controls to eliminate certain inconsistencies. In 2004, Clemson University researchers identified process measures to incorporate relevant data obtained from surveillance, auditing, and airworthiness directives work functions. They launched an on-line survey to validate the identified process measures with the help of partnering airlines. The input from this survey will allow the team to continue to refine the process measures.

Human Error and General Aviation Accidents

The Human Factors Analysis and Classification System (HFACS) is a theoretically based tool for investigating and analyzing human error associated with high-risk environments such as aviation. Previous research has shown that HFACS can be used reliably to conduct human factors analysis of commercial and general aviation accidents/incidents. Analyses have identified general tendencies in the types of human errors that have contributed to civil aviation accidents. In 2004, researchers from the Civil Aerospace Medical Institute and the University of Illinois identified specific types of recurring errors and began to measure the relative importance of each error type in the genesis of accidents.

Using records maintained by the National Transportation Safety Board and the FAA, seven pilot subject matter experts used HFACS to determine the human error categories associated with human causal factors for each aviation accident that occurred between 1990 and 2000. They examined over 17,000 accidents associated with human error, yielding nearly 34,000 causal factors. They identified aircrew skill-based errors as the most frequent unsafe act, followed by decision errors, violations, and perceptual errors. A key result of this research involved the development of the human factors intervention matrix (HFIX) to complement the HFACS framework. HFIX maps the causal categories of HFACS against five approaches to human factors intervention (organizational/ administrative, human/crew, technology/engineering, task/mission, operational/physical environment).

Human Factors Workbench

The Human Factors Workbench provides FAA employees, system developers, human factors researchers, and other associated individuals easy access to human factors information that supports aviation-related activities. It provides a compendium of essential information in an easily accessible framework on the Web.

This information is categorized under four human factors components: (1) system development and process descriptions; (2) more than 100 human factors tools; (3) Human Factors Awareness Course; and, (4) more than 1,200 publications, studies, and other papers with embedded search tools. Creation of this Workbench promotes the sharing of knowledge about best practices and human-system performance challenges in the aviation community. To access the Human Factors Workbench online visit: www.hf.faa.gov/Portal/default.aspx

Tower Siting/Visibility

The FAA currently has no means to measure potential improvements in air traffic controller visibility that might be gained by changing a tower's height and location on the airport surface. Because tower height and location affects airport safety and construction costs, it is critical that the FAA develop a means to determine optimal tower location prior to construction. In FY 2004, a team of researchers from the FAA, U.S. Army Research Laboratory, and the University of Nevada-Reno conducted tests to quantify what improvements can be gained by increasing the height of the air traffic control tower at Deer Valley Airport in Phoenix, Arizona, from 110' to 130' or 150'. This and previous studies of tower siting procedures revealed that additional visibility analyses and criteria, such as those for observer line-of-sight (look-down angle) and object obscuration, could enhance the objectivity of tower construction decisions. Many factors determine tower height and location, and visibility analysis provides additional quantitative data to assist in acquisition and construction decisions. Research results will be used in future tower construction projects, enhancing safety and protecting the nation's airport investments.

Air Traffic Control Specialist Selection

The Air Traffic Selection and Training (AT-SAT) examination battery is used to screen applicants and identify those candidates with the appropriate knowledge, skills, and abilities to enter the Air Traffic Control Specialist (ATCS) career field. The current version of AT-SAT is based on a single test for each component in the battery. Having only one version of the AT-SAT could introduce vulnerabilities, such as coaching and practice effects in its use, so researchers have started to develop alternative versions. In FY 2004, they began evaluation of those tests using Department of Defense participants. Once this study is completed, two equivalent versions of AT-SAT (both running on a Windows 2000 operating platform) will be available for operational use.

Researchers also continued collecting and archiving AT-SAT data. After granting their consent, students at the FAA Air Traffic Academy were given the test, and researchers logged their experimental personality measures. Researchers will now track the occupational progress of these newly hired ATCSs and compare their progress with archived AT-SAT data.

Longitudinal Assessment of Age and Performance

Working with FAA's Air Traffic Organization, Civil Aerospace Medical Institute researchers conducted three studies in 2004 to assess the relationship of age to controller performance. In the first study, researchers reviewed the scientific literature published both before and after Congress passed legislation mandating the separation of controllers at age 56. They found that the research conducted prior to passage of the legislation provided only weak objective support for the rationale behind the age 56 retirements and that the research conducted after enactment of the rule did not provide adequate support for the inherent stress rationale articulated for age 56 retirements.

Researchers also examined the relationship of en route operational errors (OEs) to controller age. They matched records of en route operational errors with air route traffic control center staffing data to determine the likelihood that controllers' experience and age might influence their involvement in an OE. This analysis did not support the hypothesis that the likelihood of involvement in an en route OE increases with age. Rather, it appeared that if there is a relationship between age and involvement in an en route OE, it is weak and negative. In a third study, 659 air traffic control supervisors participated in an on-line survey in which they identified seven factors distinguishing "exceptional" controllers, including technical skill and reliability/adaptability as an employee. The results of this survey will be used to help define criteria for granting waivers.

Optimizing Human Performance to Reduce ATC Operational Errors

Researchers at the Civil Aerospace Medical Institute are using the JANUS technique, jointly developed by the FAA and EUROCONTROL, to understand how individual, situational, and work-related factors influence air traffic controller performance and the occurrence of OEs. The JANUS technique uses a computerized questionnaire to gain a better understanding of the situational context in which a series of critical decisions, or a chain of events results in error. Researchers conducted a preliminary test of the JANUS technique at 12 facilities to evaluate scientific validity and operational use of the technique and to make further enhancements to the research technique. As a result of this test, as well as positive feedback from the facilities, researchers developed an e-JANUS application for the Internet and began testing this electronic tool in September 2004.

Human Factors Research on Runway Incursions

Researchers developed the Runway Incursion Severity Categorization (RISC) model as a tool to assign more objective and reliable ratings to the severity of runway incursions. The model incorporates expert knowledge in the form of specific incursion scenarios and relevant factors to provide an independent estimate of the severity of an incursion. In FY 2004, researchers at the Volpe National Transportation Systems Center validated the model using data reported from 324 runway incursions. They developed a runway incursion rating system database to capture data from incursion reports and created a natural language processing method for determining incursion scenarios from report narratives. Relevant data included weather, time-of-day, type of aircraft involved, the activity of the aircraft (i.e., takeoff, landing, or taxiing), phase of operations (e.g., final approach), location on the airport (e.g., runway-taxiway intersection), and resulting actions (e.g., crossed the hold short line but did not enter the runway). The model categorized the severity of runway incursions similarly to the way the human evaluators in the FAA Office of Runway Safety rated them at the time of the incursion.

Communication and Coordination between Technical Operations and Air Traffic Control (ATC)

Researchers are working to assess and improve communication and coordination between Technical Operations and ATC. Technical Operations specialists provide operations and maintenance support services for the National Airspace System. These specialists must communicate and coordinate with a variety of people both within and external to their organizations. When this communication fails, there is the potential for service interruptions, equipment outages, and delays of aircraft. In FY 2004, researchers collected and analyzed data on communication and coordination within Technical Operations' Operations Control Centers and made recommendations for improvements.

Future En Route Workstation

Better systems engineering is needed to meet the demands of projected increases in air traffic and to ensure that the workstations of future en route air traffic controllers are designed for all of their operational needs. For several years, human factors researchers have examined what can happen when automation tools that were developed independently are used together at the en route sector workstation. Predictable human factors issues, such as display clutter, problems with access to critical information, distracting lists, and multiple windows management, all have surfaced.

Currently, researchers are studying what the en route workstation should be in the 2015 timeframe. To ensure that the workstation will support controllers beyond the 2015 timeframe, they are estimating a 33 percent increase in traffic levels by 2015, and then an additional 66 percent increase. The project also assumes that by 2015, the aviation community will be in the middle of a transition to advanced capabilities in the cockpit and on the ground. In FY 2004, researchers completed a test plan for a human-in-the-loop experiment planned for early FY 2005 to validate new workstation concepts. In preparation for this experiment, researchers are determining the number of steps and the amount of time an air traffic control specialist needs to either retrieve or input data - and implemented those concepts into the air traffic simulator.

Weather Information Needs in the Terminal Radar Approach Control (TRACON) Facility

In FY 2004, human factors researchers began to assess controller weather information needs and weather display designs for TRACON controllers. Researchers completed a literature review on controller and pilot weather information needs and the current use of tactical weather displays. Previous research has suggested that tactical displays should be designed to minimize the amount of data on the screen. In a second project phase, researchers performed a cognitive work analysis to assess controller/pilot weather information needs and the flow of weather information within the terminal domain. Based on the data collected, researchers developed a simulation capability that allows empirical evaluations of advanced weather information and display formats. They also created dependent system measures of how having advanced weather information affects efficiency and tactical operations and how the location of weather information on the display affects controller workload. Human-in-the-loop simulations using weather scenarios are currently underway.

Safe Flight 21/Alaska Capstone

Implement new technologies that will provide increased safety in an ever-changing aviation world.

Safe Flight 21/Alaska Capstone

Safe Flight 21 is a joint government/industry effort to improve the safety, efficiency, and capacity of the National Airspace System using automatic dependent surveillance-broadcast (ADS-B) technology. ADS-B allows pilots in the cockpit and air traffic controllers on the ground to see aircraft traffic much more precisely than has been possible ever before. ADS-B equipped aircraft broadcast their precise position in space via a digital datalink along with other data, including airspeed, altitude, and whether the aircraft is turning, climbing, or descending. ADS-B receivers that are integrated in the air traffic control system or installed aboard other aircraft provide users an accurate depiction of real-time aviation traffic both in the air and on the ground. FAA's program goals include:

- Providing common, real-time traffic information to both air traffic controllers and flight crews; and
- Working to improve the safety, efficiency, and capacity of the National Airspace System.

Ohio River Valley

Under the Safe Flight 21 program, the FAA is conducting an ambitious demonstration and test program in partnership with the Cargo Airlines Association (CAA), the Aircraft Owners and Pilots Association (AOPA), with the aviation departments of several states and regional airport authorities, NASA, the Helicopter Association International, Continental Airlines, and Rockwell Collins.

Nine operational technologies selected by the RTCA are being demonstrated and validated in real-world environments to understand the capabilities of advanced surveillance systems and air traffic procedures. The enabling technologies under evaluation include: ADS-B; traffic information services broadcast (TIS-B), which uses ground based radar to determine an aircraft's position and broadcasts this information to other suitably equipped aircraft; flight information services broadcast (FIS-B), which supplies real-time weather information and other flight advisory information to pilots for enhanced situational awareness, 24 hours a day, seven days a week; and surface moving maps.

Automatic Dependent Surveillance-Broadcast

In 2004 the Safe Flight 21 program added a test bed on the east coast and continued to operate ADS-B surface and terminal area domain test beds in Memphis, TN, Louisville, KY, and in the Gulf of Mexico. Thirteen Continental Airlines 737-800 aircraft began operating with active extended squitter transponders in support of ongoing flight tests in the Gulf of Mexico. In partnership with NASA, researchers successfully conducted nine high and low altitude flight tests in the Gulf of Mexico to evaluate ADS-B and multilateration technologies.

United Parcel Service (UPS) completed equipping 107 aircraft with ADS-B avionics. Garmin Aviation received approval to produce its Universal Access Transceiver and to install the system on general aviation fixed and rotary-wing aircraft. Rockwell Collins obtained approval for its transponder and its installation on Boeing 737-800 aircraft.

The FAA completed agreements with Embry-Riddle Aeronautical University to establish an ADS-B network on its Prescott, AZ, and Daytona Beach, FL, campuses as well as with the North Carolina State Department of Transportation (DOT), Division of Aviation. The Agency also signed new agreements with Maryland DOT and Virginia DOT. Initial deployment of an East Coast Broadcast Services network has begun to support those agreements.

The Traffic Information Service-Broadcast

During 2004, the FAA continued development of Traffic Information Service-Broadcast Minimum Aviation System Performance Standards. Safe Flight 21 researchers received approval to use best sensor timing on a Common Automated Radar Terminal System at Louisville to evaluate ADS-B and radar performance. This evaluation and data collection effort will continue into 2005. FAA researchers also developed a ground station at the William J. Hughes Technical Center that will centralize processing of all the surveillance source information for TIS-B and FIS-B. Plans are underway to expand the system to approximately 40 ground stations in 2005.

Digital Airport Map Database

During FY 2004, researchers finalized specifications for a digital airport map database in preparation for a formal process certification. Once this certification is completed, the data previously produced for the 82 airports having the greatest risk of runway incursions will be reprocessed against the approved process and specifications. These improvements will enable the airport map data to be used in certified avionics applications, such as surface moving maps to enhance pilot and vehicle operator situational awareness.

Surface Management System (SMS)

FAA researchers installed the NASA-developed Surface Management System (SMS) at Louisville, KY for use by the Louisville Regional Airline Association and its aircraft. The SMS display is currently used to monitor the airport surface situation and to better react to emergencies. When fully developed, SMS will provide UPS ramp controllers with a tactical display of aircraft, both on the surface and in the vicinity of the airport, and serve UPS as a vital tool in efficient ramp management.

Alaska Capstone

Small aircraft accidents in Alaska occur at nearly five times the national average. To improve aviation safety, capacity, and efficiency in Alaska, the Safe Flight 21 program's Alaska Capstone initiative is introducing new surveillance technologies that will enhance the abilities of pilots in the state to cope with weather, terrain hazards, and potential traffic conflicts. Participating commercial aircraft are being equipped, on a voluntary basis, with a government-furnished combined data link and Global Positioning System (GPS)-based avionics package designed to increase the situational awareness of pilots in averting mid-air collisions and controlled flight into terrain. A simple, high capacity, multifunction broadcast data link known as the Universal Access Transceiver (UAT) supports all air-air, air-ground, and ground-air data link communications in Capstone. Capstone activities are having a positive impact on safety, creating an infrastructure to develop procedures to familiarize flight crews, controllers, and avionics/ground system installers with modern equipment and future National Airspace System concepts and to address certification issues.

In FY 2004, the Capstone Program issued The Safety Impact of Capstone Phase 1-Summary Report through 2003 (University of Alaska Anchorage and The MITRE Corporation, May 2004) highlighting these significant safety and efficiency results:

- Capstone-equipped aircraft have had a consistently lower accident rate than aircraft operating before Capstone and non-equipped aircraft during Capstone. From 2000 through the end of 2003, the rate of accidents for Capstone-equipped aircraft dropped by 40 percent.
- The rate of accidents for major carriers and air taxi operations has been falling since 2001 and is now at the lowest rate since 1990.
- In villages where Capstone technology has allowed instrument approaches, the fraction of time that weather makes air travel unavailable has been reduced by 50 percent.

ADS-B Infrastructure Planning

In FY 2004, the Capstone program continued preparing for the initial ADS-B infrastructure (avionics/ground) in Southeast Alaska. Planning efforts focus on:

- Expanding those technologies that have been proven on a statewide basis to continue upgrading the Alaska aviation infrastructure;
- Pursuing the development of affordable equipment so that aircraft owners will have a range of choices appropriate to their operational needs - whether they operate under visual or instrument flight rules; and
- Prototyping and demonstrating a satellite-ground infrastructure for communication, navigation, and surveillance.

Juneau Wide Area Multilateration System

The FAA began an effort to install a wide area multilateration system for the Juneau, Alaska, airport in FY 2004. This prototype system will demonstrate multilateration technology in a harsh weather region and terrain that rises from sea level to 3,300 feet elevation in an approximately 15-mile radius of the city. Multilateration measures and displays three-dimensional position, velocity, and identification of equipped aircraft. This technology will enable situational awareness in an area that has no radar coverage today.

Aircraft & Airport Safety

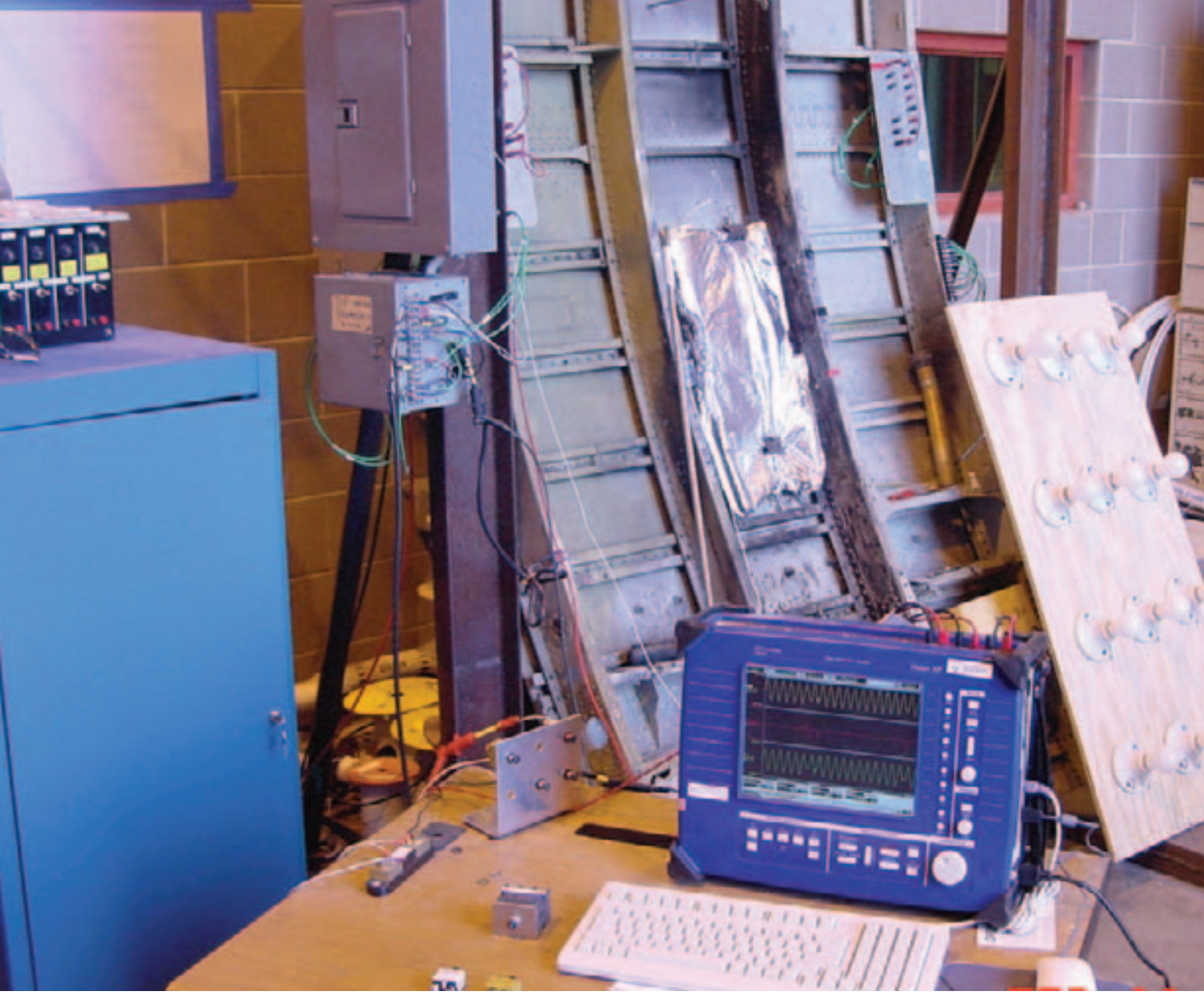
Identify and prevent accidents due to known, unknown, emerging, or previously unrecognized factors.

Center of Excellence for Advanced Materials

In December 2003, the FAA established the new Center of Excellence for Advance Materials. Led by the University of Washington and Wichita State University, the center will conduct research, engineering, and prototype development toward the safe and reliable use of advanced materials and composites in large commercial aircraft. The new center's work will focus primarily on the safety and certification of existing and emerging applications of composites and advanced materials in commercial transport aircraft. Other academic institutions participating in the new center are Washington State University, Northwestern University, Oregon State University, Purdue University, Tuskegee University, University of California at Los Angeles, University of Delaware, and Edmonds Community College, Washington.

Statistical Loads Data for the Boeing B-747

In FY 2004, the University of Dayton Research Institute, funded by the FAA, completed the collection and analysis of flight loads data from 11,066 flights of Boeing 747-400 airplanes operated in overseas, commercial service. The data, consisting of 95,883 flight hours, included typical in-service flight and ground loads data, such as accelerations, air and ground speeds, altitudes, flight duration and distance, gross weights, speed brake and spoiler cycles, thrust reverser usage, and gust velocities. The 747-400 is the first heavy widebody model added to the FAA's operational loads monitoring research program. The International Aviation Rulemaking Advisory Committee (ARAC) has used these results extensively in their efforts to harmonize the rulemaking process for Airbus's new 380 airplanes. Of particular use are the generation of typical flight profiles and the characterization of all of the special ground handling operations. This research will be used to provide the technical data to substantiate selected loads-related Federal Aviation Regulations. Boeing is also using these data to design its new fuel inerting system for the 747. For this effort, researchers processed the flight loads data to establish a vertical velocity descent profile at each operational altitude level. These statistics established the pressure regulation design requirements for the nitrogen generating system to provide acceptable fuel tank inerting.



Arc Fault Evaluation Laboratory

For the past several years, the FAA, the Naval Air Systems Command, and the Office of Naval Research have been conducting joint research to develop arc fault circuit breakers suitable for the protection of aircraft electrical wiring. Since the completion of the FAA's arc fault single-phase program, most aerospace circuit breaker manufacturers have developed arc fault detection devices. In FY 2004, to provide a means to evaluate the performance of these devices, the FAA established the Arc Fault Evaluation Laboratory. Using this lab, researchers can simulate known aircraft faults in a realistic configuration to evaluate protection devices. The lab provides researchers the flexibility to develop new arcing scenarios derived from actual incident reports.

Metallic Materials Properties Development and Standardization (MMPDS)

The Metallic Materials Properties Development and Standardization is an effort led by the FAA to continue updating and validating the Metallic Materials and Elements for Aerospace Vehicle Structures handbook (formerly MIL-HDBK-5). The handbook is recognized worldwide as the most reliable source of data on aircraft materials, such as the metallic materials, fasteners, and joints used in the design and maintenance of aircraft, missiles, and space vehicles. The objective of the MMPD is to maintain and improve the standardized process for establishing statistically based data that comply with regulations. To ensure the handbook is current, researchers continue to collect, analyze, and present statistically based aircraft and aerospace material and fastener properties to the global community. The next release of the handbook is scheduled for February 2005. The FAA plans to proceed with commercial licensing of the handbook at the Seventh MMPDS Coordination Meeting in April 2005.

Assessment of Inspection Techniques for Detecting Flaws in Composite Structures

The extreme damage tolerance and high strength-to-weight ratio of composites motivates designers to expand the role of glass and graphite fiber reinforced composites in aircraft structures, most notably in principal structural elements. The use of these composites necessitates the development of nondestructive inspection methods designed for these new composite structures. FAA researchers at the Airworthiness Assurance Nondestructive Inspection Validation Center located at Sandia National Laboratory, are developing better ways to inspect composite structures.

In FY 2004, researchers completed an experiment assessing the performance of both conventional and advanced nondestructive inspection techniques to detect various flaws within typical aircraft honeycomb panels. Researchers inspected a series of composite honeycomb specimens with statistically relevant flaw profiles using both tap test equipment and more sophisticated techniques introduced to automate and improve composite nondestructive inspection. (Tap testing uses an audible change in acoustic response to locate flaws, to detect voids, disbonds, and delaminations in adhesively bonded composite aircraft parts). The researchers then took these specimens to a number of airline maintenance shops and third party repair facilities for inspection by actual inspectors. From the collected data, the researchers established a baseline of current inspection techniques, determined a wide array of nondestructive inspection methods, and identified limitations and optimum applications for specific inspection methods.

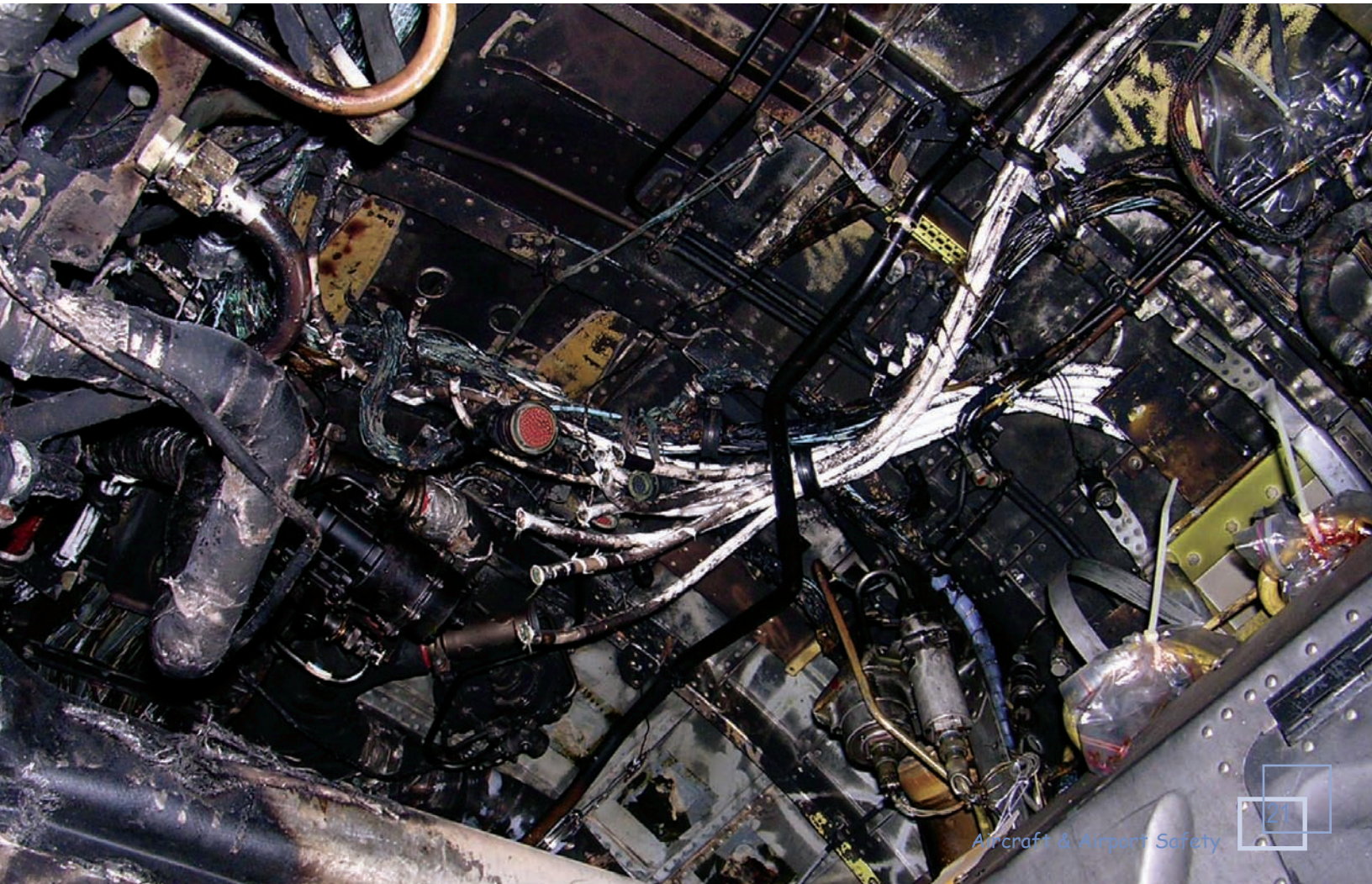
Visual Inspection of Dual Load Path Flight Control Components

FAA researchers are assessing the condition of aging flight control linkages to determine if failure in the component could result in an accident. Of particular interest are a type of safety-critical integrated or co-located hardware components - designed to last the life of the aircraft, but difficult to inspect visually - known as single component dual load path elements. In FY 2004, researchers at FAA's Airworthiness Assurance Nondestructive Inspection Validation Center cooperated with the manufacturer to assess single element, dual load path linkages from primary flight control systems on Boeing 737 and 747 commercial aircraft that had been retired in the previous six months. The team identified 21 dual load path components, and acquired three of each component from the aircraft. Aided by a fiberscope when appropriate, they visually inspected each component in three stages: as installed on the aircraft, after removal and cleaning, and when completely disassembled. The researchers looked for any visual signs of erosion, corrosion, excessive wear, cracks, impact damage, or other signs of mechanical degradation, and inspected some components against the manufacturer's specifications. As a result of this work, they recommended that visual inspections be supplemented with an eddy current inspection and a reference standard to investigate and validate results from areas that are visually inaccessible. Researchers plan to acquire additional aged dual load path inspection specimens to verify these results.

Assessment of Aircraft Wiring Inspection Tools

The continued safe operation of aircraft well beyond their expected service life depends on the safe and effective transfer of power and electrical signals between aircraft electrical components. In FY 2004, FAA researchers validated a new tool suite, ArcSafe, for the inspection and testing of aircraft electrical wiring interconnect systems. General Dynamics developed ArcSafe, consisting of the Micro-Energy Tool and the Insulation Fault Probe, to aid an operator in identifying and locating breaches in wiring insulation.

Researchers at the FAA Airworthiness Assurance Nondestructive Inspection Validation Center conducted laboratory and on-aircraft tests to validate the technology. They found the ArcSafe tools able to find and locate some faults. The geometry of the wire-harness (i.e., how loosely wires are packed in the harness) and the number of breakouts (terminations) on a given harness, however, influenced the reporting accuracy of the Micro-Energy Tool. Procedurally, this can be managed in the manner that tests are conducted.



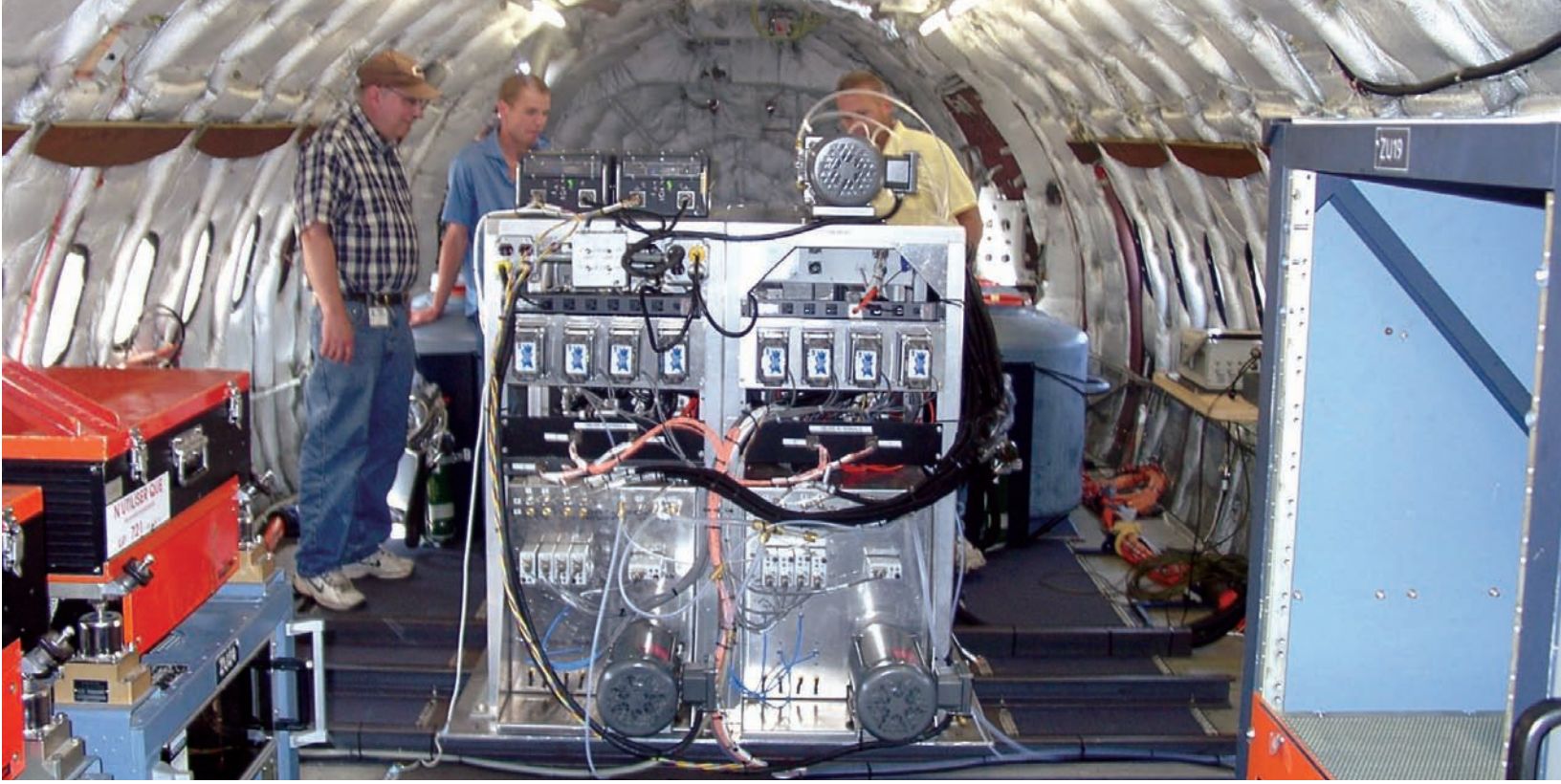
Dry-Coupled Probes For Ultrasonic Inspections

The connection that transfers the sound energy between the ultrasonic inspection probe and the inspected structure is an important part of any ultrasonic inspection procedure. Oil- or water-based gels are commonly used as the coupling for manual inspections, while water immersion or bubbler systems maintain a constant level of coupling for automated units. Liquid couplants, however, can be a detriment to numerous inspection procedures. The majority of the common problems are related to the time-consuming application and removal of the couplant. In addition, some advanced aircraft structures prohibit the application of couplants. To overcome the problems associated with liquid coupling, FAA-sponsored researchers at Northwestern University are developing dry-coupled probes for ultrasonic inspections. Dry-coupled probes have advantages for inspections of aircraft components with limited access and various spatial orientations. The researchers demonstrated very stable coupling, minimal fluctuations, and high repeatability of the ultrasonic signals regardless of spatial orientations of the aircraft components using dry-coupled rolling probes for manual scanning. They also developed a dry-coupled rolling probe procedure to inspect the DC-10 horizontal stabilizer. Even though the dry-coupled rolling probes are fairly new ultrasonic inspection tools, recent field tests have demonstrated the probes are highly effective for a number of applications on advanced aircraft materials and structures.

Effectiveness of Hand-Held Extinguishers Against Hidden Fires

FAA researchers are addressing the problem of hidden-area fires in aircraft by developing newer, more stringent fire tests for materials, such as ducting, wires, panel close-outs, clamps, and other hardware. Since the area above the cabin ceiling represents the largest inaccessible area in a transport aircraft, researchers are developing and testing fire suppression techniques and technologies to extinguish fires in these areas. Since one of the main challenges associated with fire suppression in the cabin overhead is accessibility, researchers hope to devise a method of allowing quick overhead area access. One approach is the use of panel-mounted ports that would allow insertion of the extinguisher nozzle.

In FY 2004, researchers performed 20 handheld extinguisher tests in the overhead space of both narrow and wide body aircraft, simulating a typical hidden fire in the inaccessible area above the cabin ceiling. The tests helped determine the performance of FAA-required handheld Halon 1211 extinguishers against a fire. Tests indicated that handheld extinguishers are incapable of providing adequate protection against fires in large overhead area volumes typical of wide body aircraft, regardless of the port design. However, the use of ceiling-mounted discharge ports in combination with handheld extinguishers is quite effective against fires in the more-confined overhead area typical of a narrow body aircraft.



Inerting System Flight Test

Last year, the FAA, with the assistance of several industry partners, developed and successfully tested an onboard inert gas generation system with air separation modules that use aircraft bleed air to generate nitrogen-enriched air at varying flow and purity (oxygen concentration). In FY 2004, during a commercial transport airplane flight cycle, researchers performed a series of ground and flight tests designed to prove the effectiveness of a simplified inerting concept. They mounted the FAA-developed system in the cargo bay of an Airbus 320, operated by Airbus for the purposes of research and development, and used it to inert the aircraft center-wing fuel tank during testing. They instrumented the system and fuel tank to analyze the system performance and the inerting capability. The FAA's onboard oxygen analysis system continuously measured the oxygen concentration in the fuel tank during the test flights. The results of the tests proved the validity of the simplified inerting system concept.

Smoke Detectors Certification

Federal Aviation Regulations require manufacturers to flight test cargo compartment fire detection systems to ensure proper system performance. Because of safety issues during the flight test, theatrical smoke generators are frequently used to simulate fire during the test. In FY 2004, the FAA published Comparison of Actual and Simulated Smoke for the Certification of Smoke Detectors in Aircraft Cargo Compartments (DOT/FAA/AR-03/34), which documents work conducted by Sandia National Laboratory, under contract with the FAA, to characterize the differences between smoke particles from flaming fires and the particles produced by theatrical smoke generators. In this study, researchers found the particle size from artificial and smoldering smoke sources to be much larger than the particles from flaming fires. This proved significant because the detection technology used in the vast majority of aircraft smoke detectors depends on the scattering of a light beam to produce an alarm. This implies that current detectors would be much more sensitive to artificial smoke than to smoke from actual flaming fires.

Fire safety researchers conducted a series of tests in several different aircraft cargo compartments to investigate the validity of this finding. They instrumented the compartments with laser based smoke meters, installed several models of current smoke detectors, and exposed the detectors to smoke from flaming fires, smoldering fires, and theatrical smoke generators. In all cases, the detector response time was longer with flaming fires than with either smoldering or artificial smoke sources and the smoke meter readings indicated a significantly greater quantity of smoke at the time of detector alarm for the flaming fires compared to the smoldering or artificial smoke sources.

Evaluation of Halon Replacement Agents in Protecting Against an Aerosol Can Explosion

Fire safety researchers evaluated two halon replacement fire suppression agents to determine their effectiveness in protecting against an aerosol can explosion. Researchers tested bromotrifluoropropene and pentafluoroethane, agents selected by the International Aircraft Systems Fire Protection Working Group as possible candidates to replace Halon 1301 as the suppression agent used in an aircraft cargo compartment. Researchers conducted simulated aerosol can explosion tests to determine if the candidate agents had any unusual behavior before proceeding with the other required minimum performance standard tests. They found that at concentrations below the inerting level, both agents created higher overpressures than measured in air alone, enhancing the possibility of an explosion. In contrast, Halon 1301, mitigated the explosion. Unless a means can be found to avoid the problem of subinerting concentrations of extinguishing agent, neither tested agent would be a suitable candidate for halon replacement extinguishing agents in the cargo compartment. Researchers documented these findings in Behavior of Bromotrifluoropropene and Pentafuoroethane When Subjected to a Simulated Aerosol Can Explosion (DOT/FAA/AR-TN04/4).

Retro-Reflective Markers Study

Retro-reflective markers are used to mark the edges of highways and traffic lanes. Since this type of reflector is inexpensive, relatively efficient, and easy to install, it is also used on airports to increase night identification of runway edge, centerline, and taxiway edges. Airport approved retro-reflective markers use either retro-reflective sheeting or tape, which are mounted on plastic-molded material that is either cylindrical or a flat surface. The minimum standard size for a cylinder-mounted marker is 96 square inches. In FY 2004, researchers conducted an experiment to determine if increasing the standard size to 200 square inches would make the markers more visible to aircraft and ground vehicles, and if the location of aircraft-mounted lights relative to the pilot's eyes effected the visibility of the markers. Based on the results of this evaluation, the researchers determined that increasing the size of the maker to 200 square inches would provide only slight improvement over the standard marker size for most aircraft types, and even less of an improvement for aircraft having their lights mounted farthest from the pilot. Study results can be found in L-853 Cylindrical Runway and Taxiway Retro-Reflective Markers Study (DOT/FAA/AR-04/10).

Aerodynamic Effects of Ice Formed in Super-Cooled Large Drop Conditions

At the request of representatives of airworthiness authorities, manufacturers, pilot groups, and research organizations in North America and Europe serving on the Ice Protection Harmonization Working Group, the FAA is considering the expansion of certification requirements to encompass super-cooled large drop (SLD) conditions (freezing drizzle and rain). FAA researchers began a collaborative effort with the University of Illinois and the NASA Glenn Research Center to understand better the meteorological characterization of the ice accretions that form in super-cooled large drop conditions and the aerodynamic effect of these conditions on aircraft. In FY 2004, researchers carried out ice accretion testing in the NASA Glenn Icing Research Tunnel to generate super-cooled large drop ice accretions representative of in-flight accretions. They documented the ice accretions with photographs, tracings, and ice-thickness measurements, and made moldings of these accretions to generate castings. An analysis of the data showed that the accretions could be classified as having combinations of two or more key shapes. Examination of the limited flight test data in SLD conditions showed similar features. Researchers also conducted aerodynamic performance testing at the University of Illinois.

Evaluation of Light Emitting Diode (LED) Linear Source Devices

To determine if LEDs are practical for airport use, researchers have evaluated a flexible strip of encapsulated LEDs and a rigid encapsulated LED fixture. In recent tests, they configured the light emitting diode in a linear array to enhance painted markings on the airport surface. They then developed photometric testing standards for LED linear sources to provide data needed to formulate specifications and advisory circulars. Researchers found that both light sources have the potential to further enhance visual aids. However, when installed in airport pavement, they do not remain operational for long. Industry must develop these technologies further before they can be considered for airport use. The results of these tests can be found online at http://www.airporttech.tc.faa.gov.

Runway Status Lights

The Runway Status Light (RWSL) system is an array of red lights deployed at taxiway entrances that are automatically driven by airport surveillance sensors to warn pilots and vehicle operators that a runway is unsafe to enter. During FY 2004, the FAA made great progress in assembling an operational evaluation ready RWSL system at Dallas/Ft. Worth (DFW) International Airport. Working closely with Lincoln Laboratory and Sensis Corporation, the FAA developed key system improvements to address technical issues identified during initial field testing; completed construction and installation of Siemens' airfield lighting equipment for the RWSL system; and conducted a successful field re-test of at DFW.

Weather Research

Achieve increased safety and efficiency by deploying new technologies that mitigate the adverse effects of weather.

Weather Support to Decision Making (WSDM)

A very thin layer of ice on a wing surface can increase drag and reduce airplane lift by 25 percent. Funded by the FAA, WSDM provides deicing decision makers and airport plowing crews with up-to-the-minute information on potentially hazardous freezing precipitation. WSDM uses data from Doppler radars, surface weather stations, and snow gauges located near the airport to measure accurately the amount of water in the snowfall. A "Hotplate" snow gauge and wireless communications capability makes the WSDM system low in cost and high in reliability. In FY 2004, researchers increased the two-hour WSDM precipitation forecast to four hours enhancing safety and efficiency by providing users longer lead times for more effective strategic decisions. WSDM is currently operational at Denver International Airport and will be operational at New York airports later this year. An independent assessment estimated the annual benefit of an operational WSDM system at the New York airports to be $12.7 million and $1.36 million at Denver.

Aviation Digital Data Service (ADDS)

Accurate, timely, and user-friendly forecasts of icing, turbulence, thunderstorms, and clouds are required to support safe and efficient flight operations. The availability of weather data on the Internet has made the acquisition of current weather information from sophisticated numerical models readily available to users. Developed by the FAA's Aviation Weather Research Program, ADDS is operated and maintained by the National Weather Service's Aviation Weather Center in Kansas City, Missouri. The system enables a wide variety of users, such as airline dispatchers, meteorologists, flight planning systems, weather vendors, and private and commercial pilots, to access critically needed weather information, in a variety of formats.

Researchers developed several user enhancements to ADDS in FY 2004. These enhancements include faster access to critical weather information, the capability to customize weather information (saving preferences), and the ability to print the entire screen display. By providing current and forecast information on key weather hazards to support the needs of users, the Aviation Digital Data Service enhances aviation safety and helps to reduce delays. Access to the service via the Internet has ensured that enhancements are available to users quickly and in a cost-effective manner. ADDS data can be obtained from http://adds.aviationweather.gov.

San Francisco Marine Stratus Forecast System

Pilots flying the approach zone at San Francisco International Airport (SFO) are not able to use the closely spaced parallel runways in the presence of marine stratus (a thin layer of low level clouds that from over coastal areas). This decreases the allowable arrival rate by up to 50 percent resulting in delays, airborne holds and diversions, and loss of capacity. The FAA's Aviation Weather Research Program developed a 1-6 hour forecast system to predict the time when the marine stratus will dissipate in the SFO approach zone. This system enables air traffic decision makers to release ground holds prior to actual clearing and allows the arrival rate to match the acceptance rate in an efficient and effective manner. During the early summer of FY 2004, the FAA transferred this technology to the National Weather Service to implement operationally at SFO.

Oceanic Weather Improvements

At present, aircrews for long-range oceanic flights receive a general weather briefing before departure, including a summary of flight level winds and expected en route weather conditions. Over the ocean, little or no information is available about rapidly changing weather systems that may be encountered. In FY 2004, two products entered into the test phase of research, oceanic turbulence forecast and convective (thunderstorm) diagnosis. The turbulence forecast product provides up to a 12-hour forecast of clear air turbulence conditions over the ocean, while the convective product provides current locations of convective activity.

Volcanic Ash Forecast

When volcanic ash is ingested into aircraft engines it can result in engine failure. For example, in 1989, a Boeing 747 en route to Anchorage, Alaska, with 231 passengers on board encountered volcanic ash, resulting in failure of all four engines. Although the aircraft landed safely, it required $80 million in repairs. Aircraft flying North Pacific air routes, which carry over 10,000 passengers per day, and up to 50,000 aircraft per year, could be similarly affected if a volcanic eruption occurred in the region. In FY 2004, the FAA's weather research program responded to this problem, testing a volcanic ash forecast product that provides detection information, along with a forecast of the ash plume dispersion so that dispatchers can help aircraft avoid hazardous volcanic ash clouds.

Phased Array Radar (PAR)

The FAA, DoD, Office of Naval Research, the National Oceanic and Atmospheric Administration's National Severe Storms Laboratory, Oklahoma State Regents for Higher Education, the University of Oklahoma School of Meteorology and Engineering, and Lockheed Martin have partnered to determine if phased array radar technology can provide improved, less costly information on the growth of thunderstorms. This technology also has the potential to provide aircraft surveillance and tracking capabilities. In FY 2004, researchers tested this technology at the National Weather Radar Testbed located in Norman, Oklahoma, and are now analyzing the collected data. In addition, they modified the testbed to enable 360-degree continuous rotation of the antenna. This will allow meteorologists and engineers to conduct studies to compare the performance of the phased array radar system to the weather radar currently used in the United States with this modification, meteorologists can rapidly position the radar in the quadrant of severe storms for data collection. Researchers also continued development of the track processor, that to track aircraft simultaneously while gathering meteorological data, and they expect to conduct operational tests in FY 2005.

Environment & Energy

Ensure aviation remains a good neighbor.

Aviation Environmental Design Tool (AEDT)

In 2004, the FAA, in collaboration with NASA, initiated a long-term, strategic effort to develop analytical tools to address the relationship between noise and emissions and between different types of emissions. Current analytical tools focus on noise or emissions; however, noise and emissions are interdependent phenomena. In FY 2004, at the request of the FAA, the Transportation Research Board (TRB) of the National Research Council completed a study to assess the proposed Aviation Environmental Design Tool (AEDT) that will allow integrated assessment of noise and emissions impact at the local and global levels. The TRB assembled a committee to analyze the AEDT requirements and conducted a workshop in March/April 2004. At this workshop, nearly 80 stakeholders (including manufacturers, airlines, airports, academia, and the international community) actively engaged in refining the AEDT process. The FAA and NASA received substantial input to guide development of AEDT. The FAA and NASA used the comments to refine the conceptual foundation of AEDT and to formulate a comprehensive work plan and are now fully engaged in development of this new product. The agencies also plan to develop the Aviation Environmental Portfolio Management Tool (APMT), which will allow cost-benefit analyses. The TRB will also help define APMT.

FAA's Integrated Noise Model (INM)

The FAA's Integrated Noise Model is used worldwide to evaluate aircraft noise impacts in the vicinity of airports. This modeling system is designed to help airports meet federal legal requirements on noise exposure and to facilitate long-term aviation planning. It is also the lead technology for the more complex models used by ICAO's Committee on Aviation Environmental Protection to assess international noise stringency and in systems for analyzing broad area air traffic redesigns. Research and development for INM continues to challenge FAA as research leads to new algorithms that must be merged into the fielded system. INM distribution grew over 20 percent in use both domestically and internationally. INM is distributed to 850 users in over 40 countries to aviation stakeholders in government, industry, universities, and commercial engineering firms. Companies regularly offer training in the use of the model and some universities, both domestic and international, provide INM instruction as part of their curriculum.

In FY 2004, FAA researchers continued development of both a fielded system of the Integrated Noise Model (INM 6.2) and a research system (INM 7.0). INM 6.2 supports improved modeling of terrain and expands the noise/performance modeling capability to include much more fidelity on aircraft procedures. INM 7.0 incorporates the algorithms proposed for the European Civil Aviation Conference, Society of Automotive Engineers, and ICAO. Groups studying Continuous Decent Approaches are also using INM 7.0. This INM 7.0 tool serves as a harmonized platform for making use of detailed approach noise/performance data from Boeing and Airbus. In the U.S. and Europe, researchers will use these data to assess benefits, including airport-wide level studies for up to four European airports.

In addition, FY 2004 marked the beginning of a new generation of noise modeling recommended practices beginning with the final draft of European Civil Aviation Conference Document 29 for Europe. The FAA played a major role in developing this document and initiated R&D to ensure that FAA methods support current best practice. FAA, NASA, and Eurocontrol continue to conduct joint R&D programs with aviation manufacturers to validate INM algorithms Expanded efforts with Boeing and Airbus and a new R&D effort with Bombardier, will broaden validation within the growing regional jet industry. Projects are also in development to conduct programs with Embraer and Dassault during FY 2005.

Continuous Decent Approach (CDA)

FAA's Center of Excellence, Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER), is leading the U.S. effort to develop Continuous Descent Approach procedures. CDA is a type of noise abatement procedure where aircraft descend continuously (with no level flight segments) at idle, or near-idle, thrust from cruise altitude to the runway. The primary testbed for this development effort is Louisville international Airport, the home of industry partners UPS and the Regional Airport Authority of Louisville and Jefferson County. In FY 2004, researchers conducted a flight test to demonstrate two sets of area navigation (RNAV) procedures that may eventually lead to CDA approval. In preparation for the flight test, researchers developed models for airport weather conditions and conducted both flight simulator studies and limited test flights to develop the cockpit procedures for both the Boeing 757 and 767 aircraft. The researchers used analytic studies to predict the performance of the aircraft in the expected range of weather conditions. Boeing, NASA, and UPS conducted the real-time flight simulator studies. Massachusetts Institute of Technology researchers used a newly developed fast-time Monte-Carlo simulation program to determine the variation in performance that is likely to occur and the corresponding capacity impacts when using the procedures. Next, PARTNER researchers will work with the FAA to determine the feasibility and cost/benefit of widespread implementation of CDA procedures in the National Airspace System.

PARTNER Expands

In the spring of 2004, Transport Canada joined the FAA and NASA as a sponsor of PARTNER. Canada is working to reduce smog-forming pollutants from the aviation sector and sees the partnership in the COE as a means of advancing the state of knowledge in many key areas.

ICAO Committee on Aviation Environmental Protection (CAEP)

ICAO is the only internationally recognized body charged with setting environmental standards for civil aviation. The FAA plays a critical role in developing these standards through active participation in ICAO's Committee on Aviation Environmental Protection (CAEP). For example, at the CAEP sixth plenary meeting held in February 2004, FAA analyses efforts assessing the technological, scientific, and economic aspects associated with maintaining international standards and recommended practices for aircraft noise and engine exhaust emissions played key roles in the CAEP's work.

CAEP has agreed to a significant new NOx standard, and has an aggressive program to explore long-term goals, develop better modeling, gather better technical and scientific data, and explore ways to address interdependencies of various environmental factors. (NOx is the generic term for a group of highly reactive gases, all of which contain nitrogen and oxygen.) ICAO has adopted guidance that helps give the international community a more uniform approach to managing aircraft noise at the world's airports. CAEP also adopted the FAA-developed System for Assessing Aviation's Global Emissions (SAGE) for use as a global emissions model. SAGE is FAA's analytical tool to estimate and assess aircraft emissions on a technological, operational, and geographic basis, considering emissions levels through all phases of flight. Emissions from international aviation are of continuing interest to the United Nations Framework Convention on Climate Change (UNFCCC). At the request of ICAO, FAA informed UNFCCC of SAGE's capability. The FAA also worked with ICAO to update the Intergovernmental Panel on Climate Change (IPCC) 2006 Guidelines for National Greenhouse Gas Inventories. Finally, the FAA served as a Lead Author, a highly competitive role, for aviation issues in the Energy Chapter of this IPCC report.

Emissions and Dispersion Modeling System (EDMS) Enhanced to Support VALE

Future capacity expansion may be difficult if aviation cannot keep pace with other transportation and industrial sectors in controlling emissions. The FAA has established a national voluntary program to reduce airport ground emissions at commercial service airports located in air quality nonattainment and maintenance areas. The new Voluntary Airport Low Emissions (VALE) program allows airport sponsors to obtain grants to finance low emission vehicles, refueling and recharging stations, gate electrification, and other airport air quality improvements.

To support the launch of the VALE program, in FY 2004, the FAA upgraded its Emissions and Dispersion Modeling System (EDMS) to allow assessment of emission savings from actions to reduce ground emissions. EDMS calculates emissions from airport sources and models the air quality at an airport. The EDMS enhancements enable computation of on-road and off-road vehicle emission factors. This version also includes more accurate techniques for computing Total Hydrocarbon and Volatile Organic Hydrocarbon emissions. These enhancements were needed to facilitate airport applications for FAA program funding and emissions reduction credits from the EPA.

Aircraft Noise Monitoring

Most airports worldwide must first evaluate the effects of development using a noise model before beginning a development project. The majority of airports use a modeling tool developed by the Society of Automotive Engineers. In FY 2004, the FAA, in collaboration with NASA, sponsored several projects that will help update the SAE best practice documents. To address aircraft noise issues, the FAA has sponsored noise monitor collection efforts and verification studies that support SAE-ARP-4721, "Monitoring Aircraft Noise and Operations in the Vicinity of Airports." In FY 2004, the FAA sponsored a noise monitoring study at Dallas-Fort Worth International Airport. The study team provided SAE with statistical techniques for assessing monitor data and performance metrics that address how well a monitor is able to record a series of noise events.

Particulate Matter Research

The uncertainties surrounding the atmospheric and health effects of aviation emissions complicate the development of mitigation measures and lengthen airport environmental assessments. Specifically, the impact of particulate matter and hazardous air pollutants remains unknown because of the lack of both experimental data and reliable models. NASA, FAA, EPA, and DoD collaborated to take a major step to address these issues through an emissions measurements effort in FY 2004. The Aircraft Particle Emissions Experiment (APEX), led by NASA, is characterizing particle and trace gas precursor species from a NASA-owned DC-8. The FAA's primary research objective is to help airports determine if their operations will comply with upcoming National Ambient Air Quality Standards for particles sized 2.5 microns in diameter or below. The FAA hopes the APEX data will enhance the ability of the Emissions and Dispersion Modeling System to predict particle measurements and, eventually, hazardous air pollutant concentrations from aircraft engines. The FAA is also leading a comprehensive strategic activity to formulate a National Particulate Roadmap. The Roadmap is a long-range action plan to coordinate research, development, and regulatory activities of government, industry, academia, and the public. The objective is to gain the necessary understanding of particle formation, composition, and growth and transport mechanisms to assess aviation's particulate emissions and understand their impact on human health and the environment. Ultimately, the Roadmap activities will guide aviation technology development and inform policy decisions.

Capacity Research

Create a flexible air transportation system that meets the needs of users.

En Route Descent Advisor (EDA)

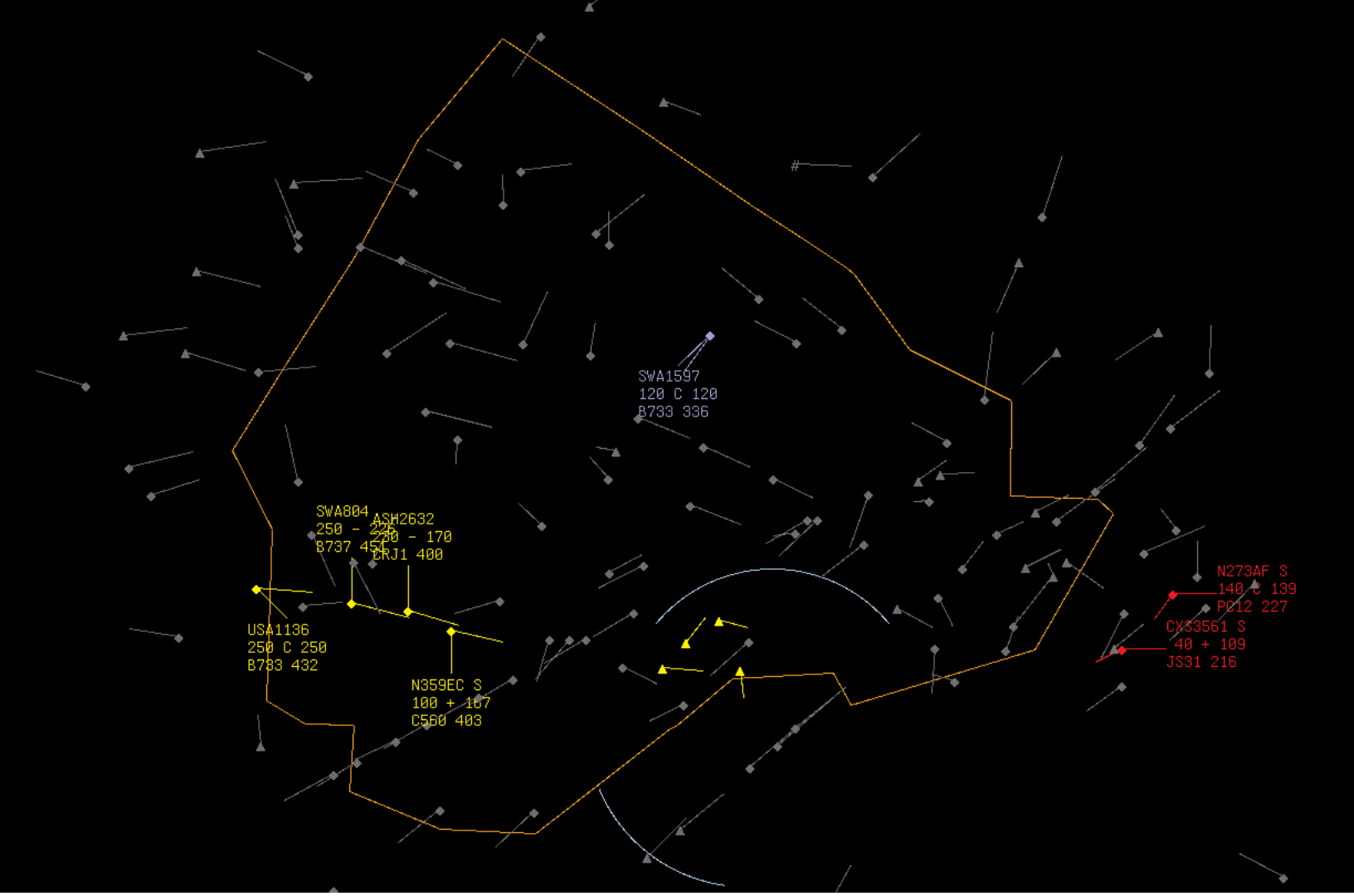
The En Route Descent Advisor, developed by NASA Ames Research Center, is an advanced decision support tool intended for use by the en route controller to handle traffic in transition airspace. EDA builds on NASA's Center-TRACON Automation System (CTAS). In FY 2004, the FAA and NASA conducted a full evaluation of the prototype EDA system. FAA operational air traffic control personnel participated in the evaluation, and provided system design reviews and recommendations periodically during the year. This successful evaluation marked the completion of a major development milestone. Although EDA is still in the early stages of development, it is maturing rapidly into a viable component of CTAS, with the potential to provide significant system capacity, fuel, and workload benefits. Future plans call for continued development with extensive validation through simulation, followed by shadow evaluations in the field and eventual deployment.

Surface Management System (SMS)

The FAA/NASA Interagency Air Traffic Management (ATM) Integrated Product Team (IAIPT) successfully completed initial SMS research. Researchers demonstrated that this technology could safely increase airport capacity and efficiency using traffic management technologies. The FAA will now undertake analysis for an investment decision to continue development and acquisition of an airport Surface Traffic Management System. The final investment decision is expected in FY 2005.

Global Communications, Navigation Surveillance System (GCNSS)

During FY 2004, the FAA continued exploring the role of satellites in providing a highly integrated and secure common information network and a broadband, two-way, secure, communications capability for air traffic management (ATM) and in-flight security. The operational requirements necessary for a next-generation ATM system have been defined through a strong systems engineering process. Analysts conducted trade studies with associated cost/benefit assessments to assure that proposed concepts have transition plans and highly positive business cases. As the result of a modeling effort, engineers developed initial versions of a national architecture flow model and a regional traffic model that allow sensitivity assessments of candidate operational and architectural concepts. During 2004, the FAA completed the first of two systems engineering studies and three demonstration projects. The first demonstration examined the capability to up and down link via satellite aircraft parameters, broadband video for cockpit ATM flight conflict monitoring, and air to ground in-flight security monitoring for Federal Air Marshals. The second, conducted in November 2003, demonstrated the use of satellites as a means to provide communications and surveillance coverage in the Gulf of Mexico, where such services are unavailable. The final project demonstrated a highly integrated, secure, networking capability that will share precise information with other agencies (i.e., Department of Homeland Security, Department of Defense, airline operation centers) and provide real-time, seamless surveillance coverage for use in ATM.



Traffic Management Advisor MultiCenter (TMA-MC)

TMA-MC is an extension of the Single-Center TMA Decision Support Tool in current use at some FAA Air Route Traffic Control Centers. The FAA and NASA are developing TMA-MC to enable TMA's time-based scheduling of arrivals to airports in the complex airspace of the Northeastern United States. High traffic congestion, multiple merging routes, narrow airspace sectors, and terminal airspace fed by more than one ARTCC characterize this airspace. During FY 2004 the TMA-MC prototype field evaluation continued with non-operational shadowing exercises conducted by NASA and the FAA at the New York, Cleveland, Washington, DC, and Boston Centers. These field exercises evaluated the distributed scheduling capability of TMA-MC and the interfacility procedures needed to meter arrivals into Philadelphia Airport. Researchers are planning an operational field evaluation of the system in FY 2005.

Airborne Alerts without Intervention

The FAA is conducting concept exploration and demonstrations of an Automated Airborne Flight Alert System (AAFAS). This system will use existing aircraft equipment to capture and transmit to the ground any data sent to an aircraft's Flight Data Recorder (FDR). When an anomaly is detected, existing aircraft communications circuits will be used to send the "trigger" data to the ground. This innovation will enable possible ground intervention following an incident and, in the worst case, provide data before the FDR has been retrieved.

LEDFAA 1.3 Software Program Release

In FY 2004, the FAA released an updated version of its Layered Elastic Design (LED) airport pavement design software program. This program, designated LEDFAA Version 1.3, incorporates many new features, including: updated aircraft libraries; a general aviation aircraft category; and full 32-bit programming for faster speed and better compatibility with current operating systems. The many programming changes in the new model represent significant technical advances. The failure models (mathematical models within the program that determine the pavement design thickness) now reflect the results of the flexible (asphalt) pavement, full-scale traffic tests conducted to date at the National Airport Pavement Test Facility. Structural models have been revised to capture the interaction between all landing gears in a multiple-gear assembly, resulting in a more accurate strain analysis. Also, the new version uses LEAF, a layered elastic analysis program developed by the FAA to replace an older program. LEAF has been designed to increase the efficiency of layered elastic calculations, and is fully documented and supportable.

The FAA has incorporated LEDFAA 1.3 into Advisory Circular 150/5320-6D, Airport Pavement Design and Evaluation, making it the required FAA pavement thickness design procedure whenever a triple-dual-tandem aircraft (e.g., Airbus 380 or Boeing 777) is in the aircraft traffic design mix. The Agency has also approved LEDFAA 1.3 as a valid alternate design procedure for all other traffic mixes covered by the advisory circular.

Reconstruction of National Airport Pavement Test Facility Rigid Test Pavements

In FY 2004, researchers completed construction of three new rigid (concrete) pavement test items at the National Airport Pavement Test Facility. The Facility's test vehicle will continue trafficking the pavements until all of the concrete slabs of the test items have failed - that is, shattered into many pieces. The results obtained from full-scale traffic testing will help the FAA to improve design procedures for both conventional and stabilized rigid pavements.

Researchers also began full-scale traffic testing using loads simulating fully loaded four- and six-wheel gears. The FAA plans to use these test results to develop new airport pavement design standards applicable to next-generation heavy commercial aircraft, including the Boeing 777 and Airbus 380.

Commercial Space Transportation

Facilitate and promote safe U.S. Commercial Space Transportation.

Flight Safety Systems

In FY 2004, FAA's Office of Commercial Space Transportation began a follow-on study to earlier work on non-traditional flight safety systems. Conventional flight safety systems minimize the threat to public safety and property posed by a malfunctioning launch vehicle. Non-traditional versions of these systems include fully autonomous systems and semi-autonomous systems that interface with pilots and/or ground controllers. In this study, researchers are applying a new verification methodology to learn more about an autonomous flight safety system currently being developed by NASA. The results and lessons learned during this trial application will provide insight into the most appropriate methods for granting regulatory approval for use of these types of systems.

Reentry Vehicle Hazard Model

Commercial space transportation researchers completed the draft handbook, Development of a Simplified Reentry Vehicle Hazard Model, providing launch and reentry vehicle developers a reference guide that they can use to estimate, first-hand, the expected casualty for a given reusable launch vehicle mission. For this handbook, researchers developed a simplified method to estimate expected casualty for the aerothermal structural demise of a spacecraft.

Aeromedical Guidelines for Commercial Launch Vehicles

In FY 2004, FAA's commercial space transportation and aeromedical researchers completed aeromedical guidelines for environmental control and life support systems as well as medical guidelines for assuring human survival during commercial launch vehicle operations. The results of this research effort will provide guidance to reusable launch vehicle operators who propose to carry crew and passengers, and will assist the FAA in the evaluation of such proposals.

Casualty Criteria for Reusable Launch Vehicles

Researchers compared a new analytical methodology, based on a traditional failure modes effects and criticality analysis (FMECA) and reliability allocation methods, with existing approaches for determining expected casualty rates for reusable launch vehicles. The results of this research will help FAA's Office of Commercial Space Transportation develop future reliability and risk assessment guidelines in support of the reusable launch vehicle license evaluation process. The researchers examined the proposed methodology by

- investigating the traditional FMECA process and identifying its advantages and disadvantages,
- assessing the current use of FMECA within FAA for aircraft certification, expendable launch vehicle licensing, and reusable launch vehicle licensing efforts, and
- comparing the proposed methodology to existing FAA processes.

The researchers determined that, although potentially simpler than the existing approach, the proposed analytical methodology does not demonstrate a sufficient level of safety in comparison to existing approaches. Concepts from this methodology that may warrant further consideration include setting vehicle reliability levels in support of system safety and using analytical methods, such as reliability allocation, to demonstrate those reliability levels.

Debris Database

FAA's Office of Commercial Space Transportation initiated an interagency R&D effort with NASA to develop a database with detailed information on the fragments recovered from the Space Shuttle Columbia. Researchers will use the data to improve methods for conducting public risk assessments that enhance public safety. In FY 2004, researchers organized an inter-agency working group dedicated to establishing the requirements for this database, developing it, and executing its first Implementation Plan under an interagency memorandum of agreement. When complete, this database will provide an important benchmark of real world data and will assist in the development of credible launch and re-entry debris models appropriate for hypersonic aerodynamic break-up conditions. This effort also responds to safety recommendations made by the Columbia Accident Investigation Board.

Space Vehicle Reentry

In FY 2004, researchers began studying the high temperature plasmas associated with space vehicle reentry, which greatly affect radio frequency signal reception between vehicle and ground control. Both voice communication and data telemetry between reentry vehicle and ground can suffer severe degradation or total loss during the critical reentry phase of the flight. The resulting radio blackout, can block controller communications and adversely affect safe operations. Researchers seek to understand the phenomena and potential mitigation strategies, and they develop recommendations for: minimizing communications outages during reentry and enabling controller communications for operation within national airspace system and near space for civilian commercial space vehicles; developing techniques for reducing radio frequency reception errors; and establishing the requisite frequency bands for uninterrupted communications through plasma fields.

Reusable Launch Vehicle Inspection Techniques

Researchers completed a project documenting the capabilities and limitations of current and potential non-destructive evaluation methods for inspecting components beneath the thermal protection systems of reusable launch vehicles. They first identified the basic issues affecting the inspection of structures protected by thermal protection systems and then described the strengths and weaknesses inherent in various nondestructive evaluation techniques. These research efforts will help to ensure that reusable launch vehicles are safe to re-fly by providing means to verify the integrity of their structure.

California Spaceport

Information Technology

Ensure the availability, reliability, security, and usability of FAA systems.

A Model of Trust

Funded by the FAA, Colorado State University researchers began work to develop a new model of trust based on FAA requirements. This model emphasizes integrity and availability. Researchers are also determining the limitations of existing trust models when applied to FAA systems and identifying different components of trust and factors that influence trust. In the next phase of this project, researchers will analyze the collected data using this new trust model.

Unintended Information Revelation

Under a FAA grant, researchers at the State University of New York, Buffalo, are developing advanced information retrieval representations that can facilitate "text mining." The detection of certain types of unintended information is a key focus. Often, the sum total of information generated by multiple authors working independently, and at different times, may reveal more than the authors individually or collectively intended. With web sites such as those maintained for the FAA, this phenomenon may lead to the organization's releasing more sensitive information than is justified under a need-to-know policy. Dealing with this key effect of text mining becomes a critical component in the cyber infrastructure needed to ensure the security of publicly disseminated information. While most research on security has approached this issue from the data access perspective, this new research is pursuing security from the perspective of quantifying the total information revealed through multiple outlets. In FY 2004, researchers analyzed the FAA web page collection. The initial round of analysis did not discover any release of sensitive information; however, the present state of concept mapping must be improved before significant patterns can be detected.

Data Fusion at the Computer Security Incident Response Center (CSIRC)

Researchers at the FAA's Computer Security Incident Response Center (CSIRC) and the Air Force Research Laboratory (AFRL) are working together to correlate and aggregate the capabilities of the current CSIRC database. The correlation of this data will facilitate recommendations on how to reduce analyst workload. The goal is to reduce the number of alarm records by an order of magnitude.

Information Systems Security Architecture

FAA researchers are continuing to develop essential inputs to the Agency's National Airspace System Architecture and the Enterprise Architecture. Version 4.0 of the Information System Security Architecture (ISSA) now integrates the results of the National Airspace System Information System Security (ISS) Requirements Working Group. The ISSA will provide security strategies and rules for physical, data flow, and functional views for future system, domain, functional areas and enterprise architectural-level diagrams. Its architectural diagrams will document key interfaces, functions, data, and networks vital to future NAS ISS services, consistent with allocated ISS requirements, and best practices.

Intrusion Quarantine

To develop a proactive response to malicious activity leading to a harmful cyber attack, FAA researchers are testing a passive monitoring system at the FAA Command Center Operational Internet Access Point (IAP) De-Militarized Zone (DMZ).

PKI Lab

In FY 2004, the FAA established a rapid prototyping laboratory at the William J. Hughes Technical Center to develop secure wireless communications solutions for use with aircraft and in administrative settings. Researchers have established the first of several planned wireless configurations in the lab, and are integrating additional systems to provide scalable services that meet the needs of FAA customers. The current system is a full National Institute of Standards and Technology Federal Information Processing Standards 140-2 Level 2 compliant system which meets the encryption requirements of the current DoD wireless standard, and which will meet the forthcoming final FAA wireless standard.

FAA Logical Access Control Pilot Program

A pilot project is currently underway to adapt existing security technologies to control access to administrative areas and assets both within the FAA itself and within the National Airspace System operational structure. FAA researchers are examining the feasibility of adapting biometrically enabled smart card and Public-Key Infrastructure technologies to create a scalable, and affordable, common credential and standard that can form the basis for these controls. Pilot findings will be used to develop requirements and a business case for full-scale acquisition/implementation.

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