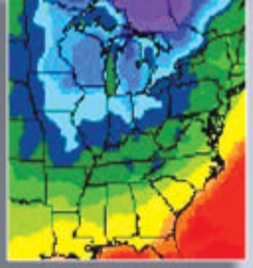


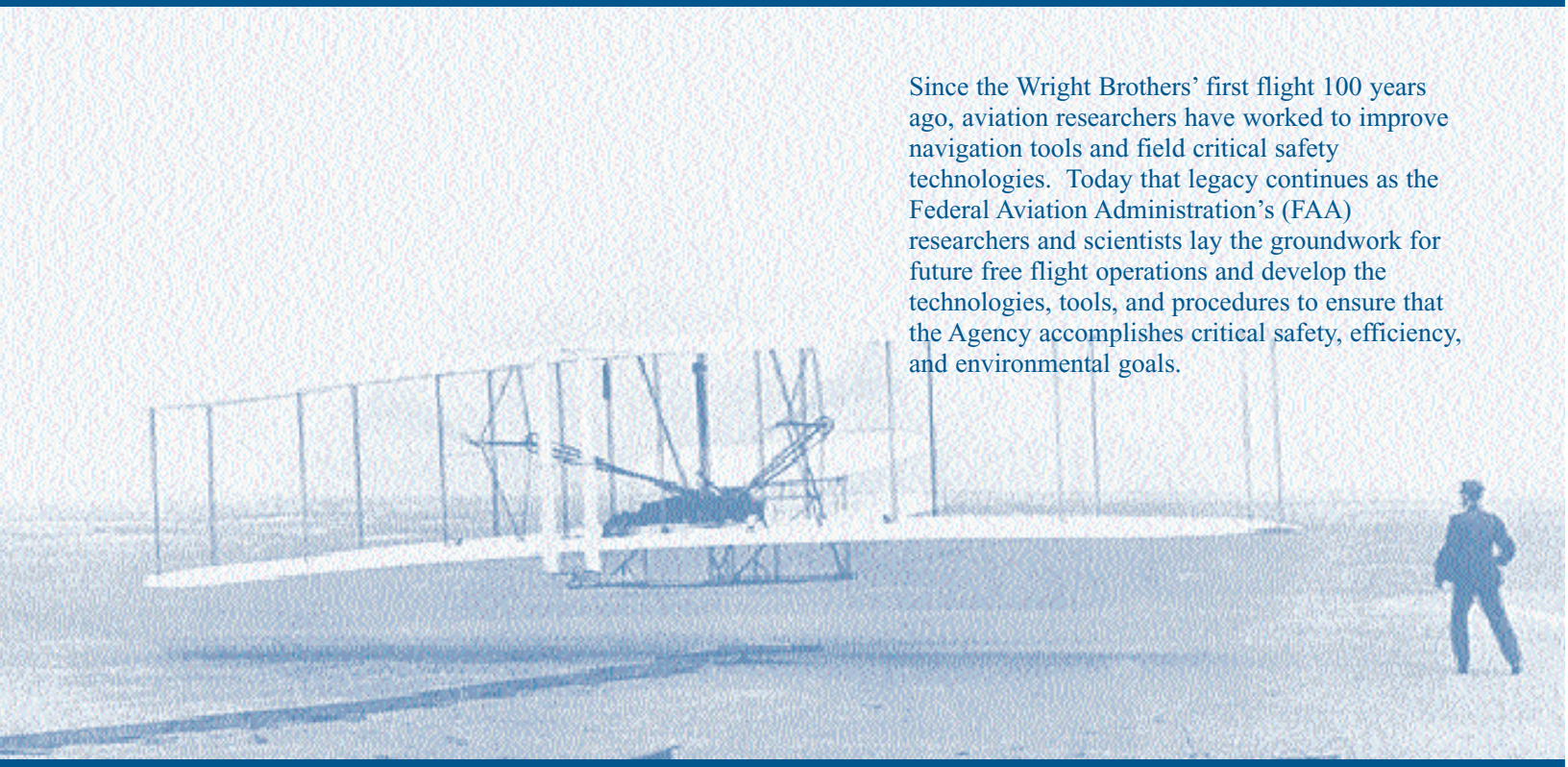



FEDERAL AVIATION ADMINISTRATION

RESEARCH & DEVELOPMENT 2002 ANNUAL REPORT

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

Charting the Next Century of Flight



Since the Wright Brothers' first flight 100 years ago, aviation researchers have worked to improve navigation tools and field critical safety technologies. Today that legacy continues as the Federal Aviation Administration's (FAA) researchers and scientists lay the groundwork for future free flight operations and develop the technologies, tools, and procedures to ensure that the Agency accomplishes critical safety, efficiency, and environmental goals.

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From the Administrator

"The FAA is laying the groundwork for the research and development program. This strong commitment to research will ensure a safe, secure, efficient, and environmentally compatible global aviation system."

Nearly one hundred years ago, two brothers from Ohio traveled by train, steamship, and small boat to the windswept dunes of North Carolina and unlocked the secret to powered flight. The Wright Brothers used experimentation, exacting science and perseverance -- the true spirit of research and development -- to achieve their historic breakthrough. As we chart a new century of flight, research and development will remain an integral part of making air travel even safer.

I want to thank our domestic and international research partners for their continued support and collaborative efforts. Combined with the hard work and dedication of the FAA's researchers, several R&D products described in this report are already paying dividends in the safety, capacity and efficiency of the aerospace system.*

This year's report includes some exciting developments, such as those made by the Office of Commercial Space Transportation in predicting how reusable launch vehicles will affect national airspace system operations.

We will continue to ensure the safety, efficiency, and environmental compatibility of this nation's aerospace system through an aggressive R&D program. To help guide current and future research, we issued the FAA R&D Strategy in FY 2002. This blueprint ensures that the FAA's R&D resources remain customer-focused and targeted toward the highest priority activities. A copy of the report and the Agency's annual National Aviation Research Plan are available online at http://research.faa.gov.

We look forward to celebrating the Centennial of Flight and our continued development of the technologies and procedures that will enhance and improve the national aerospace system. Our strong commitment to R&D will afford numerous successes for the future of aviation.

Marion C. Blakey
Administrator

* Fiscal Year 2002 saw some significant changes in the FAA's R&D program. In the wake of the tragic events of September 11, 2001, responsibility for aviation security R&D moved to the newly created Transportation Security Agency. For this reason, security R&D accomplishments are not highlighted in this report.

Our Vision

The FAA's Research and Development (R&D) program stands committed to improve the safety of the flying public through collaboration with and support of the entire aviation community.

This program, in partnership with the aviation community, helps the Agency meet its goals by providing world leadership in the conduct of high-priority research and the development of innovative technologies. The FAA's continuing leadership will assure and enhance the continued success of a safe, efficient, and environmentally acceptable global aviation system.

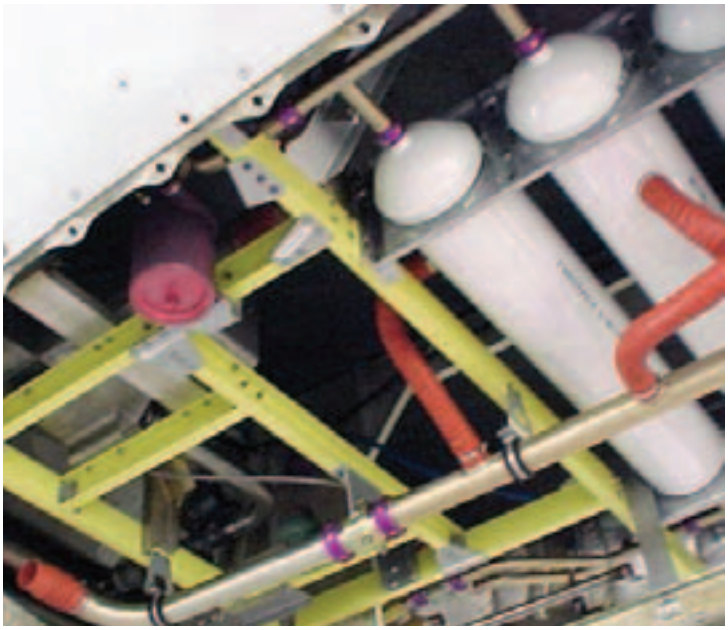
The R&D program responds to the needs of FAA activities, such as aircraft and airmen regulation and certification, airport operations, and air traffic services. It is through these activities, and the impact of R&D on the aerospace community, that the FAA's goals are achieved.

To ensure both short-and long-term R&D, continuous investment in a strong multi-faceted R&D program is vital to meeting the Agency's mission in an efficient and timely manner.

Increasing Fleet Safety

Aircraft and passenger safety depends on fault-free maintenance and operation of the nation's civil aircraft. The FAA's aircraft R&D program addresses the many hazards that face all aircraft, as well as special hazards endemic to select portions of the civil aircraft fleet.

New Breakthroughs in Fuel Inerting



VIEW OF THE FUEL TANK INERTING FROM THE UNDERSIDE OF AIRCRAFT

In FY 2002 the FAA made significant progress in the development of an inerting system to prevent fuel tank explosions. Building on previous research on ground-based inerting, FAA researchers designed and installed an on-board inerting system in the FAA's 747SP test aircraft. The design was driven by the challenge of developing a practical and reliable system that could be installed in commercial aircraft within the next several years. FAA fire safety researchers and the National Research Specialist for Fuel System Design worked together to develop and demonstrate a clever and relatively simple dual flow design for generating nitrogen enriched air in flight. By using high purity/low flow nitrogen enriched air NEA during ascent and cruise, and lower purity/high flow NEA during descent, analytical modeling showed that most aircraft models and flight regimes would remain inert upon landing, negating the need for a system operation on the ground which was expected to be costly and complicated. During the fiscal year, researchers further streamlined the inerting system design by experiments, showing that the concentration of oxygen required to inert was higher than previously thought, significantly reducing the size (and weight) of the system. Simulated flight tests in an altitude chamber, initially on an air separation membrane, followed by ¼-scale model tests of a 747 center wing tank, provided consistent data with the modeling predictions. Although flight tests are planned in FY 2003, the combination of modeling predictions, air

DIAGRAM OF THE FUEL TANK INERTING FLIGHT WORTHINESS

Safety

An important element in maintaining the public's confidence in America's aviation system is the continued safety record of this country's air carriers. The FAA is committed to reducing the U.S. aviation fatal accident rate by 80 percent, by the year 2007.

Through its R&D activities, the FAA is developing the technologies that will maintain and improve safety in an evolving, and demanding aviation environment. Such improvements reduce fatalities, injuries, aircraft losses, help create better aircraft and airport designs, and improve maintenance and inspection procedures.

separation module (ASM) and ¼-scale altitude chamber tests, and demonstrations of the prototype inerting system in the 747SP (on the ground) convinced Boeing to formally apply to the FAA to retrofit some of its 737 models with inerting systems similar to the FAA design. Following a major Press Conference at the Technical Center on December 12 for the national newspaper and TV media, the Administrator characterized the new inerting system design as "a major breakthrough."

Initiation and Distribution of Fatigue Cracks in a Fuselage Lap Joint Curved Panel

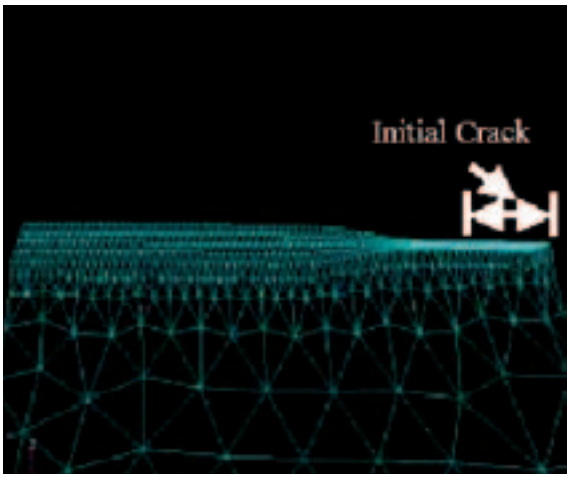


Illustration of crack in fuselage

In FY 2002, the FAA undertook a study of multiple-site damage (MSD) initiation, distribution, and linkup in an initially undamaged curved fuselage panel containing a longitudinal lap joint. Researchers used the Full-Scale Aircraft Structural Test Evaluation and Research facility for these tests. The researchers initially conducted quasi-static tests to ensure a proper load introduction to the panel. They then subjected the curved panel to fatigue loading with a marker band spectrum. During the fatigue test, the researchers periodically inspected the rivets in the panel with a rotating eddy-current probe system – a remote control crack monitoring system. The researchers initially observed all the skin cracks along rivet row A at a distance from the edge of the rivet hole, possibly because of the high residual stress field in the vicinity of the rivet head resulting from the riveting process. These cracks propagated back towards the rivets and eventually grew into the rivet holes. Other MSD cracks were observed at rivets holding the shear clips to the skin at the shear clip cutouts located at the frame-stringer intersections.

Repair of Transport Aircraft Using Composite Doublers

Location of repair site on aircraft

Bonded composite doublers offer airline maintenance facilities a cost-effective way to safely extend the lives of aircraft. Instead of riveting multiple steel or aluminum plates to repair an aircraft, it is now possible to bond a single boron-epoxy composite doubler to the damaged structure. During the fiscal year, researchers at the FAA's Airworthiness Assurance Nondestructive Inspection Validation Center (AANC) completed an experimental project where they installed composite repair doublers on in-service commercial aircraft. The project validated a family of generic composite patches used to repair various types of damage to metallic structures caused by dents, dings, lightning strikes, corrosion, and certain cracks in non-pressurized areas. Researchers also identified necessary guidance data needed to assure the continued airworthiness of composite doublers.

In conducting this program, the AANC focused their attention only on the DC-10/MD-11 aircraft and worked collaboratively with FedEx, Boeing, and Textron Specialty Materials. This project built upon research conducted with Delta Airlines to validate the use of a composite reinforcement on an L-1011 doorframe corner. In the future, this technology will be used by airlines and maintenance depots that currently apply metallic repairs. Industry interest in using composite doubler repair has grown considerably since the results from this study have shown that the finished doublers are lighter in weight, corrosion-resistant, stronger, and faster to install than a typical riveted aluminum plate repair.

Inner-Layer Crack Experiment

At the request of the FAA's Seattle Aircraft Certification Office, investigators from the AANC recently completed an experiment to assess the reliability of a sliding probe eddy-current procedure for its effectiveness in finding second-and third-layer cracks in certain Boeing 737 lap splice joints. Lap splice joints are an area on the fuselage of an aircraft where two sheets of aircraft skin overlap and are riveted together. The findings will be taken into consideration in the development of revised and new lap splice inspections.

Composite Material Control and Standardization

In recent years, FAA researchers, NASA, and industry have worked together to develop a cost-effective method of qualifying composite material systems by sharing central material qualification databases, such as the MIL-HDBK-17 and the Advanced General Aviation Transport Experiment (AGATE). Through these shared databases, a manufacturer can select an approved composite material system to fabricate parts and perform a smaller subset of testing to a specific application. To review the technical report, *Material Qualification and Equivalency for Polymer Matrix Composite Material Systems*, on-line please visit http://aar400.tc.faa.gov/aar-430/reports/00-47.pdf .

Inspection Development for Nickel Billet

Nickel Billets

One of the current activities of the Engine Titanium Consortium (ETC) is the development of improved ultrasonic inspection capability for nickel alloys used in jet engines. The ETC is an FAA-funded consortium consisting of General Electric Aircraft Engines, Honeywell, Iowa State University, and Pratt & Whitney. As a result of this effort, researchers demonstrated a significant improvement in inspection sensitivity. Billets of both Waspaloy and Inconel 718 were inspected. These are the primary nickel alloys used in critical rotating jet engine components. The program goal was to develop a 4-fold improvement in inspection sensitivity over conventional practice for billets up to 10 inches in diameter. The researchers not only met this goal, but also substantially exceeded it.

Airborne Data Monitoring Systems

DATA MONITORING SYSTEM

In FY 2002, the FAA continued their Operational Loads Monitoring Program, which includes both flight and landing loads data collection on civil transports. During the year, the FAA Operational Loads Monitoring team provided specialized operational loads data and analysis to the Aviation Rulemaking Advisory Committee, which develops recommendations for certification criteria for the A-380 airplane. Agency researchers also merged sink speed data at touchdown, collected during video landing parameter surveys at the New York John F. Kennedy International, Honolulu International, and Heathrow International airports, into a single database and presented the data to the Advisory Committee so it could assess whether or not to increase the limit load design sink speed for the new generation of super heavy widebody airplanes.

Increasing Flight Safety

The FAA's flight safety researchers find new ways to protect aircraft from both natural and manmade atmospheric hazards including: aircraft in-flight icing; aircraft ground deicing; aircraft ice detection; electromagnetic environmental effects, such as high intensity radiated fields, lightning, and hazards generated by portable electronic devices; and digital system validation technologies for flight controls and other critical avionics systems.

Dependence of Aerodynamic Effects of Ice on Aircraft Wing Geometry

ICE ON THE AIRCRAFT WING

The aerodynamic efficiency of an aircraft wing can be seriously affected by ice accretions which disrupt the normal smooth airflow over the wing. The severity of these aerodynamic effects such as loss of lift, or increase in drag depends on the ice accretion, and the aerodynamic characteristics of the wing cross section (airfoil). Recent accidents and incidents in icing conditions underscored the need for a systematic study of the sensitivity of different airfoil types to ice accretion and of the most critical ice shape locations for different types of airfoils. In response to these and related concerns, the FAA sponsored a long-term research investigation at the University of Illinois at Urbana-Champaign. The program includes aerodynamic testing in the University's wind tunnel and in NASA's low-pressure turbulence tunnel at the Langley Research Center in Hampton, Virginia, as well as extensive computational fluid dynamics investigations. An important conclusion of this investigation, reveals that the severity of the aerodynamic penalty of the ice is strongly dependent on the geometry of the airfoil as reflected in its pressure distribution and lifting characteristics.

Continued Electromagnetic Protection Integrity of Aircraft and Systems

In FY 2002, FAA researchers, in conjunction with Wichita State University's National Institute for Aviation Research, Cessna Aircraft Company, Raytheon Aircraft, QinetiQ Research, and the European Aircraft EMC Research Council, completed a series of research tasks related to the prevention of the degradation of aircraft wire bundles from high intensity radiated fields (HIRF) and lightning.

Increasing Airport Safety

There are more than 5,300 public use airports, heliports, and vertiports in the United States, and traffic demand at these landing areas is steadily increasing. As early as 2013, U.S. enplanements are projected to reach nearly 1.1 billion passengers a year. Because the possibilities for expanding or building airports are limited, FAA researchers develop and evaluate technologies that will result in new safety standards, criteria, and guidelines for those who use, design, construct, operate, and maintain this nation's airfields.

Engineering Material Arresting System (EMAS)

Research into jet blast resistant aircraft arrestor beds continued in FY 2002. A second demonstration bed at LaGuardia Airport, set back only 35 feet from the runway, 4-departure end is under construction. Success of this test bed will open opportunities for arrestor bed deployment at airports with very limited safety overrun areas. The two decks that support the runway 4 and runway 31 safety areas at LaGuardia are likely candidates.

Engineering Material Arresting System

Wildlife Hazard Mitigation

The presence of wildlife on and near airports creates a serious hazard to operating aircraft. In 2002, over 6,000 strikes were reported, verified and entered into the FAA National Wildlife Strike Database. As a result, the FAA entered into a partnership with the U.S. Air Force Research Laboratory and WaveBand, Inc. to develop and test a small portable radar designed to detect birds in the vicinity of airports and military airfields. Development efforts for a prototype radar are well under way and preliminary testing was conducted in the Fall of 2002. The prototype radar will be tested at a major commercial airport in the upcoming months.

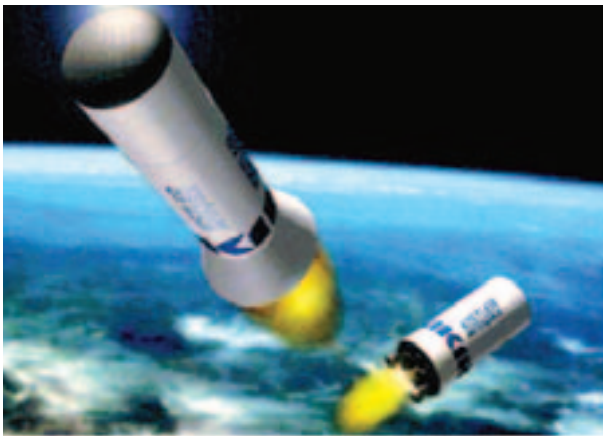
Wildlife Strike

Commercial Space Transportation

FAA's Office of Commercial Space Transportation solicits, evaluates, and selects relevant research projects to further the Agency's mission. During 2002, the FAA developed the *AST Research & Development Plan*, which provides a process for the successful implementation of research resources to identify and prioritize safety research requirements.

In addition, the Agency completed a final draft of the report titled, *Reentry Maneuverability: Public Safety and Technical Concerns Regarding Maneuvering Reentries*, with a Maneuver Analysis Tool (MAT) and a MAT operation manual. MAT is currently designed to study the unpowered flight of reentry vehicles within the Earth's atmosphere. This study identifies issues associated with the reentry vehicle, reentry corridor, size of landing area, and reentry site boundary requirements.

Researchers also conducted a Reusable Launch Vehicle Operations and Maintenance (O&M) study to determine the best practices and lessons learned from the Space Shuttle and airline O&M.



Planned Reusable Launch Vehicle

California Spaceport

Using Flashing PAPI Lights to Increase Surface Situational Awareness

Under the Runway Incursion Reduction Program, the FAA explores and evaluates current and emerging technologies that show potential for increasing runway safety in the National Airspace System (NAS). Within the scope of this program, evaluation projects are underway to assess the technical and operational suitability of new concepts in surface traffic surveillance and pilot and controller situational awareness tools. Current technology evaluation initiatives underway include the evaluation of runway status lights (RWSL), research and demonstration of ground marker beacons, light emitting diode (LED) lighting, and laser technologies.

PAPI light

One project, the flashing Precision Approach Path Indicator (PAPI) initiative, aims at reducing runway incursions and enhancing surface situational awareness. The PAPI includes a series of lights that provide the pilot with a safe and accurate glide slope on final approach to the runway. A row of PAPI light housing assemblies placed perpendicular to the approach path are seen by the pilot in combinations of red and white to indicate a path that is too high, too low, or correctly on slope. The FAA successfully demonstrated this concept of flashing the PAPI lights to improve inbound aircraft flight crew situational awareness on September 9-12, 2002 at Long Beach Municipal Airport, CA (LGB). Demonstration observers included airport management, volunteer pilot observers, air carrier and general aviation industry, and FAA air traffic controller and management representatives.

Aviation Weather Research

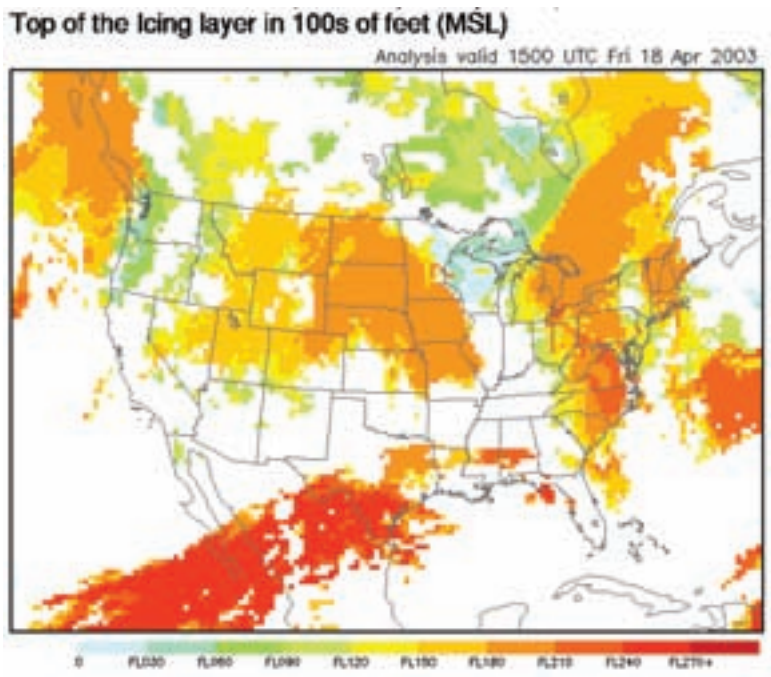
A recent estimate by the FAA identified weather as being responsible for 65 percent of flight delays and approximately 40 percent of accidents. The FAA's Aviation Weather Research Program (AWRP) provides the capability to generate more accurate and accessible weather observations, warnings, and forecasts, to solve operational problems.

The laboratories and research institutions supporting the FAA's Aviation Weather Research Program received the FAA's 2002 Excellence in Aviation Award for their ongoing work.

The Program was also the recipient of the 2002 National Weather Association's Aviation Meteorology Award. It received this award in recognition of its development and implementation of the National Convective Weather Forecast (NCWF), the Current Icing Potential, the Forecast Icing Potential products, and the Rapid Update Cycle 20, all new products designed to enhance aviation safety and efficiency.

The AWRP's Aviation Digital Data Service (ADDS), a user-friendly, web-based, dissemination system used to access several of the products, was also a recipient of this year's National Weather Association award.

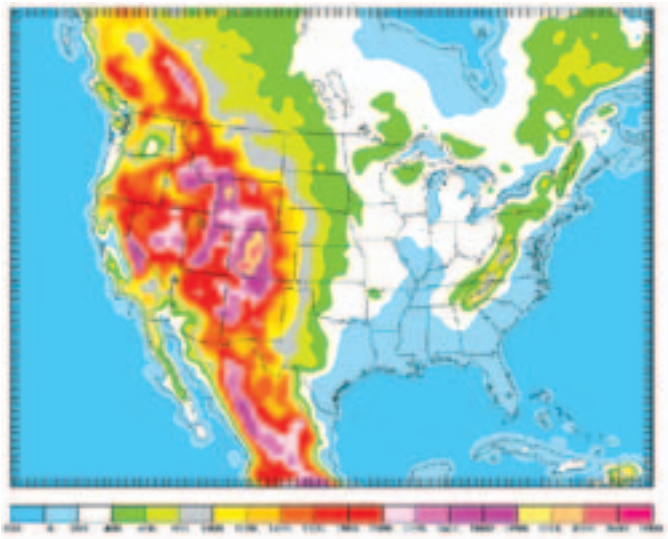
Current Icing Potential



Current Icing Potential Map

On March 27, 2002, the FAA reached a milestone in ensuring the safety of the flying public. The Current Icing Potential (CIP) weather safety product became fully operational at the National Weather Service (NWS) Aviation Weather Center in Kansas City, Missouri. This product, which generates around-the-clock support, provides information on current in-flight icing conditions and is used for flight planning, determining route changes, and altitude selection. The CIP, developed by the National Center for Atmospheric Research (NCAR) in Boulder, Colorado, with funding from the FAA's Aviation Weather Research Program, is derived from radar and satellite data, surface observations, numerical models and pilot reports. Users can access CIP information on the Internet via the Aviation Digital Data Service (ADDS) web site at http://adds.aviationweather.gov/icing/.

The Newly Improved RUC20 Weather Model



RUC20 Display

The FAA completed development and implementation of a newly improved version of the Rapid Update Cycle (RUC) numerical weather model. The RUC20, with its 20-km resolution, provides improved aviation and surface weather forecasts. It features increased horizontal resolution and 50 vertical levels. The RUC-20 also features enhanced microphysics and new model input data sources. This version advances the overall accuracy of weather data being fed into aviation-weather applications. Developed by researchers from the National Oceanic and Atmospheric Administration's Forecast Systems Laboratory, with funding from the FAA's Aviation Weather Research Program, the RUC20 is run operationally by the National Weather Services' National Center for Environmental Prediction.

Tools for the Future: Free Flight Program

The FAA's Free Flight Program encompasses two Phases:

Free Flight Phase 1 (FFP1)

FFP1 studies overall improvements to the efficiency of the National Aviation System (NAS). In accordance with industry recommendations, between 1998 and 2002, FFP1 deployed a number of tools, such as the User Request Evaluation Tool (URET), Traffic Management Advisor (TMA), and Surface Movement Advisor (SMA).

Free Flight Phase 2 (FFP2)

FFP2 maintains the momentum and continuity in the deployment of Free Flight tools to provide user benefits. Beginning in FY 2000, FFP2 served as a vehicle for further deployment and enhancement of URET, TMA, and Collaborative Decision Making. FFP2 also has a mandate to pursue research into new automation tools. During 2002, the FFP2 research program had several successes to include:

Problem Analysis, Resolution and Ranking (PARR), developed by the MITRE Center for Advanced Aviation System Development, is an extension of the Free Flight Phase 1 User Request Evaluation Tool (URET). The Initial PARR Assisted Resolution Tool (ART), being developed as part of Free Flight Phase 2 (FFP2), will provide the radar associate controller (D-side) with a set of tools to support the development of strategic resolutions to URET-predicted aircraft-to-aircraft and aircraft-to-airspace problems. In fiscal year 2002, the FAA conducted controller-in-the-loop simulations of initial PARR/ART to further refine the operational concept of use for ART.

Traffic Management Advisor-Multi-Center (TMA-MC) is an extension of the Free Flight Phase 1 Traffic Management Advisor tool to a multi-facility environment. The purpose of TMA-MC is to assist traffic management coordinators in planning and managing streams of traffic into selected airspace, as well as

into selected TRACON facilities that receive traffic from two or more en route centers. Research focuses on the Northeast corridor, with the goal of improving the arrival flows into Philadelphia International Airport, thereby increasing operational efficiency at the airport, as well as identifying the requirements for TMA-MC at the New York airports.

During fiscal year 2002, researchers established a TMA-MC test bed in the Technical Free Flight Technology Integration Laboratory (FFTIL). The FAA and NASA Ames Research Center jointly manage the research and development of TMA-MC as part of Free Flight Phase 2 with the objective of determining the operational acceptability of TMA-MC and facilitating deployment into the National Airspace System. Researchers conducted functional demonstrations, simulations, and operational evaluations at both the NASA Ames Research Center and the FFTIL test bed. In addition, in preparation for the TMA-MC field evaluation planned for fiscal year 2003, data feeds were established from New York, Washington, Cleveland, and Boston Air Route Traffic Control Centers to laboratories at both NASA Ames Research Center and the FFTIL.

Surface Management System Display

In June of 2002, the FAA/NASA Interagency Air Traffic Management Integrated Product Team Surface Area Work Team hosted an airport surface traffic management conference at the NASA Ames Research Center. This meeting brought together government and industry stakeholders to discuss airport surface research topics, and provided an opportunity for participants to reinforce networks and coordinate related projects and activities. Participants included representatives from Delta Airlines, United Parcel Service, NAV Canada, EuroControl, ARINC, Raytheon, Computer Sciences Corporation, Sensis, Metron, Seagull, MITRE/Center for Advanced Aviation System Development, Massachusetts Institute of Technology (MIT) International Center for Air Transportation, MIT/Lincoln Laboratories, and Volpe National Transportation Center. The work team seeks to develop a unified vision and concept for airport surface traffic management, and identify enabling technologies for the future airport Surface Management System (SMS). SMS is expected to address the air traffic controllers' needs while providing the airlines with collaborative decision-making information that should make both air traffic control and airline operations more efficient. In January 2002, researchers conducted a SMS evaluation in conjunction with air traffic controller teams. They demonstrated selected SMS functionality at airline ramp towers in Memphis, TN in August 2002.

In 2002, researchers successfully prototyped and evaluated the Slot Credit Substitution tool in conjunction with participating airlines. This tool allows airlines greater flexibility in swapping aircraft between slots that have been allocated to them in the ground delay program. SCS is anticipated to transition to implementation into the traffic flow management system in FY 2003.

The Integrated Aircraft Data Collection and Reporting project is a prototyping effort to evaluate the benefits and advisability of collecting and down linking operating data to a ground station for real-time or near real-time monitoring and post-flight analysis. Technology assessments, feasibility studies, and a series of prototype systems will be developed over a 3-year period. The year 2002 also marked the generation of program plans, concept of operations documents, conduct of technical assessments and evaluations, and assembly of an initial prototype.

Airborne Internet

The FAA develops and evaluates an Airborne Internet (AI) proof of concept in coordination with NASA's Small Aircraft Transportation System (SATS) program. Airborne Internet is a transmission control protocol/Internet protocol-based (TCP/IP) air-centric architecture providing aircraft with the ability to receive and transmit data for multiple simultaneous functions, including navigation, data communications, and surveillance functionality. The SATS program uses the Airborne Internet to establish a robust communications channel between aircraft and the ground network. Airborne Internet allows aircraft to run applications and transfer data over standard Internet protocols. By combining mobile network connectivity with GPS-based position determining, this capability has the potential to augment the National Airspace System secondary surveillance radar function. In FY 2002, the FAA developed a prototype system test bed in partnership with NASA and conducted a series of demonstrations between July and September 2002.

Wide Area Augmentation System Display

WAAS Providing Solutions

Finding solutions to integrity shortfalls followed by validation and verification of those solutions is the primary focus of the researchers in the Wide-Area-Augmentation System (WAAS) program. During the fiscal year, the research and development efforts by Stanford University, Boston University, JPL, and ZETA Associates on issues associated with integrity, validation, continuity, and availability to users supported this focus. Validation included analysis that provides proof that the algorithms developed for detecting and mitigating anomalous ionosphere activity and ensuring bounding of user error would satisfy the system integrity requirement.

The FAA currently provides testing and analysis services for global positioning system (GPS-L5) ultra wideband compatibility, studies on ionosphere effects on satellite based augmentation systems, and develops a full-scale engineering model prototype WAAS L1/L5 Signal Generator, which will be used to evaluate the proof of concept for dual-independent operating WAAS Signals-in-Space.

In addition, researchers continued work on interference detection, mitigation, radio frequency threat scenario development, signal quality monitoring, minimum operations performance standards and standards and recommended practices validation, time synchronization, and research into the compatibility of GPS and existing ground-based navigation aids. Researchers also modified and adapted key global positioning system software packages, such as the WAAS Ionosphere Software.

ADS-B Testing in the Ohio River Valley

Ohio River Valley

Under Safe Flight 21 (SF-21), the FAA is conducting an ambitious demonstration and test program in conjunction with the Cargo Airlines Association (CAA) and with the Aircraft Owners and Pilots Association (AOPA). The program explores how Automatic Dependent Surveillance-Broadcast (ADS-B) and other new communication, navigation, and surveillance (CNS) technologies can be used to increase situational awareness and surface safety. These demonstrations and tests are designed to collect and evaluate the data needed on ground infrastructure and avionics performance to enhance surveillance using ADS-B.

In 2002, SF-21 expanded its Memphis test bed to include wide-area multilateration and installed ADS-B technology on ten airport vehicles. Flight demonstrations using ADS-B avionics from four different vendors, conducted in May, validated the avionics performance and interoperability. Data also was collected on the use of traffic information broadcast services, terminal multilateration, and vehicle tracking performance with this equipment. The findings and results from these efforts will guide future ADS-B application demonstration and testing.

Enhancing Flight Safety in Alaska Using ADS-B and Other Technologies

Alaska Capstone Initiative

Under the Safe Flight 21 program, Alaska Capstone is a joint industry and Federal Aviation Administration (FAA) initiative to reduce the high rate of aviation accidents in Alaska by implementing new communications, navigation, and surveillance (CNS) technologies. The program's primary focus is to improve aviation safety through the introduction of new aircraft avionics and ground infrastructure that improve the pilot's situational awareness about traffic, terrain, and weather.

Under this initiative, the concept of remote, ADS-B 'radar-like services' through data link transceivers and terrain awareness using electronic multifunction displays is being validated in the Bethel and Yukon-Kuskokwim Delta area of southwestern Alaska. The use of ADS-B in mountainous areas and areas with limited or no radar coverage is one of several ambitious goals of this program.

The Capstone program is now being extended to the southeast region of Alaska, around Juneau, the state capital. This second phase improves upon earlier efforts through the enhancement of ADS-B avionics and their installation on up to 200 commercial aircraft in the Juneau area. Advanced, real-time three-dimensional terrain features will be integrated into the primary flight display, along with an expanded ground-based infrastructure.

Satellite Dish

Exploring the Role of Satellites for Providing CNS Capability in the NAS

Under a cost-sharing contract with the Boeing Company, the FAA explores the role satellite technology can play in providing communications, navigation, and surveillance (CNS) in support of air traffic management (ATM) and other capabilities. In conducting this research, the Global Communications, Navigation, and Surveillance System (GCNSS) team supports the development of a business case for this capability. The team also demonstrates a highly integrated, secure common information network (CIN) for use in air traffic management and data distribution to requiring organizations, and a broadband, secure communications capability that provides secure digitized data communications between aircraft and the ground, as well as the real-time submission of flight and voice data.

This 21-month proof-of-concept effort between the FAA and Boeing's Air Traffic Management subsidiary was awarded in July 2002. The program office's primary goal for GCNSS is the demonstration of CIN, developed collaboratively with team partners. An integrated baseline for the program has been established, and the first flight demonstration took place in Seattle in January 2003, using Boeing's Connexion test bed aircraft.

Special emphasis will be placed on conducting activities and analysis related to the Gulf of Mexico (GOM) to identify any potential near-term solutions to GOM CNS issues. These analyses will include extensive trade studies, scenario developments, modeling and simulation, and an architecture review and analysis study. Flight tests will demonstrate how new concepts, technologies, systems and procedures can be integrated with the existing FAA CNS/ATM architecture.

The National Airport Pavement Test Facility

National Airport Test Facility

The introduction of new aircraft types such as the Airbus A380 and Boeing B-777 are expected to have a severe impact on the nation's airport pavements. The National Airport Pavement Test Facility (NAPTF) is a unique test facility collecting full-scale traffic data under controlled loading conditions. The NAPTF is fully enclosed in a building 1,200 feet long by 100 feet wide. Its test vehicle can simulate up to 75,000 pounds per wheel on two landing gears (total of 12 wheels) at speeds of up to 15 mph, with lateral wander patterns and fully automatic operations. In FY 2002, FAA researchers completed the first series of full-scale traffic tests at the NAPTF under simulated loading by B-777 and B-747 aircraft, and initiated an analysis of the pavement life data. After the completion of the first stage of testing, a number of trenches were opened to take measurements and to directly observe the mode of failure. Beginning in July 2002, new pavement test sections were constructed and also tested to failure. Improved design standards based on these data will provide substantial cost savings to the AIP by better predicting pavement life and reducing costly premature failures. Over 50 gigabytes of data have been collected. A searchable database has been created and is on the web at http://www.airporttech.tc.faa.gov/naptf/.

In-pavement Runway Guard Lights at Chicago O'Hare International

In FY 2002, the FAA began a research effort to investigate operational problems resulting from the installation of in-pavement Runway Guard Lights (RGL) at entrances to the runways at Chicago O'Hare International Airport. Specifically, pilots exiting the runways at locations where flashing yellow RGLs were located reported seeing considerable reflected light from the recessed fixtures. As a result of the evaluation, the FAA changed its specification for the inset runway guard light system.

Pavement Marking Research

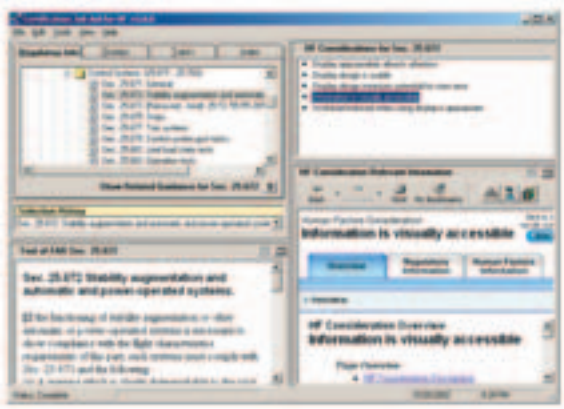
The Airport Safety Technology Section, AAR-411 conducted two evaluations concerning pavement marking research. The goals of this research are to enhance the day/night visibility of the pavement markings and to develop a criteria establishing when to repaint the surface marks. To determine the effectiveness of this test, three sets of paint lines were placed at the Atlantic City International Airport for the evaluations. Final results of the evaluations will be available between the latter part of 2002 and early 2003 fiscal year.

System Efficiency

The FAA strives to provide an aerospace transportation system that meets the needs of users and is efficient in the application of FAA and aerospace initiatives.

To accomplish this goal, FAA researchers are continually developing technologies and procedures that will reduce system delays, improve performance in bad weather, provide air traffic services to a wider range of aircraft, apply satellite-based navigation and positioning technology, and increase system flexibility and adaptability.

Human Factors Certification Job Aid



JOB AID SOFTWARE

In FY 2002, FAA researchers and certification specialists began testing a new computerized decision support tool to help Agency certification specialists and aircraft designers ensure that aircraft flight deck technologies are user friendly. This decision aid will assist certification and design personnel in identifying, assessing, and resolving potential design-induced human performance errors that could contribute to aviation incidents and accidents. In addition to enhancing the speed, accuracy, and repeatability with which certification engineers can access relevant regulatory and human factors information to make their decisions, this tool also helps designers identify possible design changes to alleviate human performance issues and enables researchers to identify gaps in current human factors knowledge. This PC-based software, designed with three major databases, addresses regulatory information, flight deck components, and human factors considerations. In the current version, the information in the databases focuses on transport category airplane flight deck displays. In the next version, which will be completed in 2003, the databases will be expanded to address transport category airplane flight controls.

Human Factors Considerations in the Design of Surface Map Displays

SURFACE MAP DISPLAY

The FAA and aviation community develop surface map displays that provide real-time information regarding traffic positions on the airport surface. In FY 2002, Human Factors researchers completed a draft report entitled, *Human Factors Considerations in the Design of Surface Map Displays*. This document captures all the human factors issues relevant to the design and development of surface map applications, and supports Aircraft Certification in review and evaluation of surface map displays. The report was used as source material for human factors guidance in the development of the RTCA SC-181 draft revision of the *Minimum Operational Performance Standards for the Depiction of Navigational Information on Electronic Maps* (DO-257).

Human Factors

Aviation safety improvements are dependent on developing a national aviation system that is not only technically sophisticated, but also human performance-based and human-centered. The FAA requires that human factors be systematically integrated at each critical step in the design, development, and testing of advanced technologies introduced into the National Airspace System. Through research in areas such as selection, training, workload, and communication, the Agency identifies the most effective procedures to be used in combination with new technology applications resulting in a more capable workforce to make the global air transportation system of the future safer and more efficient.

Scenario Generation with the RRLOS Tool

RRLOS Operational Guide

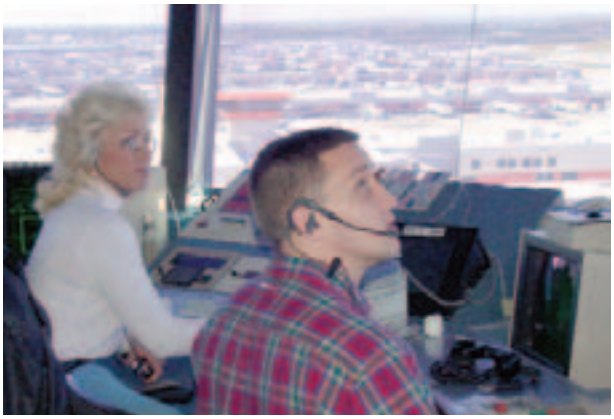
The computerized Rapidly Reconfigurable Line Operational Simulation (RRLOS) scenario generation system logically combines pilot training event sets and creates training materials. RRLOS targets specific skill areas, thereby allowing the quick generation of scenarios which are customized to the trainee and his/her training needs and includes customized training materials such situation reports, maps, and weather data. The FAA delivered the tool to over 40 air carriers and other aviation organizations. In the past year, researchers updated RRLOS twice and reengineered the tool to give it increased functionality. Additionally, the FAA provided training to multiple airlines in the use of the tool.

Human Factors Considerations in the Design and Evaluation of Electronic Flight Bags (EFBs)

Electronic flight bags are quickly becoming multi-function devices supporting an array of applications beyond those of a traditional flight bag, from electronic messaging to display of live weather. To help FAA evaluators, system designers/manufacturers, and users understand the human factors considerations that may be associated with EFBs, the Volpe National Transportation System Center developed, *Human Factors Consideration in the Design and Evaluation of EFBs, Version 2.0* for the FAA. This publication supports FAA EFB Advisory Circular (AC 120-76) and covers human factors system considerations and four EFB functions: electronic documents; electronic checklists; flight performance calculations; and electronic charts.

Human Error Analysis of CFIT Accidents

FAA researchers completed an analysis of general aviation controlled flight into terrain (CFIT) accidents and made a key presentation to the Annual Scientific Meeting of the Aerospace Medical Association in Montreal. In an analysis of over 16,500 general aviation accidents using the Human Factors Analysis and Classification System, researchers found that CFIT accidents were more often associated with perceptual errors and violations of the rules than were non-CFIT accidents. These findings and those comparing flight into terrain versus flight into obstacles like telephone wires, towers, etc., have been documented in a Technical Report currently in the review process.



Air Traffic Controllers monitoring flight

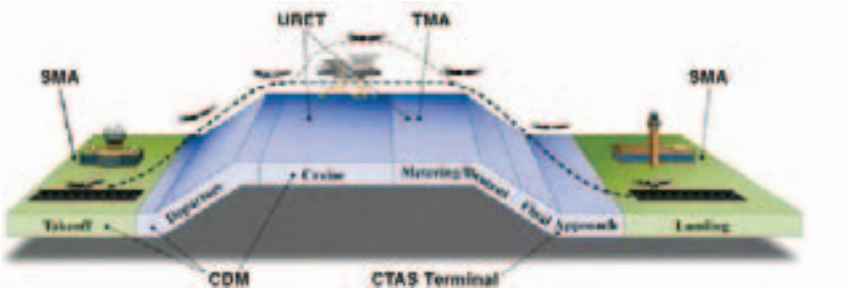
Loss of Primary Instruments

The FAA completed a collaborative study with the Air Safety Foundation of the Aircraft Owners' and Pilots' Association (AOPA) assessing the effects of vacuum-system/ attitude-indicator failures on pilot performance. Results indicated more problems with high-performance (complex) aircraft than with simple aircraft, and were consistent with the baseline data from simulator studies. The International Symposium on Aviation Psychology accepted a manuscript detailing this effort for publication and the FAA plans to publish a technical report on the research findings. In addition, the FAA is incorporating the findings into an advisory circular. To read the results of this research on-line, please visit: http://www.cami.jccbi.gov/aam-400a/Abstracts/2002TechRep.htm

Plane caught on wires

Free Flight Phase I Evaluation

During the fiscal year, researchers conducted a study to determine the potential human factors issues of co-locating some of the Free Flight Phase I technologies. Four primary human factors issues emerged from the analysis, including human-computer interface consistency, radar information presentation, roles and responsibilities for the Radar and Radar Associate controller positions, and updating the National Airspace System database. The FAA will address these potential issues in the course of the Free Flight Program's development plans.



Free Flight Phase I Diagram

Studying Shift Work and Fatigue

In FY 2002, the FAA published and distributed to 20,000 FAA controllers a pamphlet describing the results of a survey and corresponding multi-media CD containing instructions and suggestions on how to cope with shift work and fatigue. The Agency's final reports for shift work and fatigue studies, which include Office of Aviation Medicine technical reports and presentations from the Annual Scientific Meeting of the Aerospace Medical Association and the Annual Convention of the American Psychological Association, can be viewed on-line at: http://www.cami.jccbi.gov/aam-400a/Abstracts/2002TechRep.htm

Shift Work and Fatigue Technical Reports

Training for Runway Safety

The FAA, working with the Department of Transportation's Volpe National Transportation Systems Center, developed a prototype CD-ROM training tool for tower controllers. This interactive CD is based on the highly successful booklet, *Runway Safety: It's Everybody's Business*. The tool contains "learn-by-doing" modules on memory, communications, attention and perception, teamwork, and fatigue.

Air Traffic Control Operational Errors/Runway Incursions

FAA researchers and NATCA representatives conducted a beta test of JANUS, a technique for analyzing causal human factors in operational errors. As a part of this process, the FAA and NATCA signed a national memorandum of understanding for the beta test and validation processes. Researchers trained in the use of the JANUS taxonomy collected data from 79 operational errors at towers, TRACONs, and ARTCCs.

Runway Safety

Additionally, researchers provided support to the Runway Safety Program during review of the runway incursion at Linate Airport in Milan, Italy. The researchers used ATC voice transcripts and other available information to identify and classify potential human and contributing factors using the JANUS technique. The FAA also completed a draft version of JANUS for ground operations and are currently using data from existing FAA databases to assess the sufficiency of the available human factors information.

Advanced ATC Concepts Research

FAA human factors researchers examine the effectiveness of an advanced operational concept identifying a new multi-sector planning position as a way to maintain safety while improving the efficiency of controlling air traffic. Several proposals suggest the FAA implement a new multi-sector planning position that would be part of a multi-layered air traffic control system. The proposals for the multi-sector planning position involve a range of roles and responsibilities.

Thirty controllers from en route centers controlled traffic in a human-in-the-loop simulation in three operational team configurations and under low and high task loads. The controllers indicated that information needs differ significantly between radar and multi-sector controller positions. This finding has direct implications for the design of tools that transition controllers from a tactical focus on a single sector to a more strategic focus spanning several sectors.

Improving Efficiency through Visual Symbols Standardization

During FY 2002, a research team collected data on visual symbols used at maintenance control centers through site visits to six centers, review of computer-based instruction programs for various systems, interaction with subject matter experts, and a review of software documentation manuals. The complete study, including recommendations toward standardization, is contained in the new technical report titled, *A Catalog of Graphic Symbols Used at Maintenance Control Centers: Toward a Symbol Standardization Process*. This report can be found on-line at http://www.hf.faa.gov/docs/508/docs/wjhtc/tn0202.pdf.

VISUAL SYMBOLS

The Human Factors Design Guide for Acquisition

The Human Factors Design Guide for Acquisition of Commercial Off-the-Shelf Subsystems, Non-Developmental Items, and Developmental Systems is a comprehensive compilation of human factors standards, principles, and guidelines integral to the procurement, design, development, and testing of FAA systems, facilities, and equipment. The FAA is updating this important human factors reference tool. Soon to be released as a design "standard," the document will provide a single, easy-to-use source of human factors design criteria oriented to the needs of the FAA mission and systems. The new document, called the, *Human Factors Design Standard*, updates and clarifies the previously published material. It broadens the focus to include both air traffic and airway facilities systems and has been modified into a set of standards instead of a set of guidelines, providing a common source of FAA-specific design requirements. The recently revised *Chapter 5: Automation Guidelines* is now on-line at http://acb220.tc.faa.gov/hfdg/

Technology Takes a Second Look

More than 155 million Americans use some type of ophthalmic device to correct a vision deficiency. However, the use of refractive surgery, particularly Laser Insitu Keratomileusis (LASIK), is rapidly increasing in popularity. This procedure can have negative effects that should be recognized by Air Traffic Control Specialists and others who have positions that involve stringent visual standards.

The FAA's vision research team published a brochure to provide the air traffic controller with information regarding the compatibility of refractive surgery with the duties and medical requirements of air traffic controllers. The brochure can be found on-line at http://www.cami.jccbi.gov/aam-400A/Brochures/Laser_eye.htm. The report, *The Aviation Accident Experience of Civilian Airmen with Refractive Surgery*, can be found on-line at http://www.cami.jccbi.gov/aam-400a/Abstracts/2002TechRep.htm

Vision Tests

Getting out Over the Wing

The 2002 Access to Egress Study was the largest cabin evacuation study ever conducted by the FAA. A total of 2,544 people participated in various group trials to determine passageway configuration, hatch disposal location, and aircraft evacuation through a Type III exit (over the wing). Findings indicate that hatch disposal location slowed egress in some access aisle width configurations but not in others. Waist size, gender, and age all affected individual exit time. The findings are consistent with prior research showing that passageway configuration has only minimal effects on emergency egress as long as ergonomic minimums involving hatch removal are respected. In contrast, differences in the physical characteristics and lack of knowledge of individual participants produce large differences in emergency evacuation performance. The results of this research can be found on-line at http://www.cami.jccbi.gov/aam-400a/Abstracts/2002TechRep.htm.

Exiting over the Wing

Evacuation Research Saves Infants

The FAA's cabin safety researchers completed an Evacuation Slide Study research project to determine the most favorable methods for the evacuation of infants using inflatable emergency evacuation slides and the Type III (over wing) exit. Results confirm that passing an infant to another participant would produce slower egress than carrying the infant, and also suggest that the appropriate carrying position would depend on the size of the infant. These research results support cabin evacuation training and procedures development for improved infant evacuation. The results of this research can be found on-line at http://www.cami.jccbi.gov/aam-400a/Abstracts/2001/am01-18.htm.

EVACUATION OF INFANTS

MADYMO (MAthematical DYnamic MOdel) Implementation

The FAA's Biodynamics Research Team initiated a project to use the MAthematical DYnamic MOdel (MADYMO) computer program to support impact testing of aircraft occupant seats and restraints. The team completed an initial model of a double-occupant passenger seat and conducted a dynamic test to compare the results derived from the model with the actual impact test results.

MADYMO SERVO-HYDRAULIC SLED

Additional MADYMO seat models will be developed and actual seat testing will be conducted to enhance capability and improve accuracy in the seat and restraint system modeling process. The long-term objective of this project is to determine potential areas of model applicability in the aircraft seat certification process.

Environment

The adverse environmental by-products of aviation, primarily noise and emissions, are major constrains on the growth of aviation. Public concerns over the environmental affects of aircraft and airport operations, as well as increasingly stricter requirements embodied in laws and regulations, can severely constrain the ability of the aviation system to meet the nation's need for mobility, increased trade/market access, and sustained economic growth.

The FAA's environment and energy program seeks to develop superior decision support tools, and ensure response strategies that both protect the environment and aviation's economic health.

FAA-NASA Interagency Agreement for Aircraft Noise Reduction Technology

AIRCRAFT NOISE REDUCTION

On June 20, 2002, the FAA and NASA signed a new memorandum of agreement (MOA) to leverage each other's aircraft noise reduction technology investments. This MOA aims to form the basis upon which the FAA and NASA build programs to achieve the joint long-term national goal of containing objectionable aircraft noise within airport compatible land use areas. In August 2002, the FAA executed a new interagency agreement with NASA to commit to the tasks outlined in the MOA focusing on advancing the technology readiness level of noise-reduction technologies.

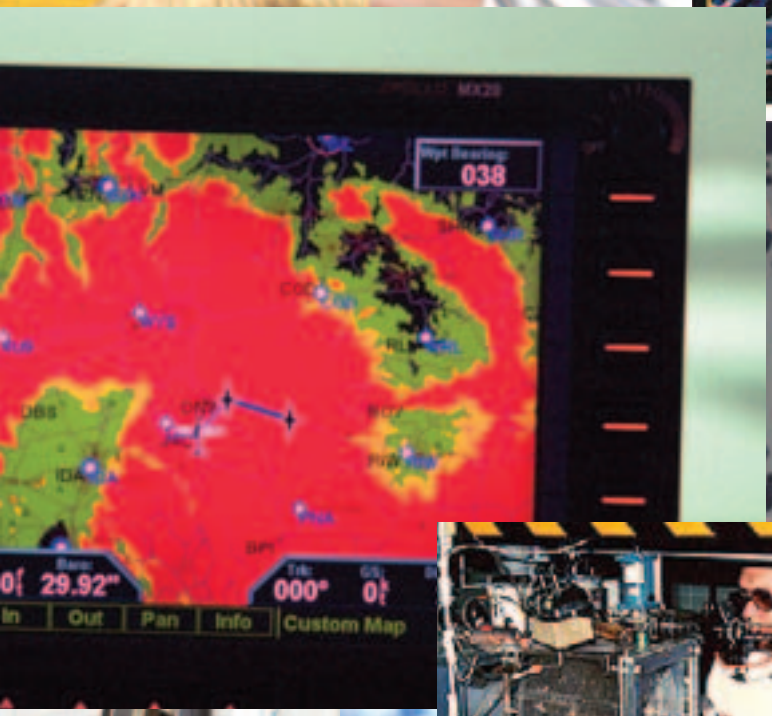
Emissions and Dispersion Modeling System (EDMS) Updated

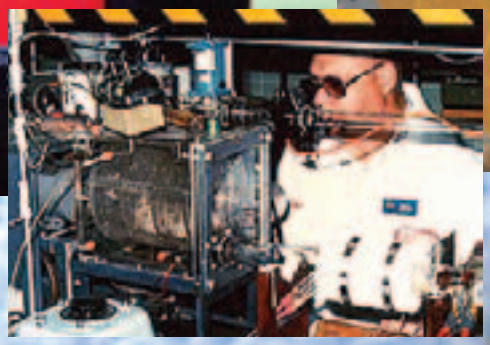
The FAA released version 4.1 of the Emissions and Dispersion Modeling System (EDMS). EDMS assesses the air quality impacts of airport emission sources, particularly aviation sources, which consist of aircraft, auxiliary power units, and ground support equipment. The Environmental Protection Agency (EPA) accepts this model as a *"Preferred Guideline"* model and is crucial to the performance of the air quality analyses of aviation emission sources for airport expansion projects. Version 4.1 incorporates enhancements resulting from a landmark aircraft plume study conducted by the FAA in coordination with the Department of Transportation's Volpe National Transportation System Center, the University of Central Florida, and the National Oceanic and Atmospheric Administration. The study provided the first-ever measurements of aircraft plume rise and spread from aircraft engine exhaust. The results allow a significantly enhanced model of aircraft plume behavior, which enables more accurate prediction of local concentrations of pollutants and greatly increase the validity of current aircraft engine exhaust dispersion modeling.

Particulate Matter (PM) Emissions Approximation Methodology

The FAA completed a review and analysis of available data and research findings on particulate matter emissions from aircraft engines. The effort enabled the FAA to develop a first-order approximation methodology to estimate particulate matter emissions from aircraft engines. Following peer review and EPA adoption for use, this methodology will fill the critical data gap that currently exists for aircraft engine particulate matter emissions and potentially remove constraints on air port capacity expansion by providing a presently nonexistent capability for environmental assessment.

Research &





Development

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