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

Federal Aviation Administration

Research & Development Annual Review 2003

Contents

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 leadership will assure and enhance the continued success of a safe, efficient, and environmentally compatible global aviation system.

The R&D program responds to the needs of FAA activities, such as aircraft and airmen regulation and certification, airport operations, air traffic services and commercial space transportation regulation, licensing and operations. 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.

From the Administrator

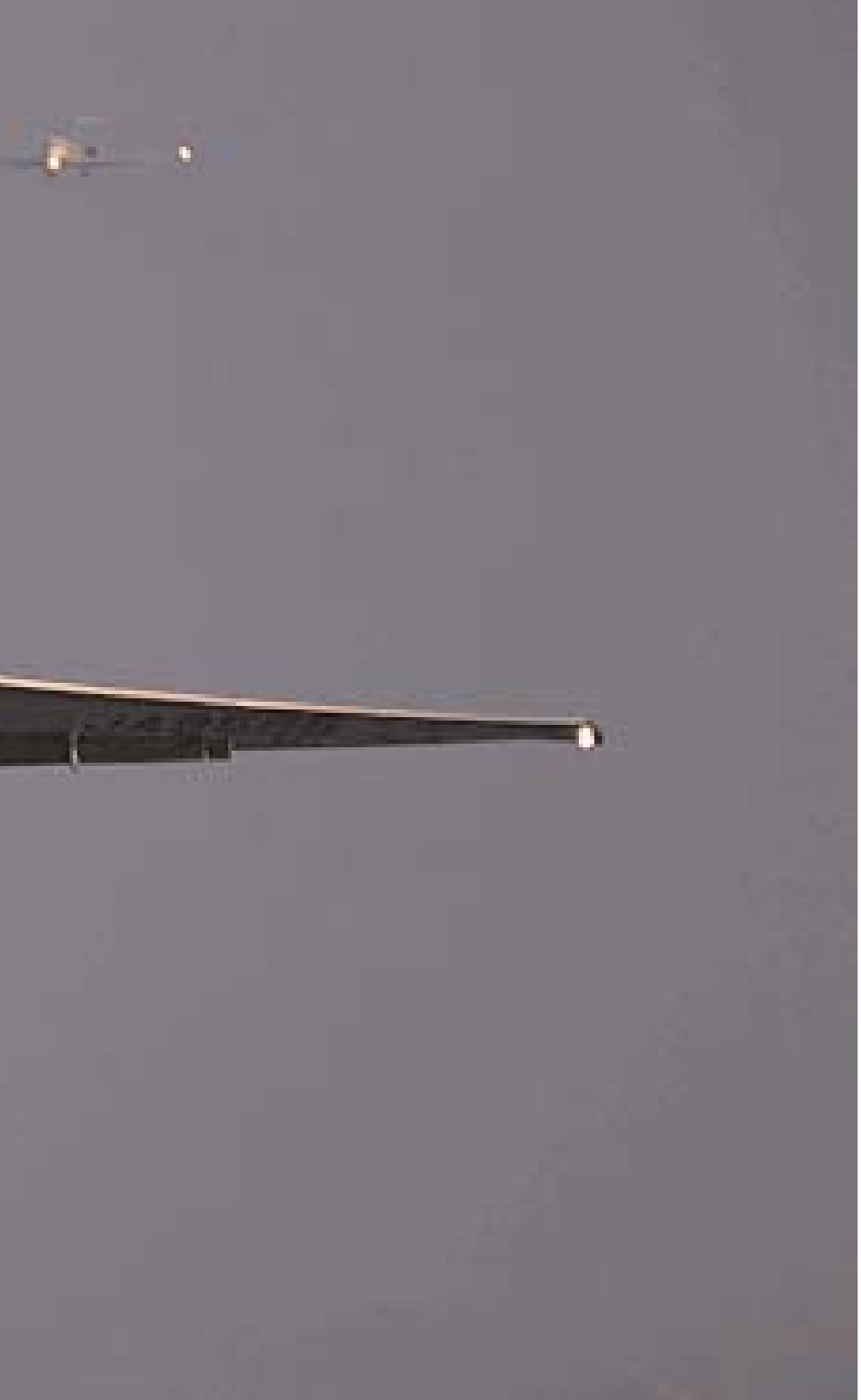
R&D Annual Review 2003

In 2003, the world celebrated the 100th anniversary of Orville and Wilbur Wright's first flight. These two brothers from Ohio-this country's first aviation researchers-used experimentation, exacting science, and perseverance to achieve their historic breakthrough. FAA researchers continue this legacy as they perform critical engineering and development to ensure U.S. global leadership in aviation. In 1903, our greatest challenge was the ability to master powered flight. In 2003, our achievements span the globe.

I would like to take this opportunity to express my appreciation to our research partners, both international and domestic, for their outstanding support and collaborative efforts. Their support, in cooperation with the diligent, committed service of FAA researchers and scientists has generated tools and technologies that continue to improve and enhance a safe, secure, efficient, and environmentally sound global aerospace system. Their work directly supports the FAA's *Flight Plan 2004-2008*. This strategic plan promotes critical goals to increase safety, provide greater capacity, maintain our international leadership, and create a world-class organization. Through cutting-edge research and development activities, we are already reducing commercial accident rates and building an air traffic control system capable of efficiently meeting future demand.

We are proud of the technological advancements that we made in 2003 and invite you to share in our accomplishments.

Marion C. Blakey
FAA Administrator



Aircraft & Airport Safety Research

R&D Annual Review 2003

An important element in maintaining the public's confidence in America's aviation system is the outstanding safety record of this country's air carriers.

Through our R&D activities, we develop the technologies and procedures that will maintain and improve safety in an evolving and demanding aviation environment.

Such improvements reduce fatalities, injuries, aircraft losses, help create better aircraft designs, and improve maintenance and inspection procedures.


FAA William J. Hughes Tech Center

ATR-42 Impact Test

Accident reports indicate that in many survivable accidents loose seat attachments and falling overhead bins and ceiling panels can seriously injure passengers. Because understanding the behavior of the cabin interior is critical to occupant survival, the FAA's crashworthiness research program is establishing cabin interior standards that will protect passengers and crew in the unlikely event of an accident. Before new standards can be set, however, the Agency needs to obtain comprehensive knowledge about structural safety issues and continuing airworthiness criteria for all types of aircraft.

In Fiscal Year 2003, the FAA conducted a vertical impact test of a high-wing regional commuter airplane. The test, the last in a planned series of commuter airplane tests, simulated a severe, but survivable, accident to evaluate the impact response of the fuselage, floor, seats, and anthropomorphic test dummies.

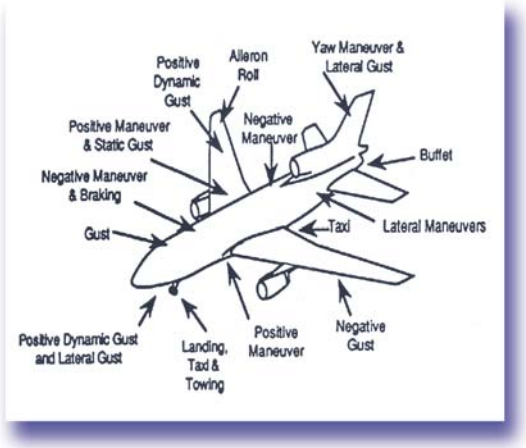
Researchers dropped an ATR-42, a 42 passenger twin engine turboprop high-wing airplane, from a height of 14 feet above the ground. It hit the surface with a final velocity of 30 feet per second. The airplane, with a wingspan of 81 feet, weighed approximately 35,000 pounds, and contained approximately 9,000 pounds of simulated fuel (water) and 2,100 pounds of luggage. Researchers configured the plane with two simulated engines, seven instrumented, anthropomorphic test dummies, three different types of seats, and 16 mannequins. Strain gages, displacement transducers, accelerometers, and onboard high-speed cameras recorded data from the drop.

The airplane sustained substantial structural damage, especially at the fuselage/wing mating area of the cabin. This test revealed the impact response characteristics of things such as overhead bins and auxiliary fuel tanks. The data collected will enable researchers to assess the adequacy of design standards and develop new regulatory requirements.

Photo Opposite Page:
ATR-42 prior to the FAA drop test

Operational Loads Monitoring

To ensure the appropriateness of the certification process for structural strength and fatigue life and to identify changes in service usage trends, researchers in FAA's Operational Loads Monitoring program are collecting flight loads data for major airplane configurations and landing loads data, such as touchdown vertical velocity, for a wide variety of airports and airplane model types. By taking advantage of newer technologies and improving data acquisition and analysis process, researchers are proactively assessing the validity of current landing loads airworthiness certification standards.



During FY 2003, researchers provided specialized operational loads data and analysis for the certification criteria for the Airbus A380 airplane; worked with the University of Dayton Research Institute to improve methods and criteria for processing and presenting commercial transport airplane flight and ground loads usage data; published statistical data concerning a regional jet airplane's usage, flight, and ground loads data, and systems operations; for the U.S. Forest Service, quantified the operational loads spectra experienced by aircraft involved in firebombing operations; and hosted a workshop to review and document the Statistical Discrete Gust (SDG) Method for use as an alternative procedure of estimating severe gust and turbulence loads. To view information on this critical research program please visit, http://aar400.tc.faa.gov/Programs/AgingAircraft/airbornedata/index.htm.

Photo Top Right:
Illustration of FAA's Operational Loads Monitoring System

Quality Assurance Methods for Fiber Reinforced Composites

The general aviation industry is now manufacturing new composite aircraft and using composite material applications in primary structures. Unlike metallic materials used in the structural part manufacturing processes, the material properties of composite materials are dependent on the fabrication process. Therefore, it is essential that those manufacturing and acquiring composite material have sufficient information to ensure that critical parameters in the material manufacture and structural fabrication process are controlled and that the composite materials meet requirements.

To ensure safety of the materials being used, FAA researchers identified the criteria for both material procurement specifications and fabrication specifications. As a result, the FAA issued two technical reports outlining specification requirements. The first report, *Guidelines and Recommended Criteria for the Development of a Material Specification for Carbon Fiber/Epoxy Unidirectional Prepregs* (DOT/FAA/AR-02/109, http://research.faa.gov/aar/tech/docs/techreport/ FY 2003/DOT-FAAAR02109.pdf), recommends guidance and criteria for the development of material specifications for carbon fiber-epoxy unidirectional prepreg tape materials used on aircraft structures and proposes the development of a shared composite material database.

Guidelines for the Development of Process Specifications, Instructions and Controls for the Fabrication of Fiber Reinforced Polymer Composites (DOT/FAA/AR-02/110, http://research.faa.gov/aar/tech/docs/techreport/FY 2003/ DOTFAAAR02109.pdf) provides a set of guidelines for the development of process information for the fabrication of continuous fiber reinforced polymer composite laminate test panels used in the generation of mechanical properties and an approach for the validation of composite fabrication processes used during the certification of composite aircraft structure.

This work provides the first level baseline for the establishment of material procurement and processing control to meet FAA requirements. The ultimate goal is to provide a catalyst to initiate industry standardization.

Photo This Page:
Composite Aircraft

On-Board Inert Gas Generation System to Prevent Fire Tank Explosions

Industry is challenging the FAA to develop a fuel tank inerting system to prevent fuel tank explosions that could be installed on commercial airliners within the next several years.

During FY 2003, FAA's researchers succeeded in developing a practical and cost-effective prototype system. Early experiments show that with this system the fuel tank continues to remain inert while the aircraft is on the ground, negating the need for labor-intensive and costly ground operations. The FAA system reduces the concentration of oxygen in a flammable fuel mixture to a level that will not support combustion by passing engine bleed air through an air separation module, a device that separates air into two streams of nitrogen-enriched air and oxygen-enriched air. The FAA system inerts the fuel tank by injecting the nitrogen-enriched air generated by the air separation module and discharges the oxygen-enriched air.

In the summer of 2003, the FAA and Airbus conducted flight tests of the FAA's inerting system in an A320 aircraft in Toulouse, France. Data from these tests is being used to enhance the inerting system's design. Also, in July 2003, Boeing began a flight test program to certify an onboard inert gas generating system based on the FAA design. FAA supported these tests with instrumentation, as described in *A Description and Analysis of the FAA Onboard Oxygen Analysis System* (DOT/FAA/AR-TN03/52. Boeing announced its intent to begin installing these systems on its 747 aircraft in FY 2005.

To view this report please go to http://www.fire.tc.faa.gov/pdf/TN03-52.pdf. For additional information on the FAA's fire safety research program visit, http://www.fire.tc.faa.gov/index.html.

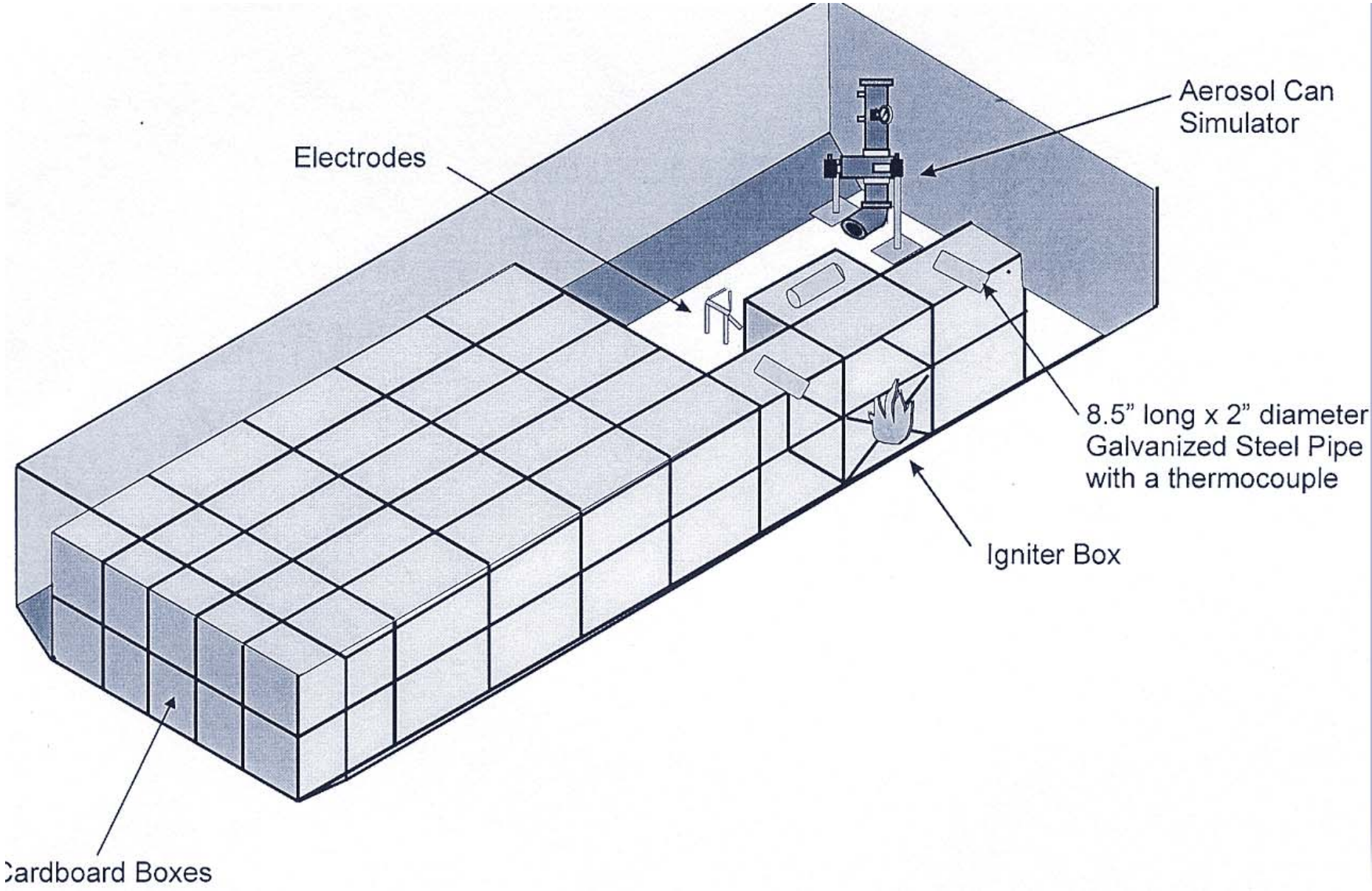
A Model for the Transport of Heat, Smoke, and Gases During a Cargo Compartment Fire

FAA regulations require that aircraft cargo compartment smoke detectors alarm within one minute of the start of a fire, to alert the crew before the fire can substantially damage the structural integrity of the airplane. Manufacturers demonstrate compliance with the regulations through the use of costly and time consuming in-flight and ground tests. To decrease the time and cost of the certification, researchers at Sandia National Laboratories developed a physics-based computational fluid dynamics tool, which couples heat, mass, and momentum transfer.

FAA researchers are currently performing validation experiments on the tool in actual aircraft cargo compartments that are extensively instrumented to record smoke, temperature, heat flux, and gas levels during the tests. They are preparing a report describing the computational approach used in the code, the graphical user interface, and the initial validation test results. If approved for use, the tool may enhance the certification process by determining worst case locations for fires, optimum placement of fire-detector sensors within the cargo compartment, and sensor alarm levels needed to achieve detection within the required certification time.

Photo Top Left:
FAA Fuel Tank Inerting System

Photo Top Right:
The inside of the Boeing 707 cargo compartment


Aerosol Can
Simulator
Electrodes
8.5" long x 2" diameter
Galvanized Steel Pipe
with a thermocouple
Igniter Box
Cardboard Boxes

Minimum Performance Standard for Halon Replacement Agents for Cargo Compartment Fires

Halon 1301 currently is the most effective means for complying with FAA fire suppression regulations. However, a ban on the production of Halon 1301, because of its harmful effects to the ozone layer, requires new fire suppression systems.

As a result of its research, in FY 2003 the FAA published *Minimum Performance Standard for Aircraft Cargo Compartment Halon Replacement Fire Suppression Systems* DOT/FAA/ARN03/6, which establishes the minimum performance standard that a Halon 1301 replacement aircraft cargo compartment fire suppression system must meet. It also describes the tests that must be performed to demonstrate that the replacement agent and suppression system provide the same level of safety as Halon 1301. The tests are one part of the total FAA and Joint Aviation Authority certification process for cargo compartment fire suppression systems.

FAA research indicates that new cargo compartment fire suppression systems must meet four different minimum performance standard fire test scenarios: bulk-load fire (Class A/C fire); containerized fire (Class A/C fire); flammable liquid fire (Class B fire); and an aerosol can explosion. To be considered for certification, new fire suppression agents must be tested 5 times under each of the minimum performance standard test scenarios.

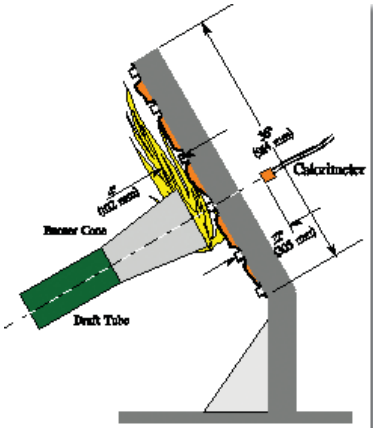
To view this report please go to http://www.fire.tc.faa.gov/pdf/TN03-6.pdf.

Photo Opposite Page:
Illustration of MPS Test Scenario, Aerosol Can Explosion Test

Photo This Page:
Radiant panel test instrument

FAA Adopts Final Rule Requiring Improved Fire Tests for Thermal Acoustic Insulation

As a result of FAA flammability tests of aircraft thermal acoustic insulation, the FAA adopted new flammability standards for the thermal and acoustic insulation materials used in transport airplanes. These standards include new flammability tests and criteria that address flame propagation and entry of an external fire into the airplane. The new standards will improve aircraft safety by reducing the incidence and severity of cabin fires by delaying the entry of postcrash fires into the cabin, allowing passengers more time for evacuation.



Previous regulations did not address the test method for postcrash fire burn-through resistance. To establish the new flammability test method, FAA researchers first created a new test apparatus, comprised of two main components: a large burner that simulates a jet fuel fire and a sample holder representative of the fuselage structural framing. Researchers set the burner flame conditions so that the melting time of aluminum sheeting would coincide with full-scale test results. By analyzing past accidents, they set the required pass/fail criteria for the insulation specimen at 4 minutes, because there would be very limited benefit beyond this period (i.e., approximately 5 minutes, factoring in the skin melting time). The FAA has tested numerous samples submitted by industry and many have passed the required criteria. Compliant specimens fall into three broad categories: advanced fibrous material (fiberglass replacement); fire barrier with existing fiberglass, and hardened film material.

The FAA's new test method, called the radiant panel test, uses a small-scale instrument to measure combustibility and flame propagation of materials subjected to a high heat flux. The pass/fail criteria require that any flaming not extend beyond a 2-inch length from the point of flame application or continue flaming after removal of the pilot flame.

Fire And Flammability

The two stages of fire development are ignition and growth. If a fire ignites and grows quickly in an aircraft cabin, there may not be enough time for passengers to escape. The FAA has determined that the heat release rate of burning plastics is the best indicator of how fast a fire can grow in aircraft compartments. Currently none of flame retardant plastic sold worldwide each year is tested for heat release rate. Instead, they are only tested for ignition resistance by measuring the time it takes for the fire to go out by itself after the material is removed from a Bunsen burner flame.

FAA researchers are studying the relationship between flame test performance and fire growth to understand the fire hazard of plastics. Researchers hypothesized that, in the absence of external heating, a plastic will cease to burn if the rate at which heat is released by the flame at the tip of the sample is insufficient to continue the burning process. To test this hypothesis, they measured the heat release rate of burning plastics without any external heating and compared these findings to the results of Bunsen burner tests of ignition resistance.

They found that the flame will go out when removed from a Bunsen burner flame if the heat release rate is below a critical value of about 100 kW/m^2. Both stages of fire development, ignition and growth, depend on the heat release rate, a quantity that is easily measured in larger quantities in a fire calorimeter or in smaller quantities in the FAA's microscale combustion calorimeter. Ultimately, heat release rate tests will enable fire protection engineers and FAA regulators to estimate more accurately the fire hazard of plastics.

Photo Opposite Page:
Bunsen Burner Test

Photo This Page:
Differential pressure gauge

Ground Tests of Aircraft Flight Deck Smoke Penetration Resistance

An International Civil Aviation Organization agreement requires new security considerations for the type certification of new aircraft. Specifically, aircraft must have special design features to prevent smoke and gases from entering the flight deck following the activation of an explosive or incendiary device anywhere in the aircraft outside the flight deck.

To help the FAA meet these new requirements, researchers conducted tests in the FAA's Boeing 747SP and 727 aircraft. Using a plastic sheet and theatrical smoke generators, they conducted aircraft ground tests to measure and demonstrate the amount of positive pressure differential needed between the flight deck and surrounding areas to prevent smoke penetration into the flight deck. As a result, in April 2003, the FAA published, *Ground Tests of Aircraft Flight Deck Smoke Penetration Resistance* (DOT/FAA/AAR/TN03/36).

The technique of using a plastic sheet to demonstrate the existence of a positive pressure differential and theatrical smoke generators to demonstrate the effectiveness of that pressure differential will be described in a new Advisory Circular as an acceptable method for complying with new regulations.

To view the report, please go to, http://www.fire.tc.faa.gov/pdf/TN03-36.pdf.

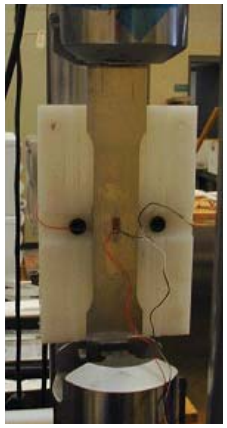
Destructive Evaluation of Aging Small Airplanes

By 2010, approximately 180,000 small airplanes will approach an average age of 40 years. Little is known about the consequences of the aging process on small airplanes, but comprehensive teardown inspections can provide critical information to determine the condition of high-time operational aircraft.

In 2003, the FAA completed both the inspection phase and teardown phase of a Cessna Model 402A. During the inspection phase, researchers performed over 100 visual inspections, as well as supplemental inspections on critical structural areas using nondestructive inspection techniques, such as visual, dye penetrant, magnetic particle, and eddy current. They also reviewed aircraft maintenance records, service bulletins, and airworthiness directives. The teardown phase included disassembly of the aircraft, inspection of aircraft systems' components, investigation of advanced nondestructive investigation methods, such as magneto optic imaging, laboratory testing of aircraft wiring, detail disassembly of aircraft sections, and microscopic examination of critical structural areas in the airframe.

This information is providing the knowledge and insight required to support rulemaking, advisory circular preparation, and findings of compliance for small aircraft.

Data and Methodologies for Structural Life Evaluation of Small Airplanes



With FAA funding, researchers at Wichita State University's National Institute for Aviation Research, in collaboration with small airplane manufacturers, are developing a structural life evaluation methodology for small airplanes. The purpose of this research is to support revision of FAA Advisory Circular 23-13, "Fatigue and Fail-Safe Evaluation of Flight Structure and Pressurized Cabin for Part 23 Airplanes."

The current fatigue-life evaluation methodology, which uses S-N (Stress levels - Number of cycles to failure) curves from full-scale test results of surplus military airplanes, often produces unrealistic estimates for fatigue life. Researchers are developing a fatigue life methodology that accounts for structural details, full-scale structural complexities, and loading spectrum. The end result will be a method that uses conventional stress concentration factors (that are functions of the structural detail) and empirical factors to determine the effective stress concentration factor for the structural detail.

Researchers have also initiated experimental work to generate appropriate empirical factors. This research will ultimately result in a database with credible S-N curves and statistical exceedance spectra, technical data to develop guidance material to support rule making, and a structural-life evaluation methodology for small airplanes.

Photo Top Left:
Disassembly of the Cessna Model 402A

Photo Top Right:
Test Specimen with Strain Gages and Antibuckling Fixture

Development Of Sonic Infrared Imaging Thermosonics Inspection for Aircraft Structures

Researchers have developed a nondestructive inspection technique, called sonic infrared imaging, or thermosonic imaging. This technique, developed by the Thermal Wave Imaging group at Wayne State University, with funding from the FAA's Airworthiness Assurance Center of Excellence, uses short pulses of ultrasound at frequencies beyond normal adult hearing capability to cause cracks in solid objects to heat up and become visible to an infrared camera. This patented technology potentially offers both broad area nondestructive inspection capability and high sensitivity to determine the presence of surface breaking and near-surface cracks, delaminations, and disbonds.

Photo Top Left:
Prototype Sonic IR system set up to inspect turbine disk

Photo Top Right:
Bonded Repair of a Composite Structure

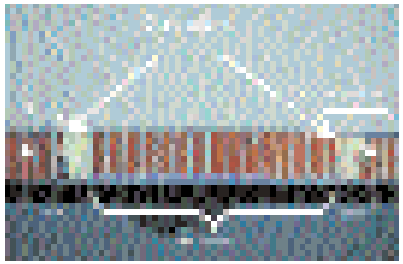
Bonded Repair of Composite Sandwich Structures

Fiber-reinforced composite sandwich structures are being used in a wide variety of aircraft components because of their improved stability and weight savings over other structural materials. However, as these become damaged or worn over time and use, it is necessary to develop repair methods that will restore the component's original design strength without compromising its structural integrity. One area of concern is whether large repairs are always necessary to restore strength or whether smaller, less-intrusive repairs can be implemented instead. Cure temperature can also become an issue if the repair patch requires curing at 350degrees fahrenheit, because bonding of the patch to the parent structure may induce further damage to the component. With these concerns in mind, in FY 2003, researchers evaluated the effectiveness of scarf repairs applied to sandwich structures given several bonding repair variables.

Researchers investigated the performance of different airline depots in repairing picture frame shear elements using two different repair methods: the Society of Automotive Engineers (SAE) Commercial Aircraft Composite Repair Committee (CACRC) developed wet lay-up procedure and an original equipment manufacturer (OEM) prepreg procedure. Each method had different cure temperatures and used different materials. They also examined the effect of different repair variables on repair performance. The variables considered included three different scarf overlaps, two different core-cell sizes (1/8-inch and 3/8-inch), and impact damage inflicted on the repair.

From the test results, it is apparent that the optimum overlap length is 0.25 inch irrespective of core cell size. Researchers also found that the 1/8-inch core beams have higher failure strains than the 3/8-inch core coupons for both the undamaged and damaged states. This research validates the use of the SAE Commercial Aircraft Composite Repair Committee repair procedures that are documented in numerous SAE publications and establishes the optimum scarf length for the repair of facesheets of composite sandwich structures.

Nondestructive Inspection of Composite Repairs



Because repairs made on the aircraft use a variety of procedures, the FAA is working to ensure these composite repair components are mechanically sound through a variety of nondestructive inspection methods and tools.

Funded as part of the FAA's Airworthiness Assurance Center of Excellence, Iowa State University researchers investigated the use and implementation of two complementary nondestructive inspection methods for composites repairs: Computer Aided Tap Testing (CATT) and Air-Coupled Ultrasonic Testing (AC-UT). The CATT, semi-automated and quantitative technique, is used to map the interior conditions of a repaired part. Tap tests need only one-sided access, but have a limited probing depth.

Researchers sought to correlate the interior conditions of a repair with the image resulting from a nondestructive inspection using both the CATT and AC-UT methods. After scanning with the CATT and AC-UT instruments, researchers sectioned and examined under optical microscope the repair panel slated for destructive sectioning and correlated their observations with the nondestructive inspection test results. They then rebuilt the skin over the re-cored region in a scarfed fashion and extended it outward to a diameter of about 8 to 9 inches, discovering a physical delamination just outside the core splice circle. On the cut surface the delamination appeared to be about 1" wide. Once they sectioned the repaired panel, they enlarged the CATT image and the AC-UT image to actual size and physically matched it to the sectioned surface.

The researchers found that both the computer aided tap test and the air-coupled ultrasonic scan could be used to image the internal features and conditions of a composite repair, including the re-cored area, the scarfed skin repair, and the delamination in the repaired skin. Overall, they discovered that the features in both the CATT scan image and the AC-UT scan image corresponded quite well with the internal conditions of the repair.

Industry is greatly interested in the potential use of these nondestructive inspection methods and has field tested both systems. At this time the air-coupled ultrasonic system is not yet capable of generating scan images in the field; however, work is underway for achieving a scan-mode air-coupled ultrasonic system for on-aircraft applications.

Damage Tolerance-Based Skin Repair Software

The effect of repairs on aircraft structural integrity is one of the critical issues that must be addressed to assure the continuing airworthiness and operational safety of aircraft. Recognizing that fact, in late 2002 the FAA published the Aging Airplane Safety Interim Final Rule, which requires the use of damage tolerance-based inspection programs on airplanes with multiple engines and ten or more passengers used in scheduled operations. To assist the small airplane industry in complying with this rule, FAA researchers developed an integrated design assessment tool, Repair Assessment Procedure and Integrated Design for Commuters (RAPIDC).

RAPIDC is an automated static strength and damage tolerance analysis tool for skin repairs and antenna installations. It automatically generates a detailed repair assessment report that includes all the design parameters and configurations, analysis methodologies, and results from damage tolerance analysis. It is a PC Windows-based software with user friendly, point-and-click graphical user interface features. A built-in advisory database provides repair guidelines. The FAA released RAPIDC, Version 2.0, on January 31, 2003, on the Internet at: http://aar400.tc.faa.gov/Programs/AgingAircraft/Commuter/RAPID.

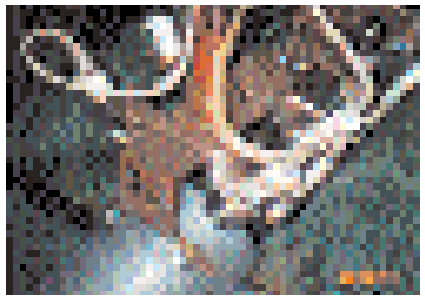
This latest version includes a built-in finite element module, an automatic finite element module mesh generator, a load spectrum generator, and static and damage tolerance analysis modules for fuselage skin repairs and antenna installations. The built-in finite element module helps determine fastener load transfer of mechanically-fastened multiple layers and the automatic mesh generator eases users' efforts for model preparation.

FAA's researchers also designed a new capability for irregular fastener pattern into the RAPIDC design process. This capability allows users to place fasteners, as found in an operational environment, rather than the straight line previously required by the program. This feature is especially critical for the design of elliptical, sausage, and teardrop repair doublers (patches).

Photo Top Left:
Composite Repair Sites

Photo Top Right:
Aircraft Skin Repairs

Inspection Development for Nickel Billet



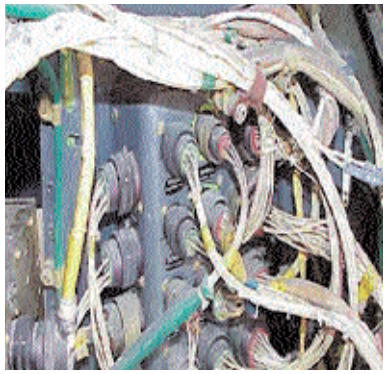
In 2003, the Engine Titanium Consortium, an FAA funded consortium consisting of General Electric, Honeywell, Iowa State University, and Pratt & Whitney, demonstrated a new ultrasonic inspection system for nickel alloys used in jet engines. The new inspection system, has improved sensitivity to material anomalies that can reduce the durability of critical rotating components.

Using this system, researchers inspected Waspaloy and Iconel 718, two of the most common alloys used for high temperature rotating components. The system showed improved detection ability over the conventional billet inspection method. In fact, it had a six-fold improvement over the conventional system. Improved production inspections are reducing the occurrence of melt related defects in final engine hardware resulting in fewer engine failures and improved flight safety.

Photo Top Left:
Inspection of Nickel Billet

Photo Top Right:
Aircraft Wires

Material Testing Research and Indenter Development for Determining Aging of Wires in Aircraft



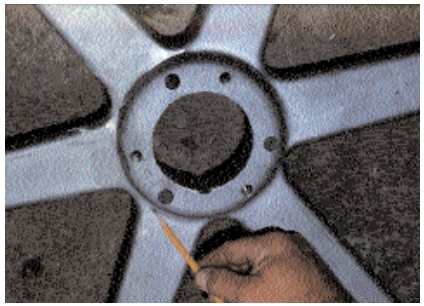
The FAA is committed to the research and development of advanced technologies for non-destructive inspection and non-destructive testing of aircraft electrical wiring interconnect systems. As wires age they become brittle and crack, which may result in significant electrical malfunctions and dangerous conditions, such as electrical arcing. Researchers are currently working to determine if changes in the hardness of a wire insulation system correlates with other accepted, though destructive test methods. As part of this effort, they developed an indentor tool, a portable, simple-to-use instrument for performing these measurements.

Typically researchers evaluate changes in mechanical properties using elongation-at-break testing. This type of testing is destructive and requires relatively large specimens, making it undesirable for analyzing installed cables. As an alternative to elongation-at-break tests, indenter tests provide a systematic indication of material aging. Periodic indenter measurements of an installed aircraft wire can be compared to elongation-at-break, indenter correlation graphs to monitor the progression of cable degradation.

In Fiscal Year 2003, researchers redesigned the indenter for compatibility with small gauge aircraft wires and for portability of the system for use within confined aircraft spaces; developed standardized test processes for using the modified indenter; accelerated thermal aging of various aircraft wire types currently used in aircraft; and evaluated the effects of accelerated aging on the insulation systems by performing indenter examinations, elongation-at-break tests, and wire insulation deterioration analysis system tests, and evaluating the correlations between these various test methods.

Researchers found that the accuracy of the data obtained by indenter is operator independent and previous indenter experience is not necessary for obtaining accurate measurements. They also found the new indenter suitable for testing small wires installed in aircraft and produces reliable data.

Automated Signal Analysis System for Aircraft Wheel Inspection

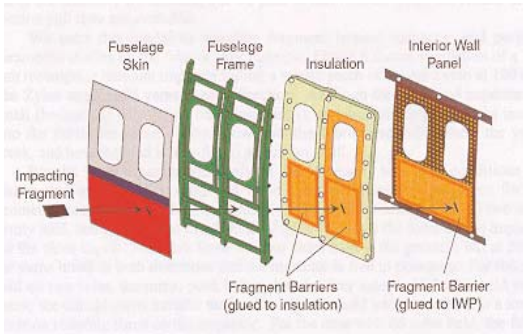


Since aircraft wheels are subject to excessive stresses during landing and taking off, the FAA requires a periodic inspection of wheels to ensure their continued integrity. Eddy current inspection is a widely used inspection technique for aircraft wheels, since it is faster and easier to implement relative to other inspection techniques.

Because analysis of eddy current signals generally depends on the decision of a human operator, the FAA, working with industry and academia, developed an automated signal analysis system for aircraft wheel inspection that makes the process fast and efficient. Under a grant from the FAA Delta Airlines is currently testing this new system created by Iowa State University, in collaboration with Northwest Airlines, and ANDEC in Toronto, Canada.

To use this system, the wheel is manually mounted on a rotating table and researchers input information about the type of wheel into a software program to determine the scan plan, such as positioning of the probe and the vertical distance covered by the probe. The eddy current probe is moved downward while the wheel is kept rotating, ensuring that virtually 100 percent of the wheel is scanned. The data collected can be displayed in time base digital strip chart form, impedance plane plots, and C-scan image form.

High-Strength Fabrics for Ballistic Protection of Flight-Critical Components from Uncontained Engine Failures



Fiscal year 2003 marks a major milestone in FAA's research to develop and apply advanced technologies for mitigating the effects of uncontained engine bursts. Uncontained engine bursts occur when inflight engine failures damage critical aircraft components.

To reduce the probability of such incidents, FAA and SRI International researchers are evaluating the ballistic effectiveness of fabric structures made from advanced polymers and developing a computational ability to design fragment barriers. The research focuses on three commercially available high-strength polymer materials—PBO (Zylon), aramid (Kevlar), and polyethylene (Spectra).

To date, researchers have found Zylon to have the most promise as a fragment barrier. The University of California at Berkeley completed small-scale ballistic testing of Zylon to verify the FAA/SRI modeling techniques. Prior to the ballistic tests, SRI and University researchers conducted modeling to predict the number of fabric layers necessary to stop the fragment. This modeling effort proved successful and resulted in a reduction in the number of tests necessary to characterize the barrier protection. SRI also completed large-scale (actual blade fragment sizes) ballistic tests on Zylon, and The Boeing Company conducted independent material development tests to verify strength and to assess environmental effects.

Photo Top Left:
Aircraft Wheel Inspection

Photo Top Right:
Armor Fabric Installation Schematic

Aircraft Engine Disk Crack Detection

Disks are heavy high-speed rotating parts inside an engine with attached fan blades that produce thrust. When a disk fails, it can have catastrophic results. Fast-moving fragments from the disk can disable or damage the airplane. FAA's aircraft disk crack detection research seeks to develop technologies that can identify a crack in a disk prior to failure.

During FY 2003, FAA researchers, in collaboration with their counterparts at the Naval Air Systems Command, U.S. Air Force, and NASA Glenn Research Center, conducted a full-scale engine test of new detection technologies.

Researchers conducted the tests at the Naval Air Warfare Center China Lake Division Weapons Survivability Laboratory on an instrumented TF-41 turbine engine, run through 4,474 cycles to propagate an embedded fault in the fan disk. Seven technology developers participated in the test. Crack detection technologies being investigated include acoustic emission, crack wire-mesh indicators, vibration, and proximity measurement to detect changes in the disk as the crack grows.

Uncontained Engine Debris Damage Assessment Model Released

Over the years, several civil aircraft accidents have occurred when fragments from in-flight engine failures damaged critical aircraft components. A single fragment from the failed part can cause the rest of the engine to be torn into sharp metal debris. The debris can then slice thought the engine casing and endanger other critical aircraft systems, crew, and passengers.

An FAA-sponsored research program is working to develop certification tools that minimize the probability of hazard to the aircraft and its occupants from uncontained engine debris. As part of that effort, researchers continued to update the uncontained engine debris damage assessment model. The tool analyzes the potential hazard to the airplane in accordance with the rotor burst guidance. The analysis can randomly simulate fragment scattering like a real event and repeat the analysis many times to develop the probability of hazard.

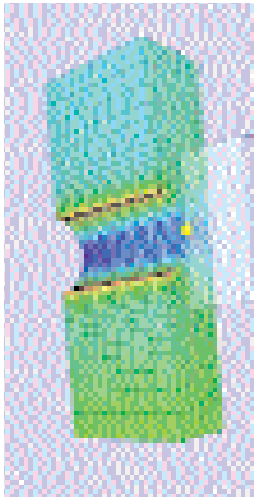
In February 2003, a training session took place for the FAA's Aviation Rulemaking Advisory Committee to familiarize airframe and engine manufacturers with version 2.0.2 of the tool, developed by the Naval Air Warfare Center Weapons Division China Lake and Service Engineering Company.

In addition to upgrades and training on the vulnerability assessment tool, researchers also published several research reports in support of developing revisions to AC 20-128, *Design Precautions for Minimizing Hazards to Aircraft from Uncontained Turbine Engine and Auxiliary Power Unit Rotor Failure*.

Photo Top Left:
Aircraft Engine Disk

Photo Top Right:
Fan Disk Failure Debris

A New Methodology for Surface Damage Tolerance Assessment



Aircraft turbine rotors can suffer rare, critical events (e.g., uncontained engine failures) caused by the presence of metallurgical (e.g., hard alpha) and manufacturing (e.g., surface damage) defects that occurred during the manufacturing process. Under a grant from the FAA, and in collaboration with major engine manufacturers, researchers at the Southwest Research Institute developed the software tool Design Assessment of Reliability With Inspection (DARWIN®) to predict the risk of fracture associated with aircraft jet engine rotors and disks subjected to surface damage. This tool computes the probability of fracture as a function of the number of flight cycles, considering random defect occurrence and location, random inspection schedules, and several other random variables.

Previous releases of DARWIN® focused on the risk assessment of titanium aircraft engine rotor disks with potential inherent hard alpha defects. To assess surface damage, developers recently introduced additional crack geometries in the DARWIN® 4.x releases. The user can now define a mission profile and crack geometry for each surface feature in the disk. Included in the mission profile definition are the stress, temperature, and stress gradient values at discrete time steps.

The recent release includes a number of enhancements, including PC and Linux versions, the capability to execute the analysis code directly from the Graphical User Interface, and improved deterministic crack growth assessment and visualization. A capability for modeling surface damage based on three-dimensional finite element geometry is currently under development for the 5.0 release.

FAA Unleaded Avgas Testing

For more than a decade the FAA has worked closely with aircraft manufacturers, engine manufacturers, petroleum producers, other regulatory agencies, and that Aircraft Owner and Pilot Association to facilitate the development of a safe, alternative unleaded fuel.

Traditionally, engines and airframes have been certified on leaded fuels that meet the American Society for Testing and Materials Standard Specification D-910. Since the octane requirement for unleaded fuels has not yet been established, FAA researchers are evaluating the performance of unleaded fuels in aircraft piston engines.

In 2003, the FAA, under a cooperative research and development agreement with the ExxonMobil Research and Engineering Company, performed a full-scale engine test on three candidate fuels supplied by Exxon Mobile and BASF. Researchers tested a continental IO 550D, 6-cylinder, naturally aspirated 300 horsepower engine for 150 hours under severe and controlled conditions to investigate issues of wear, performance, materials compatibility, deposit formation, startability, hot fuel operation, and a host of other issues. The FAA also knock-tested one prototype fuel in a Lycoming IO 540K, 6-cylinder, naturally aspirated, 300 horsepower engine for comparison to the knock behavior of a 100LL fuel in the same engine.

The results of these full-scale engine tests are very promising. ExxonMobil is considering taking the next steps necessary to validate the performance of its unleaded gasoline through engine certification and flight testing with a fleet of general aviation aircraft.

Photos This Page:
Modeling surface damage based on three-dimensional finite element geometry

Photo Top Right:
Plane landing

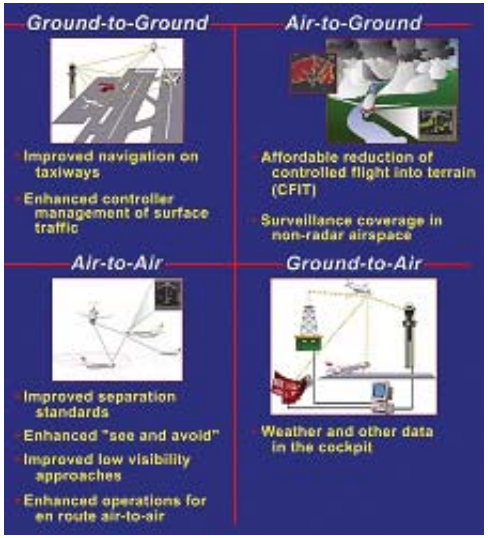
Safe Flight 21

Under the Safe Flight 21 program, the FAA is conducting an ambitious demonstration and test program in conjunction with the Cargo Airlines Association (CAA) and the Aircraft Owners and Pilots Association (AOPA). Nine operational enhancements areas selected by RTCA, are being demonstrated and validated, in real-world environments, to understand the capabilities of advanced surveillance systems and air traffic procedures. This information is providing the Federal Aviation Administration (FAA) and industry with valuable information needed to make decisions about implementing applications that have potential for significant safety, efficiency, and capacity benefits. The enabling technologies under evaluation, automatic dependent surveillance broadcast (ADS-B), traffic information services broadcast (TIS-B), flight information services broadcast (FIS-B) and surface moving maps are providing the methods to achieve safety and efficiency benefits in the National Airspace System (NAS).

In FY 2003 the Safe Flight 21 program continued to operate test beds in Memphis, TN, Louisville, KY and Fredrick, MD.

The Cockpit Display of Traffic Information (CDTI) Enhanced Flight Rules (CEFR) application was simulated to evaluate the concept using the Louisville-Standiford International Airport, KY (SDF) air traffic control environment under visual meteorological conditions and to evaluate pilot and controller human factors and procedural issues.

A supplemental type certification (STC) for enhanced situational awareness on UPS/Boeing 757/767 aircraft was approved. Based on approval, UPS begin equipping aircraft with ADS-B avionics. This was a major step in establishing the Louisville airport ADS-B test bed that will now include ADS-B ground infrastructure, automation systems and aircraft. A total of 107 ADS-B avionics suites are being installed.
Significant progress was made in the ADS-B standards development process with the RTCA approval of the 1090 MHz ADS-B Minimum Operations Performance Standard (MOPS), Rev A, and the Traffic Information Service Broadcast (TIS-B) Minimum Aviation System Performance Standards (MASPS). The 1090 MHz ADS-B MOPS, Rev A, facilitates/reduces cost of certification for 1090 MHz ADS-B avionics and the TIS-B MASPS establishes standards for use in ADS-B airborne applications in a mixed equipage environment.



Human factors evaluation and automation system upgrades continued for ADS-B integration with the Standard Terminal Automation Replacement System (STARS) and Common Automated Radar Terminal System (ARTS) automation systems. A demonstration was conducted in Memphis, TN to assess ADS-B/STARS integration efforts and the application for Final Monitor Aid (FMA).

To support surface safety applications, digital surface maps for over 80 airports with the greatest risk of runway incursions have been produced along with maintenance procedure assessments. Evaluation of the various platforms used to display the moving maps are underway and depending on the capability desired, aircraft and vehicle display platforms might range from permanent, certified displays to portable displays, such as Electronic Flight Bags (EFBs) or handheld Global Positioning Systems (GPS) units. These platforms will require varying degrees of certification before they are implemented in the NAS.

Agreements were reached with Embry-Riddle Aeronautical University (ERAU) for the Prescott, AZ and Daytona Beach, FL campuses and the North Carolina State Department of Transportation, Division of Aviation to implement ADS-B service pockets to enable general aviation broadcast service (traffic/weather) and flight following applications.

Photo This Page:
Safe Flight 21

Capstone

The Capstone program is a joint FAA and industry effort to reduce the high rate of aviation accidents in Alaska by implementing new communications, navigation, and surveillance technologies. The program's primary focus is to improve aviation safety through the introduction of technology to improve the pilot's situational awareness about traffic, terrain, and weather.

Based on successes in the Bethel, Alaska area, the next phase of the program, initiated in the Juneau area, is enhancing avionics by adding advanced, real time, three-dimensional terrain and a vector-based moving map integrated into the primary flight display. During FY 2003, the FAA selected vendors to produce enhanced avionics that include displays featuring instrument flight rules (IFR) and 3-D multifunction displays. The FAA approved a Technical Standards Order (TSO) for the Universal Access Transceiver-Automatic Dependent Surveillance Broadcast (UAT-ADS-B).

The FAA Administrator also approved Special Federal Aviation Regulation (SFAR) 97. This special "Alaska" rule authorizes properly trained pilots, using TSO C145/C146 Global Positioning System (GPS) and Wide Area Augmentation System (WAAS) navigation systems to fly air traffic routes at lower than usual altitudes using only specified GPS/WAAS avionics for navigation. Initial application of SFAR 97 in Southeast Alaska has created 41,000 feet of usable airspace spread over 1,521 nautical miles of existing routes.

Photo This Page:
Capstone Avionics

Advances in Flight Control Systems

Advances in the modern flight control design provide a means to provide a simplified control system for general aviation aircraft, which can increase aviation safety and make personal air transport available to larger numbers of people. Such a system also enables pilots with little experience to operate the aircraft in most weather conditions, provides an emergency autoland capability, and adapts to changes in aircraft behavior due to unanticipated failures or structural damage.

The FAA sponsored research at Wichita State University and the Raytheon Aircraft Company to develop a generic computer-aided flight control system concept that can provide simplified controls with enhanced safety features for a number of general aviation aircraft types.

In FY 2003, researchers investigated automatic flight control systems to determine the feasibility of designing a system with inherent capability to compensate for certain system failure conditions and abrupt changes in aircraft flight dynamics characteristics. A preliminary concept was developed and encouraging results were obtained.

Photo Top Left:
Beech Bonanza F33C

Experimental Study of Supercooled Large Droplet Impingement on Aircraft Surfaces

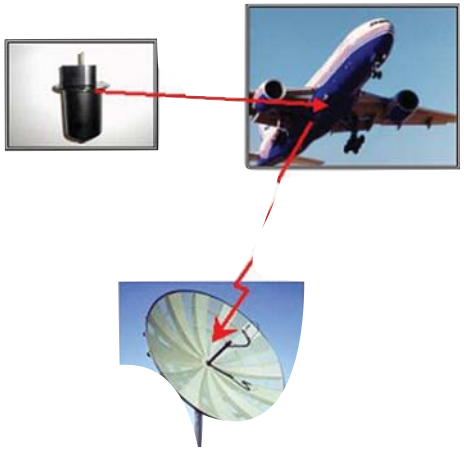
Supercooled water droplets can exist as liquid below 0 degrees Celsius, but turn to ice as the temperature rises. FAA regulations currently include recommendations on the size and location of ice protection systems on aircraft; however, to date, these standards do not take into account the development of supercooled large droplet icing conditions. Using the Glenn Research Center Icing Research Tunnel, researchers from Wichita State University, funded through an FAA grant, obtained experimental data to develop and validate droplet trajectory and impingement computer software programs.

Researchers used a dye tracer technique that had been used in the past for measuring local impingement efficiency on aircraft aerodynamic surfaces. The researchers injected water containing a small amount of water-soluble dye in the form of droplets into the air stream by means of spray nozzles. They covered the surface of the body with blotter material to absorb the dyed water and indicate the amount of impingement. At the point of impact and droplet absorption, a permanent dye deposit (dye trace) was obtained.

They conducted droplet trajectory and impingement computations with the computer program LEWICE (LEWis ICE accretion program). A comparison of the experimental data to the computer results indicate that this program over predicts droplet impingement conditions, especially in the tails of the impingement distribution. This suggests that modifications to LEWICE, and probably other such programs, will be necessary if they are to be sufficiently accurate to use for design and certification purposes.

Photo Top Right:
Spray bar nozzle system that produces super cooled water droplets

Downlinking of Icing Data from Commercial Aircraft

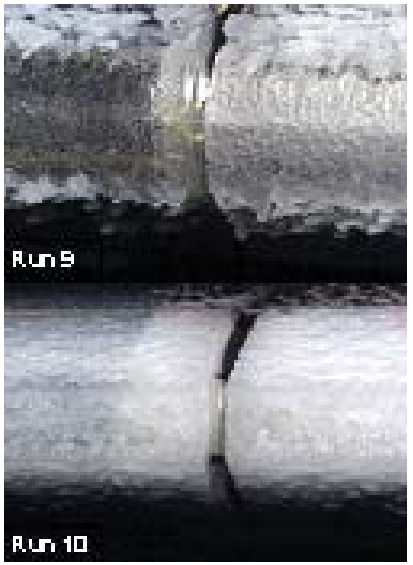


An ice detector warns the pilot when the aircraft encounters icing conditions. If information concerning an icing encounter on one aircraft could be provided in near real time to weather forecasters and to other aircraft, the pilots of other aircraft might be able to avoid potentially hazardous icing conditions. Also, archived data from icing encounters could be used in the evaluation and the modification of current icing forecast models.

The FAA, in collaboration with Goodrich Aerospace, is evaluating the viability of downlinking icing data from ice detectors mounted on commercial aircraft to ground stations. Delta Airlines agreed to participate in the demonstration project and is currently downlinking icing data from the ice detectors on its entire fleet of Boeing 777 aircraft. The demonstration project began during the 2002-2003 winter icing season and will continue for a 1-year period. The resulting data is being provided to the National Center for Atmospheric Research in Boulder, Colorado, for use in the evaluation and enhancement of icing forecasting models.

The potential safety value of providing such information in near real time to other aircraft will also be assessed. Research results look promising, and researchers are currently assessing the technical and economic feasibility of downlinking icing data from commercial aircraft. Participation by regional carriers, which spend quite a bit of time in icing conditions, would be particularly valuable. In addition, broad participation by commercial carriers would lead to the improvement of icing forecasts and to the expansion and improvement of icing information available to pilots.

Effects of Mixed-Phase Icing Conditions on Aircraft Surfaces and Aircraft Thermal Ice Protection Systems



Most atmospheric aircraft icing is a result of super cooled liquid droplets freezing on aircraft surfaces. Many clouds, however, contain both super cooled droplets and ice particles. The National Transportation Safety Board has recommended that FAA examine whether or not aircraft icing certification requirements should be expanded to include mixed phase icing conditions. Since there is only limited scientific information available on mixed phase icing conditions, FAA researchers are undertaking the necessary work to assess if certification requirements should be changed.

In recent tests using a wing section equipped with a thermal ice protection system, FAA researchers, in collaboration with Wichita State University, Cox & Company, and NASA Glenn Research Center scientists, found that in mixed-phase icing conditions, super cooled water droplets present in the mixed-phase cloud cause ice accretion. For glaze ice, which occurs at temperatures close to 32 degrees fahrenheit, the ice particles in the mixed-phase clouds actually reduce the overall size of the ice accretion. This may be due to shedding or splashing of water from a surface water film resulting from ice particles bouncing in the film, and less likely to erosion of accreted ice by the incoming particles.

Photos This Page:
Top Left, Downlinking of Icing Data
Top Right, View of Aircraft Icing

Photos Opposite Page:
Top Left, Airport Pavement Test
Top Right, Runway Status Lights
Bottom Right, Turkey hit aircraft

Repaint Criteria for Airport Surface Markings

Paint markings on runways, taxiways, and ramps play an important role in preventing runway incursions. The visibility of paint markings, however, deteriorates over time and paint must be replaced. The FAA is developing methods and equipment to help determine the effectiveness of airport surface markings, and to establish standards to measure the need to reapply or restore airport surface markings. Currently, visibility is determined by visual inspections of segments of these markings, but the validity of these inspections cannot always be confirmed.

In FY 2003, researchers developed a method for using three measurement tools for a quick and accurate evaluation of paint markings. This manual method eliminates subjectivity in the current assessment method. Researchers used a retroreflectometer to determine the retroreflectivity of the beads, a spectrophotometer to determine whether or not the paint marking had faded, and a transparent grid to determine paint coverage. If any one of these three tests failed, the pavement marking failed.

FAA's researchers also created an automated method to evaluate larger surface markings using a van-mounted Laserlux or similar mobile unit to increase speed and sample size. This technique works well for large airports that have very long runway centerlines and threshold markings. They also established a threshold pass/fail limit for white and yellow paint. The retroreflective threshold limit for yellow paint is 70 mcd/m²/lx and for white paint 100 mcd/m²/lx. The coverage threshold pass/fail limit is 50%.

This research is summarized in *Development of Methods for Determining Airport Pavement Marking Effectiveness* DOT/FAA/TN03-22. To view this report please visit, http://research.faa.gov/aar/tech/docs/techreport/FY2003/DOTFAAARTNo322.pdf.

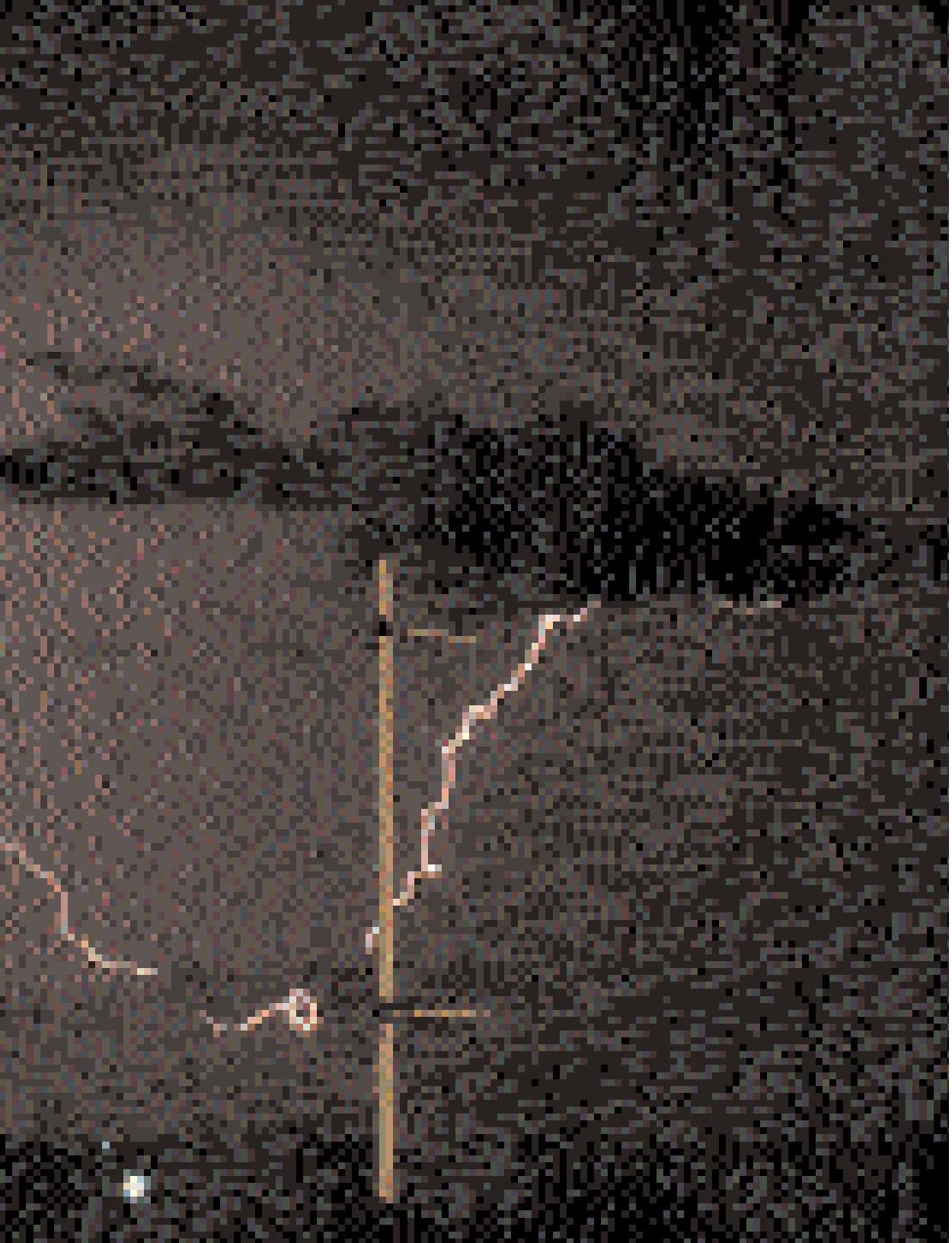
Runway Status Lights

FAA researchers explore and evaluate current and emerging technologies for potential application toward increasing runway safety in the National Airspace System. Runway status lights, ground marker beacons, enhanced lighting configurations, ultra violet sensors, and addressable boards are some of the FY 2003 technology evaluation efforts.

The technical and operational suitability of a runway status lights (RWSL) system is being evaluated at Dallas- Ft. Worth (DFW) International Airport. The RWSL concept provides a surveillance-driven automated system of in-pavement lights to provide pilots and vehicle operators a real-time visual indication that it is unsafe to enter a runway. FY 2003 efforts focused on developing, optimizing, and installing the RWSL safety software at DFW for shadow operations evaluation by facility air traffic personnel. Successful completion of shadow operations at DFW will lead to the installation and integration of the RWSL airfield lighting for a full system operational evaluation during FY 2004.

Wildlife Mitigation

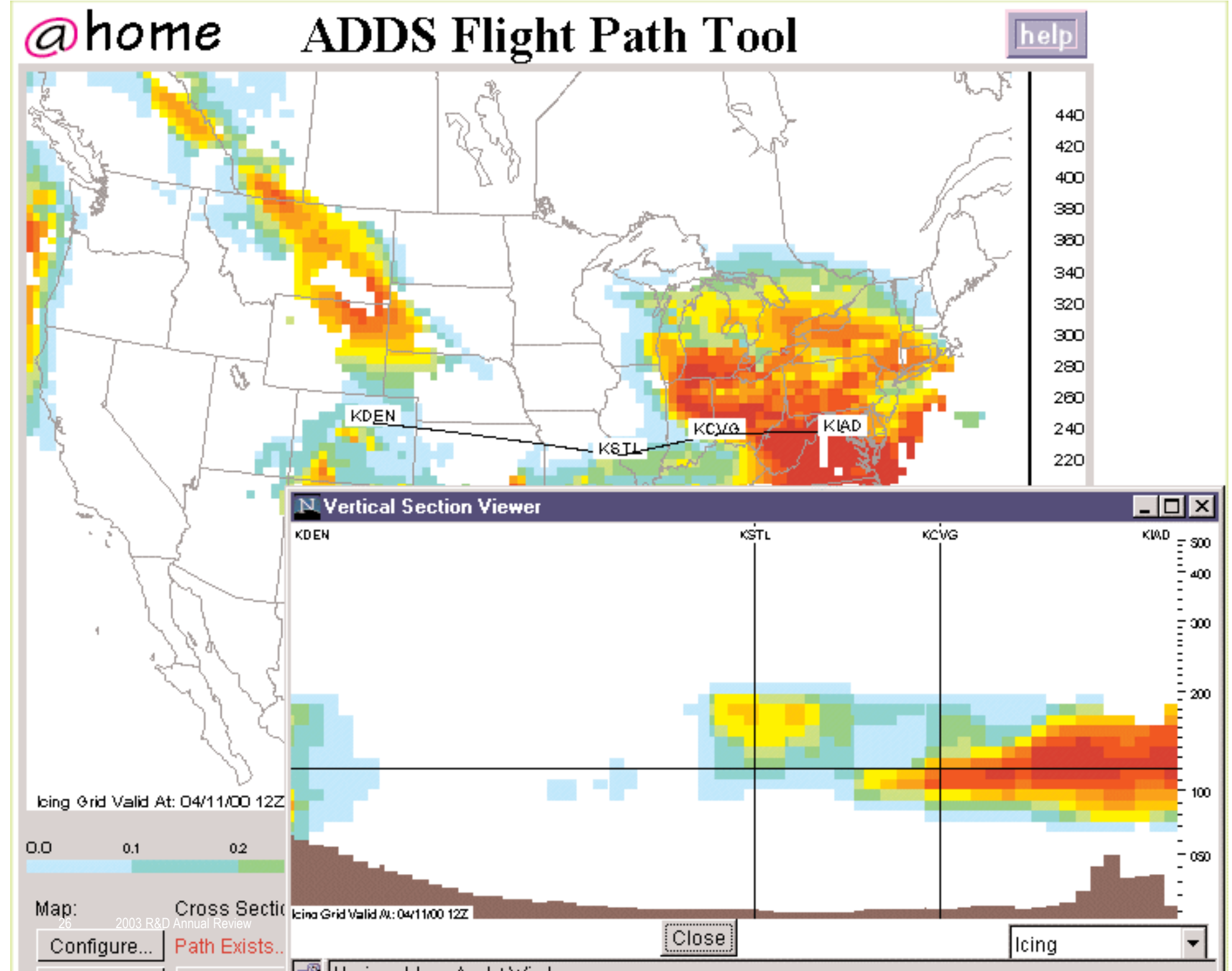
The presence of wildlife on and near airports creates a very serious hazard to operating aircraft. In 2003, over 6,000 bird strikes were reported to the FAA National Wildlife Strike Database. Some of these were quite severe and resulted in a few fatalities. Over the last few years, the FAA has undertaken a comprehensive research program to mitigate bird strikes at and near airports. In 2003, the FAA continued the development and preliminary testing of a prototype radar to detect dangerous birds. Performance testing of the radar are planned for Fall of 2003 and Spring of 2004 and will take place at two major commercial airports



Aviation Weather Research

R&D Annual Review 2003

The Aviation Weather Research Program focuses on applied research to provide weather observations, warnings, and forecasts that are more accurate, accessible, and efficient than existing services. Resulting upgrades enhance flight safety, reduce air traffic controller and pilot workload, improve flight planning, increase productivity, and enhance situational awareness. Our weather research efforts are also providing critical efficiency and capacity benefits.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ADDS Flight Path Tool
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Aviation Digital Data Service

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.

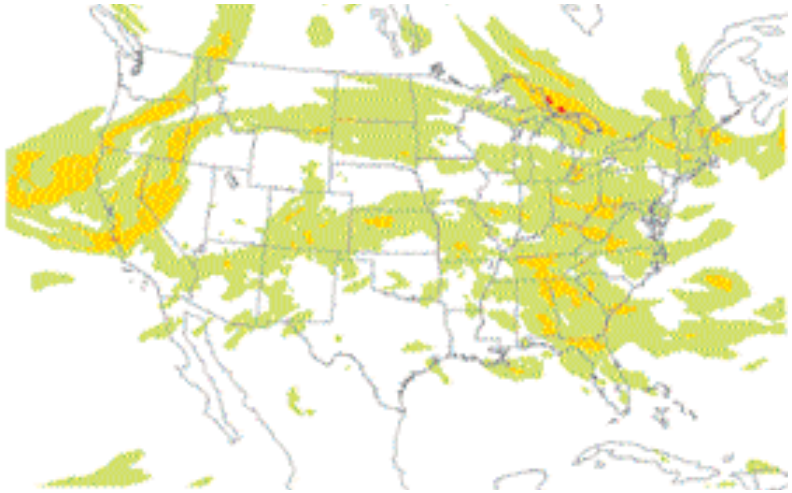
In FY 2003, the FAA's Aviation Digital Data Service (ADDS) became operational. Developed by the FAA's Aviation Weather Research Program, this service enables a wide variety of users, such as private and commercial pilots, airline dispatchers, flight planning systems, and weather vendors, to easily access critically needed weather information, in a variety of formats: (graphical, text, and gridded) including winds, temperature, turbulence, convection and icing.

The National Weather Service's Aviation Weather Center in Kansas City, Missouri, operates and maintains the Aviation Digital Data Service. By providing current and forecast information on key weather hazards to support the needs of airlines, aviation product vendors, and general aviation, the Aviation Digital Data Service enhances aviation safety and reduces delays. Its access via the internet has ensured that enhancements are available to users quickly, and in a cost-effective way. ADDS data can be obtained through the web site at: http://adds.aviationweather.gov.

Photo Opposite Page:
Aviation Digital Data Service showing the Current Icing Potential

Photo Top Right:
Weather Display of Graphical Turbulence

Atmospheric Turbulence Product Helps Smooth a Bumpy Ride



Commercial and general aviation aircraft continue to encounter unexpected turbulence that ranges in intensity from crew and passenger discomfort to hazardous conditions that threaten the aircraft, passengers and crew. Atmospheric turbulence is a significant safety issue. In FY 2003, the FAA's Aviation Weather Research Program responded to the need for more accurate turbulence forecasts by completing the initial development of the Graphical Turbulence Guidance product and transitioning it to the National Weather Service for operational implementation.

The Graphical Turbulence Guidance (GTG) Product automatically provides a graphical depiction of turbulence intensity at 0, 3, 6, 9, and 12 hours and provides forecasts for 20,000 feet and above for clear air turbulence. Current research is focused on enhancing this product to provide forecasts for all sources of turbulence at all levels of the atmosphere.

Meteorologists at the National Weather Service's Aviation Weather Center in Kansas City and other forecasters are the primary users of this product. The GTG is available via the Aviation Digital Data Service (ADDS) web site at: http://adds.aviationweather.gov.

New Tool Aids in Aircraft Ground Deicing Decisions

From pilots who fly single-engine Cessnas to those flying jumbo jets for the airlines, icing is one of the most feared and respected weather hazards among aviators. Any commercial airline passenger who has experienced long delays while waiting for their aircraft to be deiced knows that airlines take the deicing process very seriously at the expense of late takeoffs and revised schedules.

Even a very thin layer of ice on a wing surface can increase drag and reduce airplane lift by 25 percent. This type of ice accumulation was a cause or factor in 10 commercial aircraft takeoff accidents between 1978 and 1997. The FAA's Aviation Weather Research Program, in an effort to fully understand this problem, began supporting ground deicing research in 1991. The research resulted in development of an integrated display system that depicts accurate, real-time determinations of snowfall rate, temperature, humidity, wind speed and direction, called the Weather Support to Deicing Decision Making (WSDDM) system. WSDDM is a system that directly enhances aviation safety and efficiency by providing deicing decision makers and airport plowing crews with up-to-the-minute information on potentially hazardous freezing precipitation.

The sources of weather data used by WSDDM include Doppler radars, surface weather stations, and snow gauges located near the airport, which accurately measure the amount of water in the snow. This system, which is sponsored by the FAA, has been used at the three major New York airports and at Denver International Airport. An independent assessment estimated the annual benefit of an operational WSDDM system at the New York airports to be $12.7M.

In FY 2003, enhancements to WSDDM included a "Hotplate" snow gauge and the implementation of wireless communications to provide weather data to users. The advantages of the Hotplate snow gauge include: lower cost; smaller footprint; and reduced maintenance requirements. The combination of the Hotplate snow gauge and the modern communications suite has reduced the cost of the system and increased its reliability.

Photo Opposite Page:
Weather Support to Deicing Decision Making

Current Icing Potential

As a result of FAA development of the Current Icing Potential product, airlines have a product for avoiding in-flight icing. This product offers high-precision maps and plots, updated hourly, to identify areas of potential aircraft icing in the continental United States.

With funding from the FAA, researchers at the National Center for Atmospheric Research developed new methods and software for detecting and diagnosing icing potential in the atmosphere. They then applied these methods to produce the Current Icing Potential product.

The National Weather Service operates the product from the Aviation Weather Center in Kansas City, Missouri. This product will most benefit commuter planes and other propeller-driven aircraft. Smaller aircraft are more vulnerable to icing hazards because they cruise at lower, ice-prone altitudes.

In FY 2003, the Current Icing Potential - Alaska product became a publicly available experimental product. The software graphically depicts areas of icing at user-selected flight levels in Alaska.

Photo Opposite Page:
Icing on Aircraft Wing

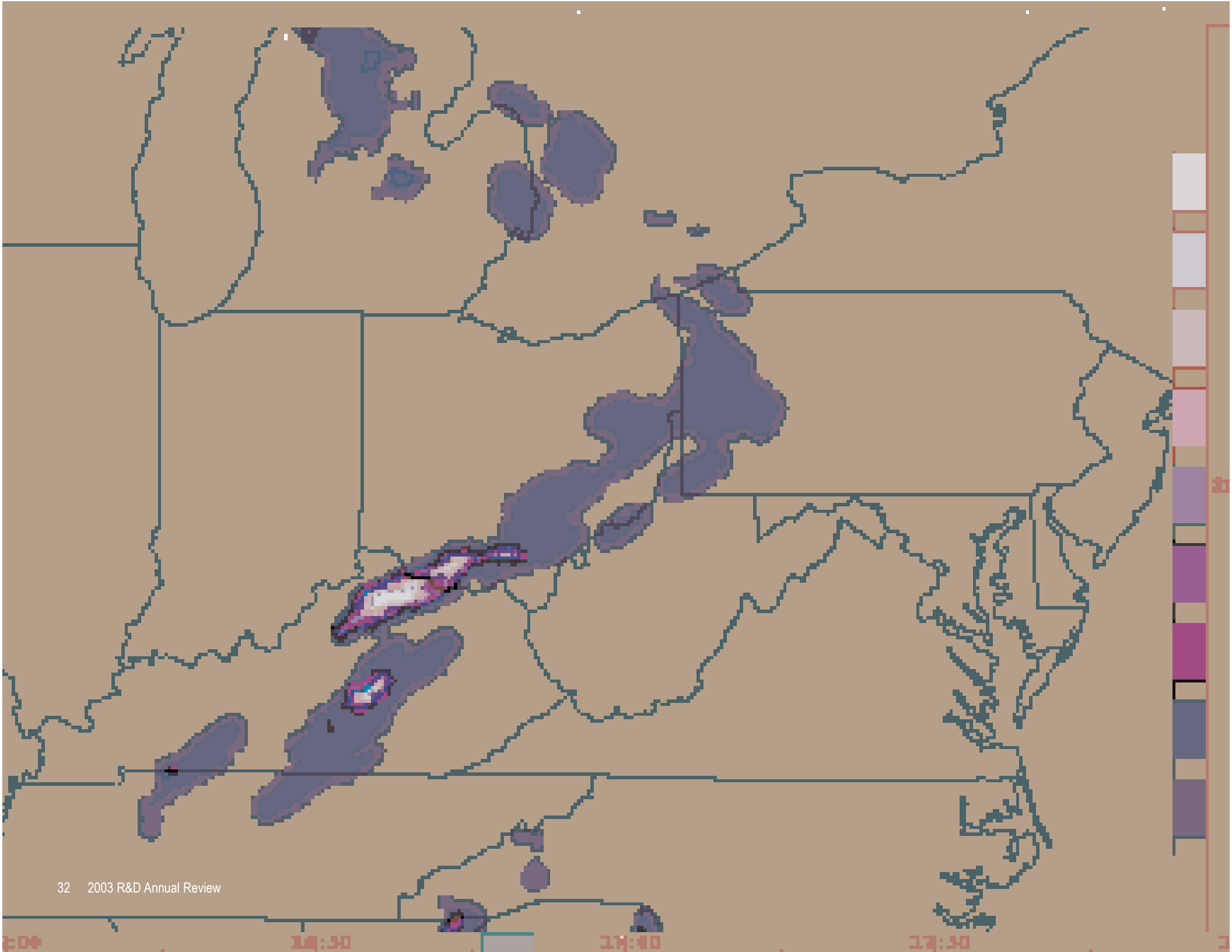
Photo Top Right:
Aircraft De-Icing

New Product Predicts Icing

Predicting in-flight icing just got a little easier thanks to a product developed by the FAA. Using the web-based Forecast Icing Potential product, aviation meteorologists and airline dispatchers can warn pilots about icing hazards up to 12 hours in the future. With information provided by this automated product, pilots flying aircraft under 18,000 feet, can make critical flight decisions.

Those aircraft may not have sophisticated wing-deicing equipment used by larger commercial aircraft. The Forecast Icing Potential product helps determine safe routes for travel. It provides a high-tech color weather map and/or a flight route display of icing potential at flight levels from 3,000 to 18,000 feet. The user can select forecast times from three-, six-, nine-, and twelve-hour intervals.

The Forecast Icing Potential Product, developed by the National Center for Atmospheric Research in Boulder, Colorado, for the FAA's Aviation Weather Research Program, joins the growing FAA-developed suite of weather products, such as the Current Icing Potential product. This product becomes operational in FY 2004. The National Weather Service operates these products for the FAA. They are publicly available on-line http://adds.aviationweather.gov.



National Convective Weather Forecast

The FAA began testing the National Convective Weather Forecast 2-hour product in FY 2003. This product automatically provides current convective hazards and 2-hour extrapolation forecasts of thunderstorm hazard locations. This product is an upgrade to the 1-hour forecast product already in use. The web-based product, developed by scientists at the National Center for Atmospheric Research, with funding from the FAA Aviation Weather Research Program, provides graphical information regarding the current detection and forecast locations of thunderstorms both nationally and regionally.

The FAA has completed a human factors demonstration of the National Convective Weather Forecast, which assessed its usability, performance, and user-computer interface aspects. Researchers also assessed job-task benefits to the airline dispatcher community. Dispatchers who participated in the study provided data via the use of questionnaires, on-line logs, and individual structured interviews.

Photo Opposite Page:
National Convective Weather Forecast (2-hour)

San Francisco Marine Stratus

Airports often experience takeoff and landing delays because of their geographic location. For example, San Francisco International Airport (SFO) is unable to use independent parallel approaches to its closely-spaced parallel runways when marine stratus is present in the approach zone. The inability to accurately forecast the onset and dissipation of stratus in the approach paths results in delays, airborne holding and diversions, and loss of capacity.

The Aviation Weather Research Program developed a 1-6 hour forecast for the time when the marine stratus will dissipate at San Francisco International Airport. This enables air traffic controllers to allow resumption of simultaneous parallel approaches. During the summer of FY 2003, researchers conducted a successful evaluation of this product as a precursor to the transfer of this technology to the National Weather Service for operational implementation in FY 2004.

Photo Top Right:
San Francisco International Airport

System Efficiency Research

R&D Annual Review 2003

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

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

The National Airport Pavement Test Facility

With the introduction of new aircraft types, such as the Airbus A380 and Boeing B-777, expected to have a major impact on the nation's airport pavements, researchers at a unique test facility, the National Airport Pavement Test Facility, are collecting full-scale traffic data under controlled loading conditions. This facility, fully enclosed in a building 1,200 feet long by 100 feet wide, uses a test vehicle to simulate aircraft landings 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 2003, researchers used this facility to test four new asphalt pavement test items constructed on low-strength subgrade soil. They varied the depth of the pavement structure in these items to provide a range of expected pavement fatigue lives for 4- and 6-wheel aircraft landing gear loads. After trafficking to failure, researchers opened a number of trenches to measure and observe the mode of failure. They are also reconstructing three concrete pavement test items to be tested in FY 2004. Improved design standards, based on data from NAPTF tests, will provide substantial cost savings for airports by better predicting pavement life and reducing costly premature failures. To date, the FAA has collected over 63 gigabytes of data at the NAPTF. This data can be accessed on the web at, http://www.airporttech.tc.faa.gov/naptf/.

Photo Opposite Page:
National Airport Pavement Test Facility

Advanced Pavement Design Software

In March 2003, the FAA released an upgrade to its LEDFAA (Layered Elastic Design – FAA) airport pavement thickness design software. Among the significant improvements, the new version adds the Airbus A380 and A340-500/600 aircraft families to the design aircraft library. A change to all 32-bit programming improves speed and makes the software compatible with all current Windows® operating systems. The new software can be used to design airport pavements for traffic mixes that include the new generation of super-heavy aircraft. LEDFAA version 1.3 can be downloaded from the FAA's web site at http://www2.faa.gov/arp/engineering/software.cfm.

Photo Top Right:
A-380aircraft

Ground Marker System

A ground marker system is being evaluated as an alternative method of improving pilot situational awareness on the airport surface. This system uses a low power 75 MHz radio to transmit location advisories to aircraft or vehicles equipped with an instrument landing system (ILS) marker beacon 75 MHz receiver.

Inductive loops embedded in the taxiway sense the presence of an aircraft or vehicle within a specified zone and trigger the transmission of a pre-programmed digital voice message (for example – "Taxiway Alpha at Taxiway Bravo"). A dipole antenna – also embedded in the taxiway – serves as the radio-frequency source of the signal that is received by equipped aircraft within a specified coverage volume. During FY 2003, researchers selected Buchanan Airfield in Concord, California, to conduct the ground marker system evaluation. The ground marker system is installed at six locations on the airport surface for a 9-month evaluation that began in October 2003.

Taxiway Deviation Study

Within the next few years, the Airbus A380 will begin flying into U.S. airports. This airplane, categorized as a Design Group VI airplane, is the largest commercial airplane expected to serve the United States. The FAA recommends that the straight section of the taxiway be at least 100 feet wide to accommodate this type of aircraft. However, most airports currently have 75-foot wide taxiways, which meets current requirements.

In an effort to mitigate the potential impact of this large aircraft, FAA researchers are conducting field data collection efforts focused on the width of taxiway straight sections. During this multi-year effort, researchers are measuring the extent to which Boeing 747 aircraft laterally deviate from the taxiway centerline of 75-foot taxiways to determine the possibility of reducing the 100-foot taxiway width standard for all airplanes. Data is being collected at New York's John F. Kennedy International Airport and Anchorage, Alaska's Ted Stevens International Airport. Based on preliminary analysis of the data, in August 2003, the FAA issued Engineering Brief No. 63 (http://www1.faa.gov/arp/engineering/briefs/eb63.doc), allowing the A380 to use the existing 75-foot wide taxiways on an interim basis.

The introduction of the A380 is expected to have a similar impact on other design standards in addition to taxiway widths, including separation of taxiway and taxilane from runways and clearances from fixed and movable objects. The FAA is conducting similar data collection efforts in the field to support the mitigation of these impacts.

Photo Top Left:
Airport Ground Marker System

Photo Top Right
Taxiway Deviation Study Testing Equipment

Global Communications Navigation Surveillance System (GCNSS)

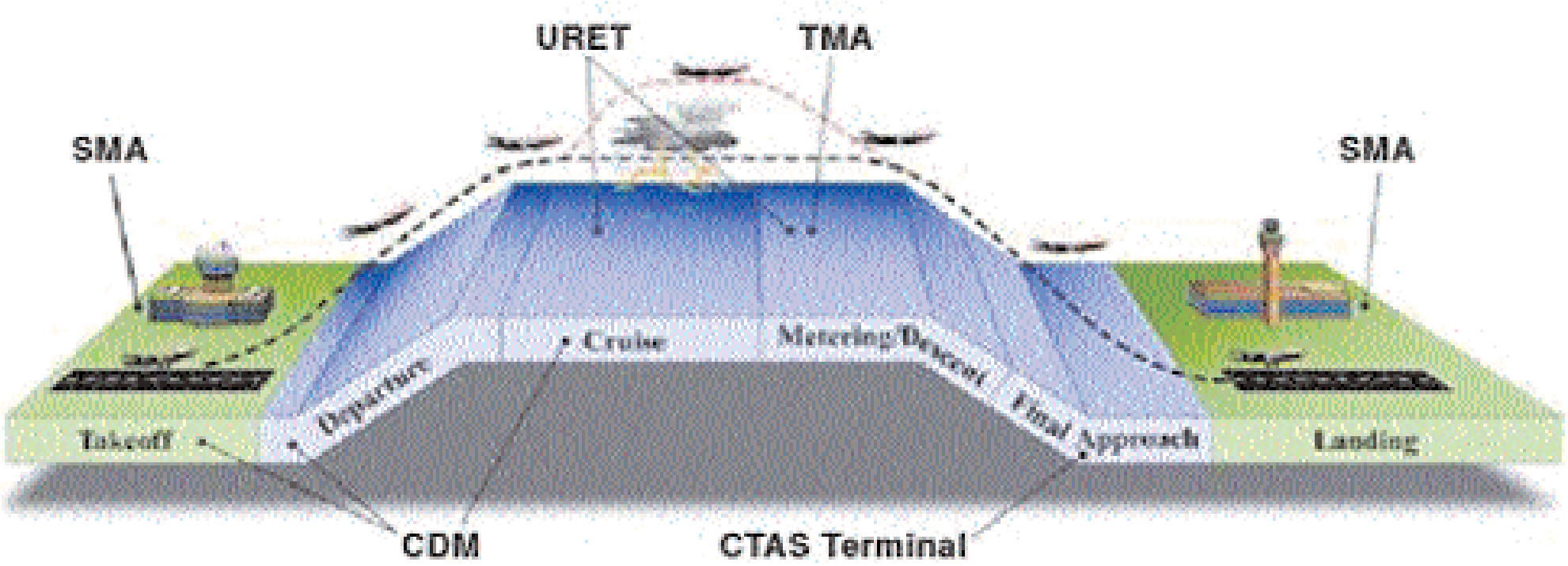
The FAA is exploring the role of satellite technology can play in providing communications, navigation, and surveillance to improve the capacity, efficiency, safety, and security of the National Airspace System. By providing both air- and ground-based personnel with improved real-time situational awareness of the entire flying environment.

Under an FAA contract, Boeing's Air Traffic Management business unit is working with the Agency to conduct several proof-of-concept studies to demonstrate technologies that could be used by the FAA to help modernize America's air transportation system.

In February 2003, using Boeing's Connexion 737-400 demonstration aircraft, researchers tested up- and down-linked weather awareness, an aircraft deviation alerting system, ground display of aircraft flight data monitoring links using an onboard wireless local area network, and an offboard wide area network.

Researchers are currently developing the demonstration plan for the FY 2004 series of flights. This next phase of the program will evaluate the surveillance data network and common information network applications. The analyses will include extensive studies, scenario developments, modeling and simulations, and an architecture review and analysis study.

Photo Top Right:
Boeing's Connexion 737-400



URET=User Request Evaluation Tool
SMA=Surface Movement Advisor
CDM=Collaborative Decision Making
CTAS=Center Tracon Automation System
TMA=Traffic Management Advisor

Photo This Page:
Free Flight Technologies

Tools for the Future: Free Flight Program

The Free Flight program is introducing new tools, technologies and procedures that are enhancing the aviation community's ability to share data and to view and optimize all phases of flight - from planning and surface operations to en route flight paths. Deployed systems are being integrated into the traffic management system with operational procedures and training to minimize risk and achieve greater user satisfaction. In FY 2003, in collaboration with NASA Ames and MITRE's Center for Advanced Aviation System Development (CAASD), FAA's researchers continued Free Flight research targeted on air and surface traffic flow management.

The Problem Analysis, Resolution and Ranking (PARR) tool, developed by CAASD, 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, 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 January 2003, the FAA conducted controller-in-the-loop simulations of PARR/ART to further refine the operational concept of use for ART.

The purpose of the Traffic Management Advisor-Multi-Center (TMA-MC) tool is to assist traffic management coordinators in planning and managing streams of traffic into selected airspace, as well as into selected Terminal Radar Approach Control (TRACON) facilities that receive traffic from two or more en route centers. Multi-center metering will enable controllers and traffic management specialists operating within different centers to establish optimal arrival sequences across center boundaries. Research focused on the Northeast corridor with the goal of improving the arrival flows into Philadelphia International Airport. During FY 2003, the FAA conducted extensive field trials with participants from the New York, Cleveland, Boston, and Washington Centers and the Philadelphia TRACON. These efforts provided the FAA and NASA with an understanding of the multi-center collaborative environment. Researchers successfully integrated the lessons learned from these trials into the TMA-MC Concept of Operations. TMA-MC operational trial evaluation is the next critical milestone and is currently scheduled for the summer of 2004.

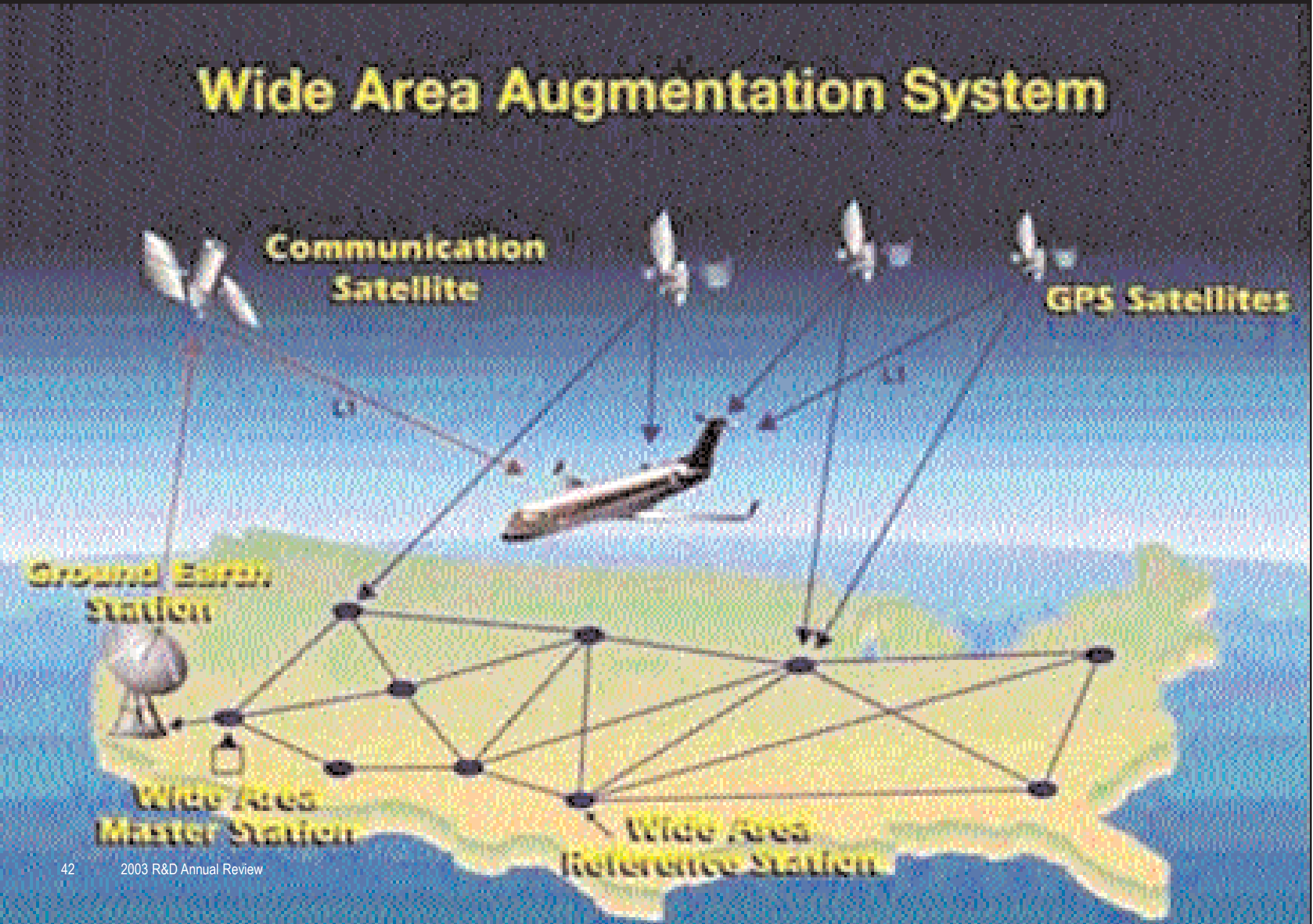
The Surface Management System (SMS) decision support tool is targeted to provide the ground and tower controllers with enhanced surface management awareness that when coupled with the collaborative decision-making information it provides to the airlines should make terminal air traffic operations safer and more efficient. In FY 2003, researchers completed demonstrations, SMS concept of operations and field trials at the Memphis Tower, Memphis TRACON and FedEx ramp tower. OEP's SMS operational field evaluation milestone was met upon completion of the SMS operational trial in September 2004. The results from the field trial were used to quantify SMS benefits on surface flow management and tower operations. SMS was successfully transitioned from the Free Flight Program Office to the Terminal Business Unit for integration into ASDE-X.

The En Route Descent Advisor (EDA) is an automated decision support tool intended for use by the en route controller to handle traffic in transition airspace. EDA builds on NASA Ames' Center-TRACON Automation System (CTAS) to provide controllers with maneuver advisories to enable arrival aircraft to cross TRACON metering fixes in accordance with scheduled time-of-arrival and sequence constraints derived from CTAS, while guaranteeing separation assurance and maximizing fuel efficiency. In FY 2003, the FAA and NASA conducted initial operational demonstrations of EDA in the NASA Ames development laboratory to refine further the EDA operational concept.

Direct-To is a decision support tool for the radar controller (R-side) that will provide advisories for traffic conflicts and direct routes. It includes an interactive trial planning function that allows the controller to quickly visualize, evaluate and enter route and altitude changes. In FY 2003, the FAA and NASA further refined the FAA's operational concept of use for Direct-To by conducting operational evaluations in the FAA's Integration and Interoperability Facility.

The Integrated Aircraft Data Collection and Reporting (iADCR) 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 led to refinements in the concept of operations. In FY 2003, the FAA demonstrated a prototype iADCR.

Research on the Equitable Allocation of Limited Resources (EALR) focused on the equitable distribution of resources, such as arrival slot assignments during a ground delay program or flow constrained re-routes, to ensure no one customer is disproportionately impacted by these decisions. During FY-03, a survey of the current and future ground delay program efforts were conducted. Researchers were able to identify metrics that could be used to assess equity. This work resulted in recommendations for the establishment of policies to govern the implementation of equity based rules into the acquisition development process. EALR research will eventually be integrated into the future development of a system wide traffic flow management problem predictor and resource allocation capability.


Wide Area Augmentation System
Communication Satellite
GPS Satellites
Ground Earth Station
Wide Area Master Station
Wide Area Reference Station

Wide-Area-Augmentation-System

In FY 2003, Wide Area Augmentation System (WAAS) researchers focused on validation and verification of integrity solutions developed over the last several years. This validation effort supported the final sell-off indicating that WAAS integrity levels were achieved.
At present researchers from Stanford University, Jet Propulsion Lab (JPL), Boston College and Zeta Associates were working to improve on current levels of WAAS performance by developing new and/or improved system algorithms and their ability to provide safe use of WAAS in areas where increased ionospheric activity (Mexico) is present. The FAA is supporting the globalization of WAAS technology through research cooperation with other Satellite Based Augmentation Service (SBAS) providers.

The FAA research community is participating in the development of new minimum operations performance standards and recommended practices that will take full advantage of the new civil GPS signals (L5). This has included prototyping and validating WAAS receivers and antennas that will support reception of the GPS L5 signal.

With the WAAS commissioned in the NAS, it becomes increasingly important that continuity performance is improved. FAA research efforts have been involved with assessing both system and environmental sources of error with the intention of developing the means to mitigate these error sources (signal interference, signal multipath, ionosphere), thus providing improved operational performance of WAAS.

Photo Opposite Page:
Wide Area Augmentation System Map

Human Factors Research and Engineering & Aeromedical Research

R&D Annual Review 2003

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.

Human Factors Analysis and Classification System

FAA researchers further refined the Human Factors Analysis and Classification System (HFACS), a tool for investigating and analyzing human error associated with aviation accidents and incidents. Previous HFACS research has shown that this system can be reliably used to analyze the underlying human factors causes of both commercial and general aviation accidents. Furthermore, these analyses have helped identify general trends in the types of human factors issues and aircrew errors that have contributed to civil aviation accidents.

In FY 2003, researchers used HFACS to determine the global human error categories associated with aviation accidents. They developed: detailed analysis of each of the different error forms, decisions, violations, skill-based and perceptual errors to determine the exact nature of their genesis and relative importance in the causal sequence of events. As in previous studies using HFACS analysis, researchers found that skill-based errors are consistently the most common error leading to a general aviation accident and in most cases is the precipitating error form as well. Furthermore, when violations are associated with a general aviation accident, they are more likely to result in a fatality. It is also noteworthy that efforts to inform pilots of the hazards of spatial disorientation and visual illusions appear to be successful since perceptual errors are the least common among all four categories of unsafe acts.

Assessment of Personal Computer Aviation Training Devices (PCATD)

Current FAA policy allows pilots to complete 10 hours of instrument training using an approved personal computer training device. FAA researchers are comparing the effectiveness of a Personal Computer Aviation Training Device (PCATD) against training and performance in an aircraft. In FY 2003, human factors specialists used an incremental transfer of training research design to measure the effectiveness of a Flight Training Device (FTD) and a PCATD to determine the point at which additional training in a FTD or PCATD was no longer effective. The collected data will enable certification personnel to determine what credit to award for different classes of flight training devices within an instrument training curriculum. Preliminary results suggest that flight training devices and personal computer aviation training devices are effective; however definitive statements cannot be made until the sample has been completed.

Photo Opposite Page:
Airplane caught on wires

Photo Top Right:
Flight Training Device

Threat and Error Management Model

Human factors specialists are investigating the relationships among flight crew error, operational complexity, and crew performance in normal flight operations. The knowledge gained will help support safety efforts through early identification of incident and accident precursors before they become consequential. Researchers are currently involved in the development and refinement of two data collection programs: the Line Operations Safety Audit (LOSA) and the Aviation Safety Action Program (ASAP).

Researchers developed a set of on-line tools to help carriers categorize and analyze crew incident reports. This set of tools enables pilots to submit reports online using threat and error management taxonomies and aids Event Review Committee members in making data driven decisions by enabling them to assign risk level assessments and behavioral marker ratings to each event. Human factors specialists have now developed and tested the first set of threat and error management tools with Continental Airlines. Based on initial findings, they are developing more user-friendly tools.

Photo Opposite Page:
Flight Simulator

Photo Top Right:
Flight Simulator

Platform Motion Requirements

Flight simulator qualification standards, which may soon become regulatory, need to be sufficient and effective, yet affordable. Current research is examining the requirement for platform motion in the context of continuing qualification of airline pilots, which could greatly impact simulator acquisition and maintenance costs. In FY 2003, researchers from the Volpe National Transportation Systems Center worked with the FAA and NASA to reconfigure the FAA-NASA Boeing 747-400 Level D simulator to examine the effect of enhanced motion on pilot performance and behavior. They evaluated and trained 20 current airline pilots in the simulator with and without motion, calculated and analyzed pilot-vehicle performance and pilot control inputs in all axes from simulator variables. The pilots also compared the simulator to the airplane or their company simulator on extensive questionnaires, covering control feel, handling qualities, general cues, progress achieved, and acceptability.

Researchers discovered many effects of roll, pitch, and bank motions that have never been shown in an airline pilot context. Specifically, they found that enhanced hexapod platform motion does affect the accuracy of recurrent evaluation on continuing qualification of airline pilots, provided that it is configured for the specific tasks based on the guidelines in the literature. The reaction-time advantage of the motion group during evaluation and training for an engine failure with continued takeoff, for example, confirmed that motion cues alert to disturbances faster than visual cues. This research is providing the scientific data necessary for the FAA's effort to develop motion requirements that will allow cost-effective equipment solutions for pilot continuing qualification.

Advanced Technology to Support Inspection Training in the General Aviation Industry

A sound aircraft inspection and maintenance system is vital in providing the public with a continuing safe, reliable air transportation system. This is true for both general as well as commercial aviation. Since it is difficult to eliminate errors altogether, continuing emphasis must be placed on developing interventions to make the inspection/maintenance system more reliable and error tolerant. Training is a primary intervention strategy to improve the quality and reliability of aircraft inspection and reduce errors.

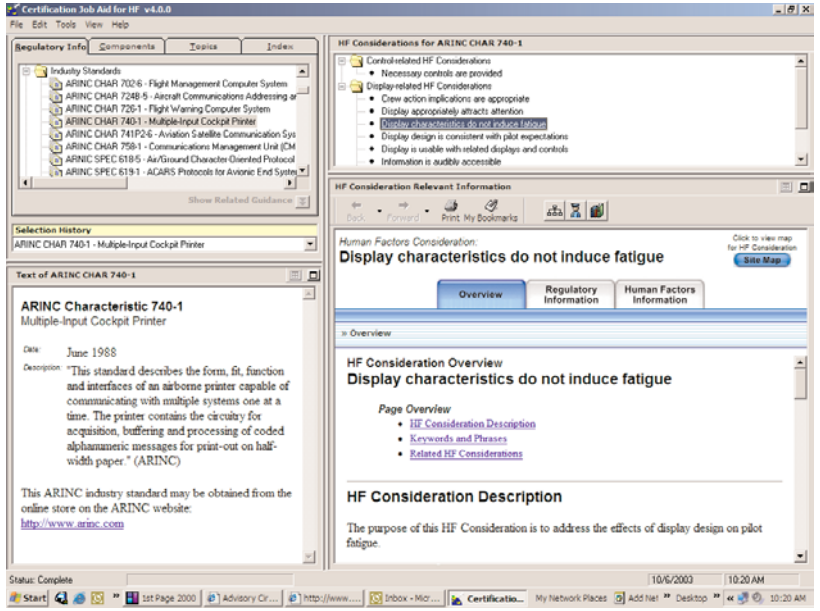
FAA researchers are demonstrating how advanced technology and computer software applications can be used for inspection training and reducing inspector errors within the general aviation industry. This is the first time an effort has been made to extend computer-based technology to enhance inspector performance and standardize the inspection training process in the general aviation environment.

In FY 2003, researchers developed a tool that uses a multi-media presentational approach with interaction opportunities between the user and computer. Specifically designed for training maintenance technicians in inspection skills, this tool will systematize and standardize the inspection training process in the general aviation industry. The literature is available online at: http://www.hf.faa.gov.

Photo Opposite Page:
General Aviation Aircraft

Photo Top Right:
Certification Job Aid

FAA Aircraft Certification Job Aid for Flight Deck Human Factors



Aircraft certification requires judgments about whether new aircraft designs are safe to fly in the global airspace by current and future pilots. Although experience has shown that design-induced human performance errors have contributed to many aviation incidents and accidents, there is a lack of guidance describing what human performance areas should be evaluated, and, until now, there have been only a few methods available to help certification personnel predict the future occurrence of such errors based on analysis of the aircraft design. To aid certification experts and aircraft designers, FAA's human factors specialists developed a certification job aid for flight deck human factors. This decision support tool is assisting 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 will help researchers identify gaps in current human factors knowledge. In FY 2003, researchers incorporated industry standards into the tool. In the current version, the information in the databases is focused on flight deck displays and flight controls for transport category airplanes.

Electronic Flight Bags

Electronic flight bags, electronic information management devices used by pilots in performing flight tasks, present many human factors challenges.

Researchers have identified, prioritized, and recorded these challenges in collaboration with vendors and operators, to help designers and evaluators make informed choices. Because of its breadth and depth, the report documenting this research proved difficult to use, so researchers are now developing and testing a tool based on the report that can be used for short periodic structured assessments of electronic flight bag usability by FAA field inspectors.

In FY 2003, aviation human-factors experts evaluated Electronic Flight Bags against the full-length document. In a second test, researchers used two different paper assessment tools, a checklist based on the full document and a short high-level list of usability topics, to conduct expert reviews and team evaluations. Initial tests of a prototype electronic flight bag usability assessment tool uncovered areas for improvement, such as the need for more intuitive terminology. Once it is refined, the new tool will be a useful aid, helping inspectors to conduct more structured, thorough, and predictable regulatory evaluations. For industry designers, the tool will allow them to anticipate and resolve human factors issues before going through a formal regulatory evaluation.

Photo Opposite Page:
Electronic Flight Bag

Photo Top Right:
Air Traffic Controllers in Tower

A Model to Assess the Severity of Runway Incursions

The Office of Runway Safety classifies the severity of runway incursions into four categories: A, B, C, and D. An "A" represents an accident or an accident that was narrowly averted. A "D" represents an incident that meets the definition of a runway incursion, but where no potential for collision existed. Currently, these categorizations are made by a group of subject matter experts. Researchers are developing a model that provides a more structured and objective method for determining the severity rating. The DOT Inspector General issued a report in 2003 assessing the runway incursion severity index.

Researchers detailed scenarios that could result in runway incursions and their relevant factors (visibility, pilot response time, and aircraft performance characteristics). They collected data on pilot response time and other factors relevant to runway incursions.

Initial research is complete, and development of the model is now underway. Based on their scenario development work, researchers worked with the FAA's Office of Runway Safety to review the needs for the runway incursion severity model. At a preliminary meeting, the Office of Runway Safety reviewed fundamentals of the presented model and discussed the preliminary results of the analysis of several incursions.

Communication and Coordination Lessons Learned in Operations Control Centers

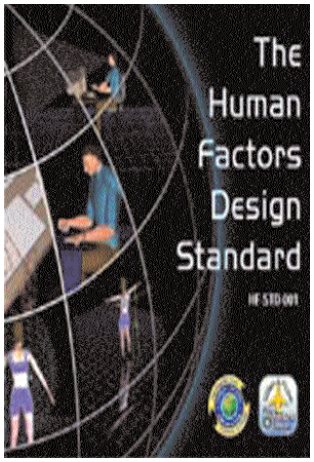
Recently, the FAA consolidated its Airways Facilities communication and coordination operations such that they will now be performed in three newly created Operations Control Centers (OCCs). While streamlining much of the duplicative work, anecdotal reports indicate that communication and coordination within these centers needs improvement. Through comparison with prior communication and coordination efforts, this study identified problematic issues with these newly formed centers to develop human factors best practices. This study compares and contrasts current communication and coordination at the OCCs with studies from Maintenance Control Centers that existed prior to the OCCs and human factors best practices.

Researchers visited the three OCCs to collect observational data and conduct structured interviews. The structured interview consisted of a series of statements in which specialists were asked to indicate their level of agreement with a statement by selecting a response in a range from strongly disagree to strongly agree. Each question had room for the specialist to provide comments or further explain their rating. The structured interview also contained open-ended questions that allowed the specialists to address issues not covered in earlier questions.

While still preliminary, the report written in September provided a quick look at the data collected during the site visits. Researchers found that OCCs did not function as planned nor did they followed staffing levels and procedures outlined in initial planning documents. In addition, researchers found differences between the three OCCs in such areas as training, workload, communication between supervisor and specialists, perceived relationships with external customers, and understanding of individual roles and responsibilities. They also recommended improvements to the tools used to communicate information to the specialists, such as the telephone system and the large screen displays.

Although this effort is still in progress, researchers have already collected critical data that will ultimately result in improved operations.

The Human Factors Design Standard



Initially released in 1996, the *Human Factors Design Guide* is a primary human factors reference guide in the acquisition and development of systems for the FAA. Although used by the FAA and its contractors, as well as other federal agencies and industry, the *Guide* needed to be updated to include new research and procedures. In FY 2003, the FAA released its new *Human Factors Design Standard*. This comprehensive human factors reference incorporates best practices and information from a broad range of human factors sources, including government, industry, and academia. The *Standard* replaces and expands upon the *Guide.* It includes both air traffic and airway facilities systems, providing a common source of FAA-specific design requirements. The resulting set of standards can be tailored to meet the needs of any system or program.

With over 100 new rules and guidelines and a reorganization of material based on information from users, the *Human Factors Design Standard* presents information in the form of "should" and "shall" statements. These statements can be easily converted into system-specific requirements documents or checklists. The *Standard* is now available for download through the internet at (http://hf.tc.faa.gov/hfds/) or in CD ROM format.

Photo Top Left:
Depiction of Control Center

Photo Top Right:
Human Factors Design Guide

Collocation of User Request Evaluation Tool, Traffic Management Advisor, and Controller Pilot Data Link Communication

The FAA is deploying new automation systems for use by air traffic control specialists under the Free Flight Program. Researchers developed the User Request Evaluation Tool (URET), Traffic Management Advisor (TMA), and Controller Pilot Data Link (CPDLC) as stand-alone tools, meeting the Free Flight Program's goal of achieving early benefits for aviation with low-risk technologies. Collocating the systems may result in both benefits and human factors issues for air traffic control specialists. By identifying the issues and applying human factors guidelines, researchers seek to mitigate potential collocation problems.

During FY 2003, FAA's engineering research psychologists conducted a human-in-the-loop simulation study of collocating the three systems. Twelve controllers, six URET and six TMA qualified, from six air traffic control centers participated in the two-week protocol. The researchers examined six primary areas: availability of the information; radar and radar associate roles and responsibilities; teamwork and communications; workload and situational awareness; information interactions among the tools; and other important interoperability issues that surfaced.

Preliminary findings indicate that with moderate traffic, workload was not excessively raised. However, the experimental design for collocation of URET and CPDLC on the radar associate display caused excessive clutter and may have inhibited timely access to information. This study presented the first systematic human factors evaluation of collocating all three systems and identified issues about the collocated use of the tools at the sector, which would have not otherwise been identified.

Photo Top Left:
Air Traffic Control Tower

Photo Top Right:
JANUS Interview

Optimizing Human Performance to Reduce Air Traffic Control Operational Errors

In April of 2003, the Department of Transportation, Office of the Inspector General conducted an audit of the FAA's air traffic control operational error reduction plan and reported to the FAA Administrator that while research in this area is resulting in the reduction of operational errors, more can and should be done. As a result, researchers developed and tested a new human factors technique, called JANUS, to identify causal factors related to operational errors.

Through a series of activities, researchers harmonized and tested two existing human error taxonomies (U.S. and EUROCONTROL) originally developed for retrospective analysis of aviation accident/incident data. They compared the models' similarities and differences and evaluated their strengths and weaknesses. As a result, they developed JANUS, a new incident investigation technique incorporating the best of both models. Air traffic control subject matter experts in both Europe and the U.S. participated in testing the tool and adapting it to meet each user group's distinct investigation needs.

For the FAA model, specific to the U.S. air traffic environment, researchers conducted 215 interviews of 79 operational errors. Results showed that initial analysis of both objective data from interviews and subjective data from the feedback and expert forums support using this approach. Taken together, the EUROCONTROL and FAA results provided converging evidence that the new technique appears to be more sensitive, useful, comprehensive, and practical than the current processes to identify operational error causal factors. Some scientific issues remain to be more fully answered through further research before operational implementation. These include (a) identifying improvements to increase agreement and reliability between users, (b) using this information to develop appropriate training for users, (c) refining the taxonomy, (d) further standardizing the methodology, (e) making design changes to the computer-based interface, (f) relating causal factors to objective temporal markers in incidents, and (g) linking outputs with ATC error mitigation strategies.

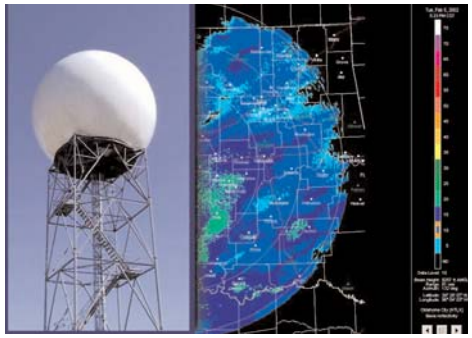
Through work jointly conducted by EUROCONTROL and the FAA, researchers quickly developed and tested the FAA JANUS technique for operational error causal factors identification. Crucial to the success of this project was the joint work and collaborative participation of FAA air traffic control management and facility managers, controllers, and European incident investigators with researchers.

Human Factors Considerations in Future Oceanic Air Transportation Systems Architectures

As air traffic increases there is a greater demand for reduced separation and more efficient routing over the ocean. Therefore, oceanic air traffic control systems and processes are quickly evolving to meet these objectives with the integration of new technologies, integrated information systems, and procedures. This new environment will significantly change the tasks of the controller and the pilot. To provide human factors support to modernization efforts, collaborative research studies are being undertaken by the FAA, Massachusetts Institute of Technology, University of Iceland, and Iceland's Civil Aviation Administration.

After site visits at the New York and Reykjavik Centers, researchers have identified the key issues faced by air traffic controllers in the current oceanic air traffic control system. Future research will further categorize and refine these issues so strategies can be formulated for the current and future oceanic air traffic control system.

Weather Information Needs in the TRACON Environment



In the National Airspace System (NAS), weather reportedly causes over 70% of all delays. For several years, researchers and air traffic control personnel have debated how to best use weather representations on operational air traffic control displays to optimize traffic flow around and through weather. This research program addresses controller weather information needs to determine how the information should be used and displayed.

Researchers completed a literature review and task analysis designed to define the information needs of terminal radar approach controllers, and studied how to best display that information as well as what procedures will be required to integrate the new information into the air traffic controller workstations. The researchers are working to upgrade the FAA's simulation platform to accommodate a future human-in-the-loop study. In addition, they are developing metrics to assess the benefits of the weather displays.

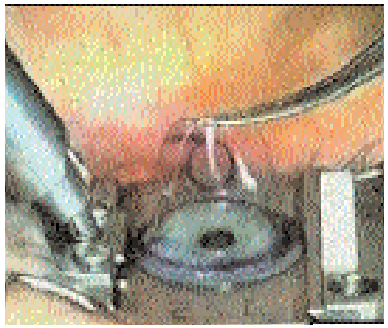
The literature review revealed that very little research has been conducted on the weather information needs of terminal radar approach control (TRACON) controllers or how the information should be displayed and used. Application of human factors principles suggests that the display of information should minimize the requirement for a controller's mental integration and provide the user with meaningful, effortless information pick-up comprehension. Researchers are now examining weather information needs, important issues related to weather phenomena for pilots and controller operations, and current deficiencies in the display and dissemination of weather information to pilots and controllers.

A literature review leading to the derivation of human factors principles was reviewed by a controller-pilot work group and submitted for publication by the Air Traffic Control Association.

Photo Top Left:
Aircraft at Takeoff

Photo Top Right:
Weather Capabilities

Vision Research



FAA's Vision Research Team conducts research associated with the visual aspects of aerospace safety to identify ophthalmic deficiencies and corrective methods that may impact aerospace safety. Their research also supports airman certification, identifies aircraft/airport environment vision hazards, and supports related education/corrective programs.

In FY 2003, researchers studied the vision requirements for persons maintaining and inspecting aircraft to develop a uniform vision standard for such personnel. In collaboration with the Ohio State University College of Optometry and NASA Ames Research Center, researchers completed site visits to 9 aircraft maintenance facilities. The team completed the survey phase of the Nondestructive Inspection/Nondestructive Testing Vision Standards Study, developed a vision task analysis and demographic profile of aircraft inspection workers, and proposed a vision screen for the inspection workers based on age. Final products will include documentation of the recommended vision standards for aircraft maintenance personnel based on the analysis of task-specific and demographic data collected during this research study.

Photo Top Left:
Vision Testing and Analysis

Photo Top Right:
Conducting Toxicology Research

Prevalence of Selective Serotonin Reuptake Inhibitors

Selective serotonin reuptake inhibitors (SSRIs)—fluoxetine (Prozac®), sertraline (Zoloft®), paroxetine (Paxil®), and citalopram (Celexa®)—are effective medications for the treatment of depression. These drugs are prescribed because of low incidences of untoward adverse effects associated with their use, allowing SSRIs to remain in the top 200 most dispensed prescriptions in the United States. While some aviators need to use SSRIs, the United States aeromedical regulatory authorities have not approved these psychotropic medications for use. Since patients with depression are frequently treated with multiple drugs, inhibition of the metabolism of these drugs by SSRIs can lead to drug-interactions, toxicity, and even death. Little is known about the postmortem aviation forensic toxicology of SSRIs. Findings on the prevalence of SSRIs in aviation accident pilot fatalities with the concentrations of SSRIs in the associated postmortem biosamples will be useful in the investigations of SSRI-associated aviation accidents. Such information will also be important to aeromedical regulatory authorities for making a possible future decision on the use of SSRIs by aviators.

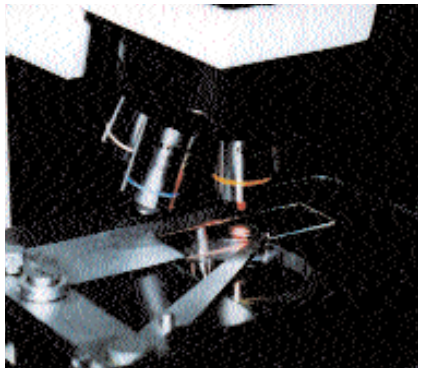
In FY 2003, researchers found that out of 4,184 fatal civil aviation accidents from which the FAA's Civil Aerospace Medical Institute (CAMI) received samples, there were 61 accidents in which pilot fatalities had SSRIs in their system. Of these accidents, 56 were of the general aviation category, two were of the air taxi and commuter category, two were of the agricultural category, and one was of the ultra light category. In 39 of the 61 pilots, other drugs such as analgesics, antihistaminics, benzodiazepines, narcotic analgesics, and/or sympathomimetics, and/or ethanol were also present. As determined by the National Transportation Safety Board, the use of an SSRI [with or without other drug(s) and/or ethanol] was a contributory factor in at least nine of the 61 accidents. Numbers of SSRI-involved accidents were low, and blood SSRI concentrations in the associated pilot fatalities ranged from subtherapeutic to toxic levels. However, the interactive effects of other drug(s), ethanol, and/or even altitude hypoxia in producing adverse effects in the fatal-pilots cannot be ruled out.

Biodynamics Research

The FAA's Biodynamic Researchers evaluate the injury potential of new materials and structures by using advanced computational and impact test techniques under simulated crash environments and support other FAA elements in conducting dynamic tests. They are developing new methods, techniques, and equipment for evaluating injury potential and providing research products to support FAA aircraft certification and rulemaking organizations.

In FY 2003, researchers initiated a program to develop improved/simplified methods to conduct aircraft seat certification testing. As part of the certification-streamlining program, the FAA funded the National Institute for Aviation Research at Wichita State University to develop a test device, called the Head-Impact-Criteria Component Tester, that could simulate the motion and forces that result from occupant head impact on an aircraft structure or seat. To support this effort, researchers evaluated the tester to develop design enhancements and validate the effectiveness of the device. They conducted a series of biodynamic tests comparing the tester to full-scale impact sled tests with instrumented crash dummies. The test program identified a number of design improvements for the tester. Analysis of the data is ongoing; however, a preliminary review indicates that the tester may duplicate full-scale sled testing in some areas. This could significantly reduce the complexity and time required by the manufacturing industry to certify aircraft seats, thereby streamlining the certification process.

Toxicology Analysis



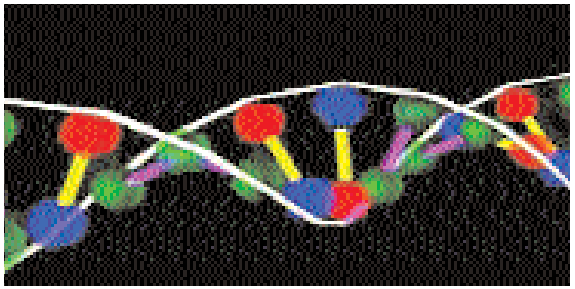
Specimens from fatal aviation accident victims are submitted to the FAA's Civil Aerospace Medical Institute for toxicological analysis. Until recently, toxicologists had difficulty determining if the ethanol present in the body was the result of alcoholic beverages (ethanol is the main component of all alcoholic drinks), or the result of normal postmortem ethanol formation in the body as a natural fermentation process. FAA researchers have now discovered the key to determining more accurately the origin of ethanol and can now predict pre-death alcohol consumption.

The consumption of alcoholic beverages alters the concentration of two major serotonin metabolites, 5-hydroxytryptophol (5-HTOL) and 5-hydroxyindole-3-acetic acid (5-HIAA). While the 5-HTOL/5-HIAA ratio is normally very low, previous studies using live subjects have demonstrated that the urinary 5-HTOL/5-HIAA ratio is significantly elevated for 11-19 hours after acute alcohol ingestion. The 5-HTOL/5-HIAA ratio is not affected by the postmortem microbial formation of ethanol or the consumption of serotonin rich foods.

In FY 2003, researchers investigated the 5-HTOL/5-HIAA ratio as a potential indicator of ethanol origin in postmortem urine specimens. They developed and subsequently validated a novel method for the simultaneous determination of 5-HTOL and 5-HIAA in forensic urine specimens using a simple liquid/liquid extraction in combination with liquid chromatographic with mass detection (LC/MS) method.

Using the LC/MS method, researchers examined the 5-HTOL/5-HIAA ratio in 21 ethanol-negative and 23 true ethanol-positive postmortem urine specimens. They found that all ethanol-negative specimens had 5-HTOL/5-HIAA ratios significantly below 15 pmol/nmol, a previously established antemortem urine cutoff for recent ethanol ingestion. All ethanol-positive urine samples had 5-HTOL/5-HIAA ratios above 15 pmol/nmol. The data obtained statistically validated the 15 pmol/nmol antemortem cutoff for use with postmortem urine specimens. This method is currently being used to examine cases that contain ethanol from an unknown origin, but are suspected of containing ethanol formed postmortem.

Functional Genomics Research



FAA's Functional Genomics Research Program seeks to understand the genesis of human error through application of genomics, proteomics, and bioinformatics for ensuring aerospace safety. Studies conducted by the researchers are assisting the FAA, as well as the National Transportation Safety Board, in post-crash accident investigations, enhancing the FAA's drug abatement objectives, and the existing knowledge base for various human conditions of particular concern in pilot certification.

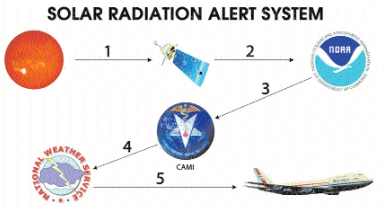
In FY 2003, researchers, in collaboration with the University of Utah and its affiliated Center for Human Toxicology, worked to define measurable parameters that are indicative of alcohol induced functional impairment. The first phase of this project identified alcohol responsive genes in blood cellular element for further investigations.

Researchers also studied physiological stress due to circadian desynchronosis as a model of fatigue, since fatigue is an invariable consequence of sleep-deprived condition that leads to performance deficits and accidents. The results from this study will provide insight for analyzing the human factor of accidents whether fatigue is the consequence of jet lag, rotating shifts, working overtime, or other stress conditions. Understanding the molecular basis of fatigue is important for implementing rational interventions to overcome the effects of fatigue, assisting the FAA in its efforts to maintain safe and effective air operations.

Photos Opposite Page:
Top Left, Head Impact Criteria Component
Top Right, Identifying Specimens

Photos This Page:
Top Left, DNA Sequence Strand
Top Right, Solar Radiation Alert System

Radiation Exposure



One of the potential hazards of air travel is accumulated exposure to ionizing radiation over the course of a flying career. Damage from the radiation leads to an increased risk of cancer in the individual and an increased risk of genetic defects in future generations. Flight personnel are generally unaware of these risks.

In FY 2003, FAA's Radiobiology Research Team, in collaboration with the Space Environment Center of the National Oceanic and Atmospheric Administration (NOAA), developed a Solar Radiation Alert system to predict solar radiation events. The Solar Radiation Alert system uses solar proton measurements, made by instruments aboard satellites, to estimate radiation levels at specified high-latitude locations at altitudes from 20,000 feet to 80,000 feet in 10,000 feet intervals. If the radiation level at any of these altitudes equals or exceeds 20 microsieverts per hour, an alert is transmitted worldwide to subscribers of NOAA's Weather Wire Service. The entire process, from measurements by satellite instruments to issuance of a Solar Radiation Alert (if appropriate) takes 5-10 minutes. For air-carrier aircraft, the recommended response to an alert is to minimize flight time at altitudes where the radiation level equals or exceeds 20 microsieverts per hour. A "recommended maximum flight altitude" in the alert message is the maximum altitude, at the specified high-latitude locations, where the radiation level is below 20 microsieverts per hour.

To help frequent flyers determine their exposure to ionizing radiation, researchers developed computer programs to estimate radiation dosage on flights. These user-friendly programs are available free at, http://www.cami.jccbi.gov/radiation.html. The programs calculate the effective dosage rate of galactic radiation received on an aircraft flying a great circle route or on a user-defined route. In addition to these computer programs, researchers have developed educational materials for the flying public explaining the potential risks of frequently flying at high altitudes. In FY 2003, FAA researchers wrote an informational brochure, *What Aircrews Should Know About Their Occupational Exposure to Ionizing Radiation* (http://www.cami.jccbi.gov/AAM-600/Radiation/trainingquestions.htm) and published "Perspectives: Ionizing Radiation Safety" in *Avionics Magazine*.

Cabin Safety Research

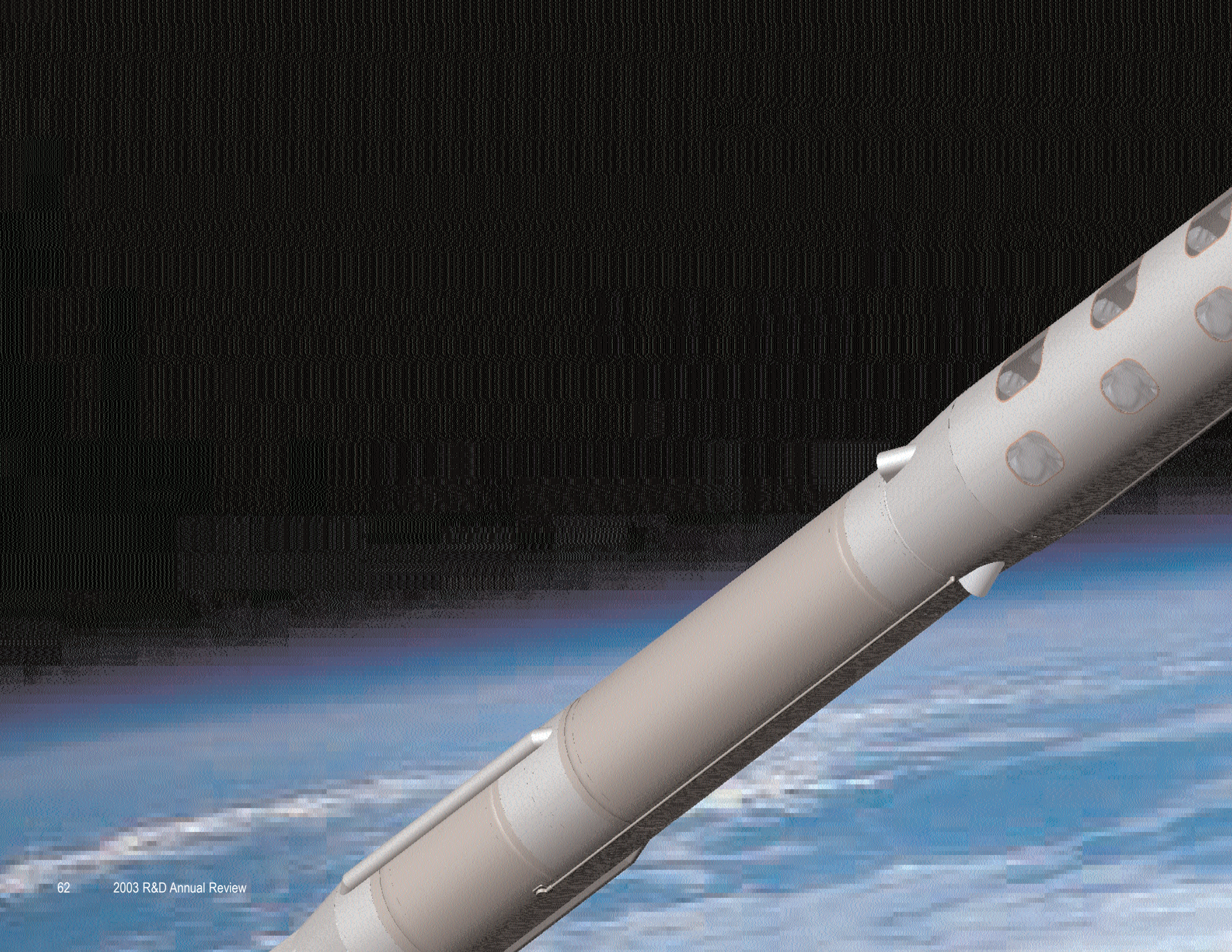
FAA's safety researchers monitor aircraft cabin safety problems and conduct research studies and tests pertaining to the emergency evacuation of aircraft and subsequent survival situations. In FY 2003, researchers obtained questionnaire data from subjects participating in a study of emergency egress through cabin emergency exits to support a replication of a 1979 FAA study of passenger safety awareness. Analysis of the data will reveal the degree to which current airline passengers make themselves aware of the safety information available onboard commercial transport airplanes, revealing the extent to which such passengers are in need of additional information and alternate safety information presentation methods. The results will be presented initially at the 2004 Annual Scientific Meeting of the Aerospace Medical Association.

Certification procedures for new transport category aircraft require manufacturers to show the aircraft can meet certification criteria for passengers evacuated onto land. Evacuation criteria for ditching scenarios, in which passengers must evacuate into life rafts or into the water, are not included in those requirements. Instead, certification requirements for ditching have generally been demonstrated via the use of a flotation-time analysis for each new airplane type. The differences in the proposed design and operation of new very large transport airplanes, e.g., the Airbus 380, which will conduct many extended over-water operations, raises questions regarding some of the assumptions in the flotation-time analyses.

In a successful Airbus 380 ditching, the height above water level for emergency exits has been predicted to range from just a few inches to about 6 feet. This may create significant deviations from the historically assumed passenger flow rates into the water. During the fiscal year, researchers conducted a series of tests to evaluate water evacuation flow rates with test subjects entering the water from Type A (42" wide) and Type 1 (24" wide) exits. The tests evaluated exit heights of 6", 2', 4' and 6' above water level with the subjects using 3 different types of flotation equipment (seat cushions, life preserver inflated prior to water entry and life preserver inflated after water entry). Findings indicate that the exit flow rate decreased with higher over water exit heights and that evacuation rates for subjects using seat cushions for flotation was slower than evacuations with subjects wearing life vests.

FAA researchers also worked with NASA to undertake a live subject study to determine the time required for an air crew to secure an aircraft cabin in preparation for clear air turbulence. This NASA-led and funded experiment used the CAMI Boeing 747 Aircraft Environmental Research Facility as a wide body test facility. The research team for the study consisted of personnel from six airlines, two flight attendant labor unions, NASA, and the FAA. CAMI provided subject, logistic, and data analysis support for the study. The study placed subjects in test start positions that might be expected from three different cabin scenarios (after movies, after snack service, and during full meal service) and evaluated the time required to secure the cabin using standard and expedited passenger handling/clean-up procedures. The experiment was conducted in October, at the FAA's Mike Monroney Aeronautical Center, Oklahoma City, Oklahoma. Results indicate that subject seating times were consistent through out all trial conditions.

Photo Opposite Page:
FAA Ditching Test



Commercial Space Transportation Research

R&D Annual Review 2003

The Commercial Space Transportation Research program supports the FAA mission to ensure protection of the public health and safety and the safety of property, during a commercial launch or re-entry activity.

The program supports the protection of national security and foreign policy interests and it encourages, facilitates, and promotes the U.S. commercial space transportation industry.

Commercial Space

Flight safety systems minimize the threat to public safety and property created 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. Integrated vehicle health management systems detect, report, and isolate malfunctioning units and sub-systems of a vehicle to ensure safety and mission success. The utility of both of these safety systems may be crucial to the development of a reusable launch vehicle capable of maintaining a consistent level of safety at a variety of ranges and spaceports.

In FY 2003, FAA researchers completed a report on non-traditional flight safety systems and integrated vehicle health management systems. The report describes proposed and existing designs for these systems based on a survey of the commercial launch industry and government research efforts. Further, it suggests and describes enabling technologies and verification methods that will assist in their regulation. The results of this research will help to evaluate the efficacy of a reusable launch vehicle operators' flight safety system to provide an adequate level of safety to protect the uninvolved public from vehicle failures.

Researchers also developed and are currently calibrating an acceptable method of estimating a vehicle's breakup and survivability process. The model will be used to estimate the risk posed by debris to the public, and will allow the commercial space transportation industry to reduce risk to the public during the launch and/or reentry of their licensed operations. The results of this research may be used to define space vehicle flight corridors that adequately protect the public from commercial space transportation operations. In addition, researchers completed a draft document for use by the FAA and industry to perform a first-hand estimation of the expected casualty for a given mission.

In early 2003, FAA's Civil Aerospace Medical Institute worked with the National Academy of Sciences National Research Council to establish a post-doctoral research associate program in support of FAA commercial space research activities. FAA's first post-doctoral scholar is studying the "Minimum Requirements for Environmental Control and Life Support System (ECLSS) on Manned Commercial RLVs." This research effort will provide the FAA with critical information on the limits of reusable launch vehicle equipment to provide a proper environment that will ensure the survivability of the flight crew as part of the flight safety system.

The FAA also began a project to document the capabilities and limitations of current and potential non-destructive evaluation methods used to inspect components beneath thermal protection systems of reusable launch vehicles. This effort will ensure that reusable launch vehicles are safe to re-fly by providing means to verify the integrity of the vehicle's structure.

Photo Opposite Page:
Planned Reusable Launch Vehicle

Environment & Energy Research

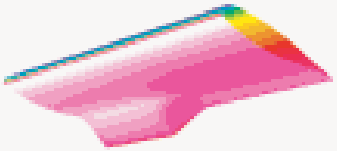
R&D Annual Review 2003

The FAA's Environment and Energy Research Program develops superior decision support tools, and ensures responsive strategies that allow aviation to grow in an environmentally responsible manner.

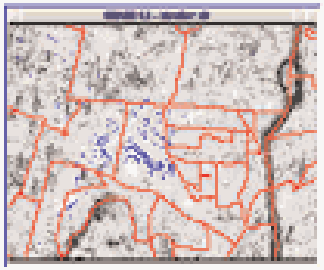
This program addresses public concerns about the environmental affects of aircraft and airport operations.

By targeting the adverse environmental by-products of aviation, primarily noise and emissions, the Environment and Energy Research Program enhances public mobility and ensures the continued growth of aviation.

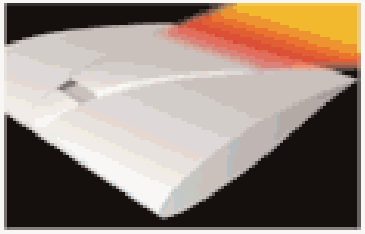
Quiet Aircraft Technology Program



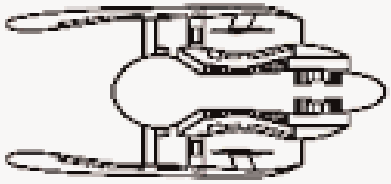
Airframe Noise Reduction



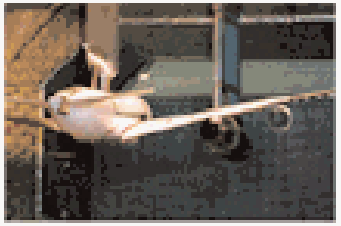
Community Noise Impact



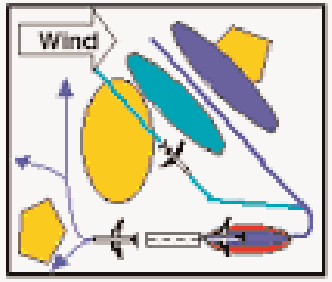
Jet Noise Reduction



Broadband Fan Noise Reduction



Propulsion/Airframe Aeroacoustics



Advanced Operations

FAA and NASA Advance Readiness of Noise-Reduction Technologies

In 2003, the FAA and NASA signed a new memorandum of agreement to work collaboratively on noise reduction technologies, with a long-term goal of containing objectionable aircraft noise within airport boundaries. They also expanded joint research efforts, focusing on maturing promising technologies to increase the confidence in projected noise impact benefits.

Areas of research under the FAA- NASA "Quiet Aircraft Technology" (QAT) program include engine systems noise reduction technologies, airframe systems noise reduction concepts, and community noise impact. Engine technology efforts include demonstrating the noise reduction benefit of various fan blade and vane concepts and variable area nozzles, developing new liner materials and an active noise control system, and reducing jet noise through advanced chevrons, air injection, variable geometry chevrons, active control technologies, and other concepts.

Airframe efforts are exploring high-lift systems and novel landing gear noise reduction concepts. Community noise efforts include investigating low noise approach profiles and ways to implement them in the air traffic management system using new and modified air traffic controller procedures. Some preliminary airframe systems component tests produce noise reductions from 5-10 decibels. Fabrication of prototypes of promising technologies is underway and critical tests will take place in FY 2004.

Photo Opposite Page:
Noise Reduction System

Photo Right Page:
Louisville International Airport

New Flight Procedures Reduce Aircraft Noise

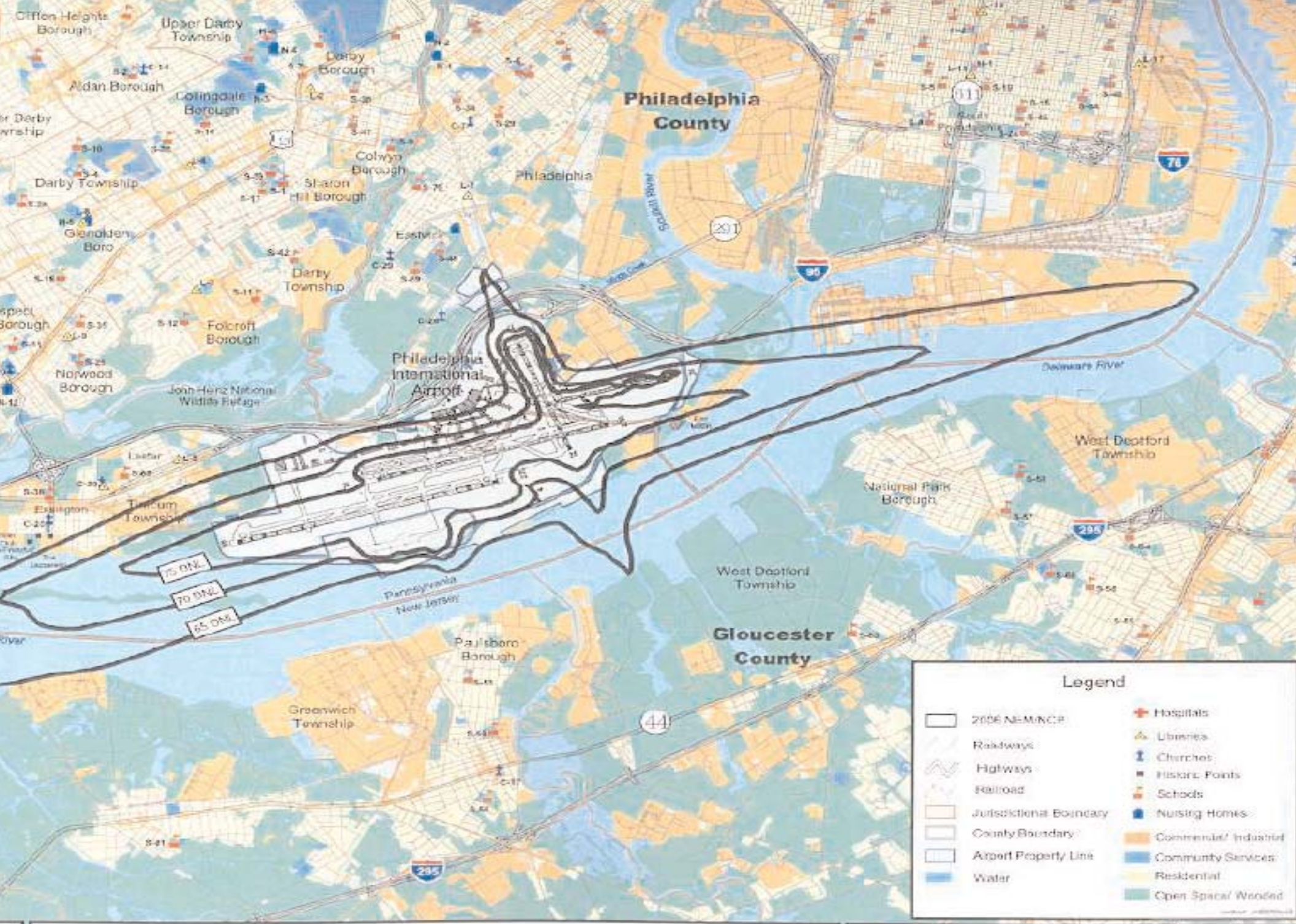
In FY 2003, Louisville International Airport hosted tests of a Continuous Descent Approach (CDA) flight procedure. CDA offers hope for a reduction in aircraft noise for residents living about 10–30 miles off the end of airport runways.

The test, conducted by a team from the FAA, Boeing, the Massachusetts Institute of Technology, NASA, UPS, and the Regional Airport Authority, included eight fly-over noise measurements over a two-week period.

During the tests, 14 highly sensitive NASA and Boeing microphones at seven locations in southern Indiana recorded two UPS 767s equipped with special onboard Flight Management Systems. One aircraft flew a standard approach, which involves flying closer to the ground for as many as 30 miles before landing, while the other flew a never-before tested flight pattern that requires the aircraft to stay at higher altitudes longer than is presently done when preparing for landing. Previously, the procedure had been modeled on computer simulations only.

Results show that the average noise reduction during the CDA procedure is between three and six decibels. A three-decibel difference is noticeably different to the average human ear, while a reduction of 10 decibels, for example, would be a 50 percent reduction in noise. Additionally, the CDA procedure is more fuel-efficient.

Now that the anticipated and significant reduction in noise has been demonstrated, the next step is for airports, airlines, and air traffic controllers nationwide to incorporate the procedure into practical applications and flight patterns. Implementing the procedure at Louisville International Airport could provide a significant reduction in aircraft noise to residents living 10 to 30 miles off the ends of the runways, such as Clark and Floyd counties in southern Indiana and Bullitt County in Kentucky.



Future Baseline Contour

FINAL

Prepared by Landrum and Brown

Exhibit 3 - 2

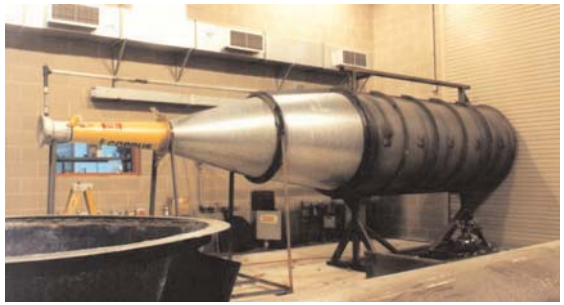
New Version of Integrated Noise Model (INM) Released

The FAA released version 6.1 of the Integrated Noise Model (INM) in March 2003. Commercial engineering firms and government authorities, both domestic and international, use this computer tool to assess aircraft noise around airports. Agencies, companies, and institutions in 42 countries around the world have purchased over 700 copies of the INM software for the purpose of evaluating aircraft noise exposure around airports, making it the de facto world standard in noise modeling.

This new version of INM includes six new noise and performance data sets developed in collaboration with NASA and EUROCONTROL, new data sets for military aircraft, and new capabilities for satellite-based geographic information systems. INM 6.1 includes up-to-date airport information from the National Airspace System Resource Aeronautical Data System and contains an expanded set of routines to process U.S. Census data from the Department of Commerce. It also implements changes to noise propagation based on research performed internationally in support of updates to Society of Automotive Engineers best practice documents for noise modeling. Future plans include developing a new flight dynamics model for assessing operational procedures and an internationally accepted helicopter noise model.

Overall, the INM software has a track record of flexibility across a diverse array of users. It is successfully being used as either a standalone model or as part of a broader research planning system. The FAA's INM is a proven tool that is succeeding in ensuring a desirable outcome for both aviation and the local communities on a number of levels, including increased quality of the local environment, economic growth, and greater access to transportation.

New Tool for Assessing Global Aircraft Emissions

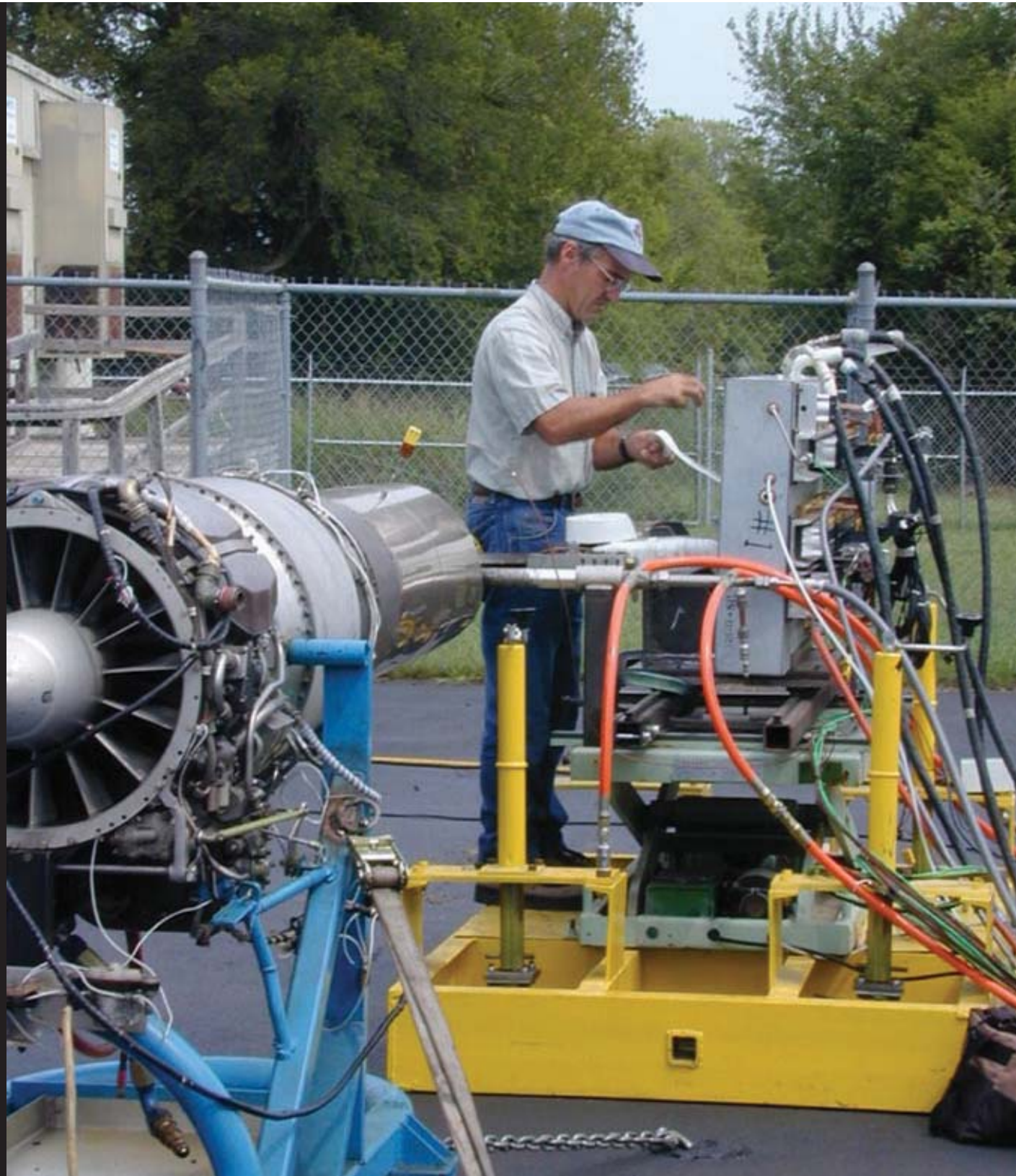


In FY 2003, the FAA, in collaboration with the Volpe National Transportation Systems Center, the Massachusetts Institute of Technology, and the Logistics Management Institute developed a unique capability to estimate aircraft emissions ranging from a single flight to regional and worldwide scales. While aircraft are not a primary source of emissions resulting from fossil fuel combustion, they are the only anthropogenic contributor to deposit pollutants in the upper troposphere and lower stratosphere. Aviation is a global enterprise, and System for Assessing Aviation's Global Emissions (SAGE) offers the unprecedented capability to vary base year inputs and operational, policy, and technology-related scenarios to assess aviation global emissions.

SAGE is a computer tool to estimate and assess aircraft emissions on a technological, operational, and geographical basis, considering emissions levels through all phases of flight. At the heart of the model are technical modules, including aircraft performance, aircraft movements, capacity and delay, forecasting, fuel burn, and emissions. One typical application allows users to develop emissions inventories based upon fleet forecasts. However, the model also has the capability to estimate emissions, taking into account aircraft routing and flight trajectories, and outputting emissions levels by geographic location. The model, currently limited in use to research applications, signifies a major achievement in capturing the logistical complexities of global aviation operations. The FAA plans future enhancements of the model.

Photo Opposite Page:
Noise Exposure Map - Philadelphia International Airport

Photo Right Page:
Aircraft Engine



Hazardous Air Pollutants

Aviation-related emissions are a growing concern for the FAA, airport authorities, and communities surrounding airports. In particular, there is a growing interest in the potential effects of hazardous air pollutants. According to the Environmental Protection Agency, 14 of the 188 air pollutants considered hazardous are present in the exhaust of aircraft and airport ground support equipment.

In recent years, several air quality-monitoring studies have focused on emissions from aircraft and airport operations, and their effect on local and regional air quality. Both proponents and opponents of airport expansion, as well as state and local environmental agencies, have conducted these studies, with conflicting or mixed results.

To address concerns on air quality, the FAA reviewed publicly available information to determine the state of the science on assessing hazardous air pollutants from aircraft and airport-related activities and published a report. The report includes a bibliography of over 100 published articles to guide readers in locating articles on specific topics on hazardous air pollutants. Ultimately, this review will assist the FAA's development of guidelines and methodologies for assessing and mitigating hazardous air pollutants in a consistent and uniform manner. The review also identified significant knowledge gaps. Filling these gaps will require new test data and information, the development of scientific assumptions, and the application of sound judgment. Because this is such a complex undertaking, the FAA is actively working with the aviation, scientific, regulatory, and environmental communities to address concerns posed by hazardous air pollutants.

To view or download a copy of the report, *Selected Resource Materials and Annotated Bibliography on the Topic of Hazardous Air Pollutants Associated with Aircraft, Airports, and Aviation, please* go to www.aee.faa.gov/emissions/airindex.htm.

Photo Opposite Page:
Aircraft Emissions Testing & Test Equipment

Photo Right Page:
Satellite Photo Used for Land Use Classification

Modeling System for Assessing Global Noise Exposure (MAGENTA) Updated

The FAA enhanced the Model for Assessing Global Exposure from Noise of Transport Airplanes (MAGENTA) to include satellite geographic information system capability to identify imagery derived land use classifications. This update provides an enhanced capability to assess the impact of development projects on numbers of people exposed to noise.

Developed by the FAA and Wyle Laboratories, MAGENTA provides the capability for global assessments of aircraft noise and the impact of mitigation measures. The MAGENTA software and its database estimates global noise exposure caused by civil aircraft operations. Computing noise exposure contours around a large number of civil airports and counting the number of people residing within them. The model includes information on more than 1,700 civil airports that handle jet traffic and offers a landmark capability to assess global benefits of noise mitigation policy options.

Future plans include expanding MAGENTA's capabilities to assess the effectiveness of land-use mitigation measures and incorporating the Enhanced Traffic Management System to provide more accurate modeling of airport flight operations. The FAA currently uses the Enhanced Traffic Management System to predict, on national and local scales, traffic surges, gaps, and volume based on current and anticipated airborne aircraft. It captures every aircraft that flies within coverage of the FAA's radars, including unscheduled, cargo, military, charter, and scheduled flights.

U.S. Department of Transportation
Federal Aviation Administration
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