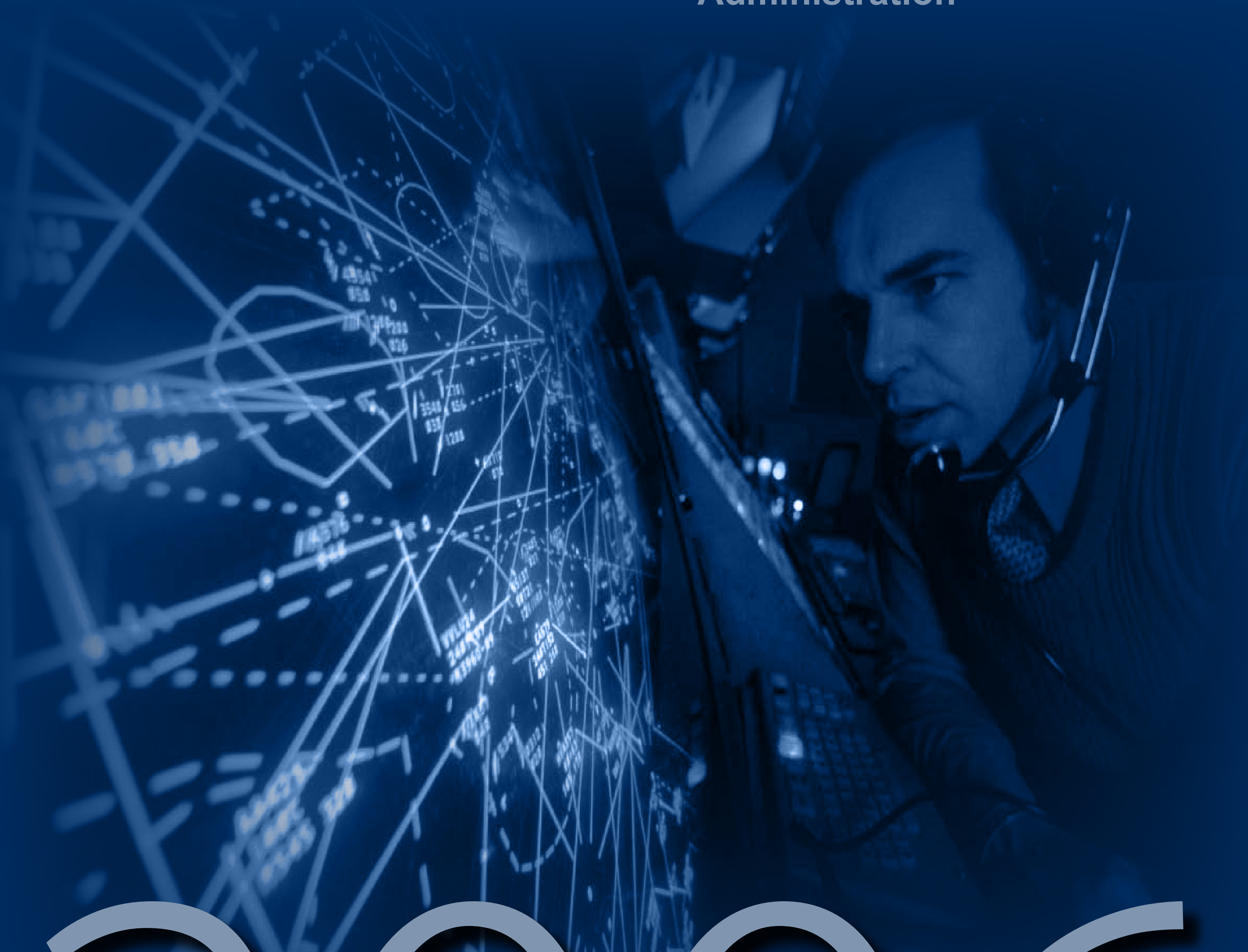
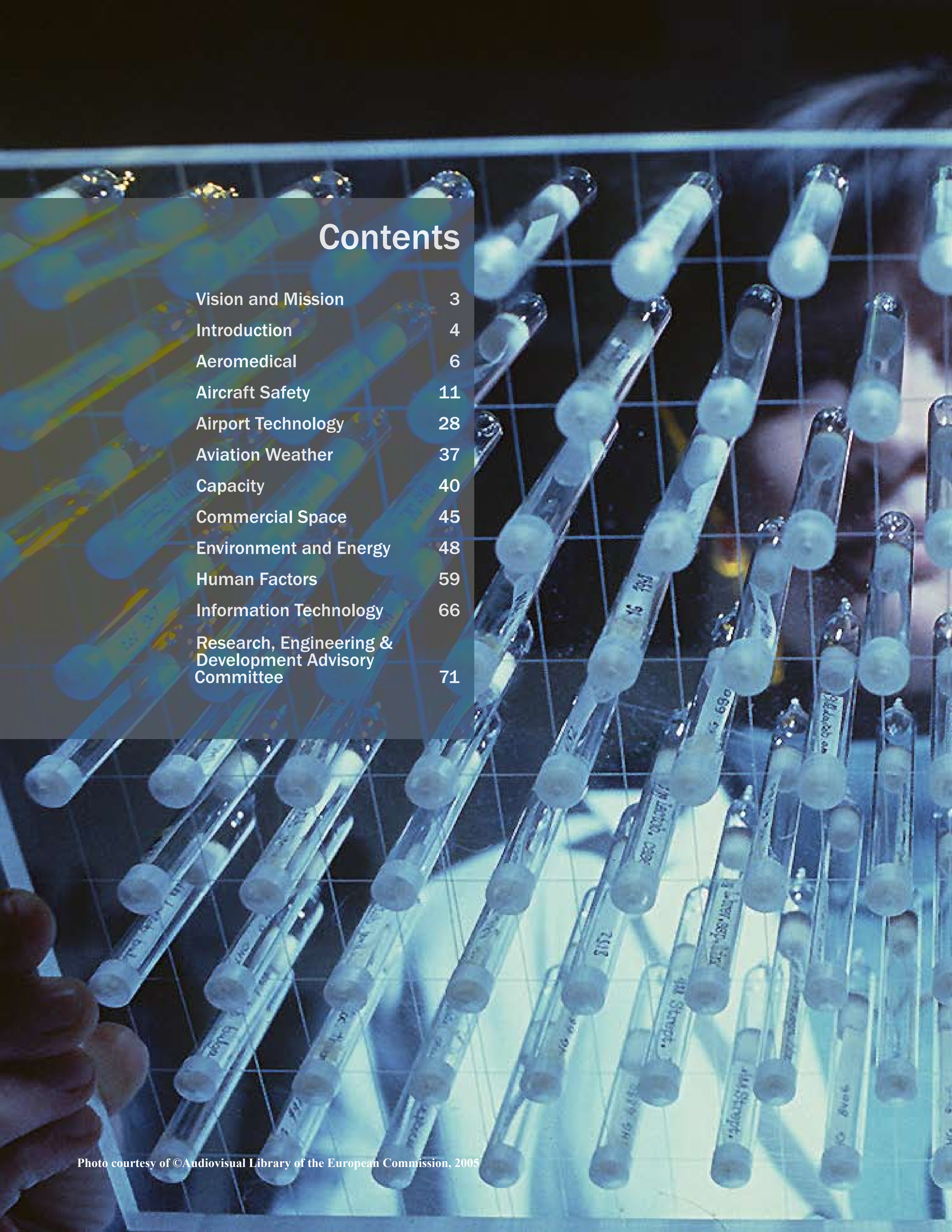
Federal Aviation Administration



2006

R&D Annual Review



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Vision: **Provide the best air transportation system through the conduct of world-class, cutting edge research, engineering and development.**

Mission: **Conduct, coordinate, and support domestic and international R&D of aviation-related products and services that will ensure a safe, efficient, and environmentally compatible global air transportation system.**

Aviation is an integral part of our daily lives. Airplanes bring individuals closer to family and friends. Record numbers of us now "catch a plane" from time to time for work or recreation. Special aircraft provide emergency transportation, deliver medical services and supplies, and rush critical safety services wherever they are needed.

Critical to our national well-being and interests, aviation serves as our first line of defense in an uncertain world. It provides invaluable opportunities for new business, for jobs, and for the general growth and development of the U.S. economy. It serves an important role in attracting investment to local communities and helps stimulate and sustain growth by opening new markets and supply chains, nationally and internationally.

The United States has an aviation system that is second to none – one that has proven it can respond quickly to our changing and expanding needs. It is a complex global system with numerous public and private sector stakeholders. It consists of thousands of aircraft and airports supporting business travel, scheduled passenger service, airfreight, and recreational flying.

The U.S. continually introduces new technologies, procedures, policies, and management practices to ensure our worldwide aviation leadership. Research and development (R&D) is central to this innovation. Ever evolving R&D helps to achieve virtually all of the FAA's short- and long-term goals and objectives. Dedicated professionals facilitate the day-to-day operations of the national aerospace system while they simultaneously develop the next generation air transportation system. The R&D community conducts research activities from materials and human factors development to the creation of new products, services, and procedures.

The FAA has established the following goals to focus an integrated R&D program on meeting the nation's needs:

- Reduce aerospace environmental impact in absolute terms
- Develop a system that moves anyone and anything, anywhere, anytime quickly on schedules that meet customer needs
- Maintain the best qualified and trained workforce in the world
- Create an aerospace system that adapts to, compensates for, and augments human performance
- Ensure no fatalities, injuries, and adverse health impacts on people due to aerospace operations
- Prevent accidents and incidents due to aerospace vehicle design, structure, and subsystems
- Prevent accidents and incidents due to aerospace vehicle operations in the air and on the ground
- Provide common, accurate, and real-time information on aerospace operations, events, crisis, obstacles, and weather
- Assess how change to the system impacts performance and risk, and how the system itself impacts the nation
- Be a globally recognized leader in aerospace technology, systems, and operations

Our researchers, scientists, engineers, and professional staff are creating the tools, technologies, and procedures that will lead us to the next generation aerospace transportation system. We are conducting critical research for aviation's future.

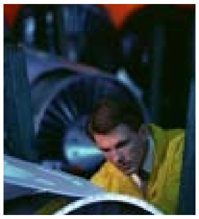
The Fiscal Year (FY) 2006 R&D Annual Review tells readers what we have accomplished to achieve our ambitious goals.

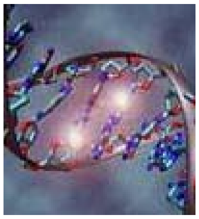
For additional information on the R&D program, please see the *National Aviation Research Plan*, which includes a description of our R&D projects, our research partners, budget information, and anticipated results.

Aeromedical

"We are improving the health and safety of passengers and aircrews."

Melchor J. Antuñano, M.D.
Director, Civil Aerospace Medical Institute





Determining the Prevalence of Methamphetamine in U.S. Aviation Accident Pilot Fatalities between 1995 and 2004

FAA medical researchers continue to improve our understanding of health factors that can affect aircraft pilots, crews, and passengers. After a fatal aircraft accident, the Agency's forensic toxicologists routinely attempt to detect and measure drugs, alcohol, toxic gases, and toxic industrial chemicals in the remains of aviation personnel to rank these factors among the causes of the event.

Methamphetamine is an addictive stimulant drug that strongly activates certain systems in the brain, and its abuse is one of the fastest growing epidemics in America. Upon toxicological analysis, a methamphetamine positive in postmortem fluids and/or tissues of crew members has serious legal consequences and may help determine the cause of an aviation accident. In FY 2006, researchers conducted an epidemiological study examining drug findings from aviation pilot fatalities from 1995 to 2004. Results showed that fatal aviation accidents associated with methamphetamine are infrequent, accounting for only 0.37 percent of all fatal events in a given period. These findings will serve as baseline data to evaluate future prevalence of methamphetamine. Furthermore, by evaluating chemical parameters affecting aviation personnel, potential mitigation strategies may become apparent for accident prevention.

Discovering Gene Expression Changes as a Result of Sleeplessness

Fatigue is well recognized in both the public sector and in military units as a factor affecting human performance. To date, research has focused on how being tired affects a person physiologically and what can be done to treat fatigue symptoms. Little attention has been paid, however, to finding the underlying molecular changes that occur as a result of fatigue or how they might cause changes in performance or cognition.

Discovery of the molecular basis for fatigue is important to the future of aviation medicine for several reasons. A more exact understanding of the biochemical changes resulting from sleeplessness may allow accident investigators to prove that fatigue is a factor in the probable cause of some accidents. In addition, knowledge gained from this inquiry may improve the FAA's ability to prepare fact-based, scientifically defensible regulations. These investigations may also lead to the development of new intervention therapies for situations where extended duty-cycles are unavoidable. By targeting the specific biochemical pathways clinically shown to be affected by fatigue, doctors may be able to help aviation personnel to increase performance levels and alertness in ways that neither harm the aviators nor jeopardize the public.

In collaboration with military investigators at the U.S. Air Force Brooks-City Base, FAA

researchers conducted a study of the changes in gene expression over an extended period of sleeplessness. The study was designed to collect participant samples at 24 hour intervals for four days, including two samples collected after 15 and 35 hours of being awake. Researchers discovered 158 genes that affect fatigue. Some of the biochemical pathways affected by fatigue are cell-cell signaling, cellular assembly and organization, lipid metabolism, hematological system development and function, and small-molecule biochemistry. Clustering by expression pattern revealed that the differentially expressed genes follow one of five expression patterns over time. When validating their results, researchers observed that genes in similar biochemical pathways have the same expression pattern clusters. Functional analysis of clustered genes demonstrated that there was coordinated regulation of genes within clusters.

These results will serve as baseline data upon which to extend this work to a broader population. Working with larger numbers of more diverse subjects will help the project to achieve its goal of isolating biomarkers that are useful both in accident investigations and in other forensic applications.

Testing General Aviation Oxygen Systems at Altitude

Innovative new designs in aviation equipment are not always described in existing FAA regulations or guidelines. To ensure safety, Agency researchers often study new equipment to ensure compatibility with existing regulations and, if necessary, to recommend changes or additions to those regulations.

In 2006, researchers studied a new type of oxygen system designed for use in general aviation aircraft. The pulse oxygen delivery system relies on simple oxygen delivery equipment similar to the passenger masks found in commercial aircraft. It can also use the type of nasal cannula that delivers oxygen to medical patients. As with the latter system, the design of the pulse oxygen system provides a simple, inexpensive system that conserves the aircraft's oxygen supply.

When this hybrid oxygen system was first developed, current regulations did not provide applicable standards or criteria for its testing. The researchers therefore drew upon available resources and used the FAA Civil Aerospace Medical Institute's (CAMI) altitude chamber to develop and execute a test protocol on human subjects. Ten male and six female subjects were exposed to altitudes reaching 25,000 feet. Two different pulse oxygen systems were tested, one that used a mechanical regulator to determine when and how much oxygen should be delivered, and one that used an electronically controlled regulator for oxygen delivery.

Researchers also conducted tests of the oxygen systems at 18,000 feet with the subject wearing a nasal cannula and at 25,000 feet with the subjects wearing an oxygen mask. While at these altitudes, the subjects alternatively used each of the regulator systems to maintain the blood oxygen saturation at a level equivalent to altitude exposure at 5,000 feet. This is considered to be the lowest altitude where the effects of hypoxia (lack of oxygen) could result in symptoms such as a loss of night vision.

The test results showed that, at either 25,000 or 18,000 feet, the mechanical system could not provide adequate oxygen to maintain the subject's blood oxygen saturation at the 5,000 foot equivalent level. With the mechanical system, some of the subjects experienced symptoms of hypoxia and had to switch to an emergency oxygen system to recover. The electronic oxygen delivery system, however, did provide adequate oxygen to keep the subject's blood oxygen saturation level at or below the 5,000 foot criteria. Besides conducting certification testing for the two pulse oxygen systems, researchers exposed the subjects to altitudes of 10,000, 12,500, and 14,000 feet without supplemental oxygen.

Findings from these tests showed that, as the exposure altitude increased, the various subjects reacted in increasingly different ways. Current regulations allow flight at altitudes up to 12,500 feet without supplemental oxygen, and pilots are permitted to stay at altitudes between 12,500 and 14,000 feet for 30 minutes without supplemental oxygen. Results from these studies indicate that some individuals may not be able to tolerate even these altitudes without supplemental oxygen.

Certifying Aircraft Seats

To be certified for use, any new or modified aircraft seat must be shown to be safe through impact testing. Manufacturers are required to provide test results demonstrating that the seat and its restraint system will protect their occupant during a representative emergency landing or crash. These tests are expensive, destroy the specially built test article, and can only demonstrate a small number of potential crash scenarios. FAA certification and research personnel are working with industry experts to streamline the process of seat certification to include the use of computer modeling as an aid in certification. The computer model can significantly reduce the cost of testing and can allow more test scenarios to be evaluated to identify potential deficiencies. However, the computer model must be determined to be accurate when compared to actual impact tests.

To provide assurances that modeling does provide valid analyses, researchers conducted a comparison test. They set out to determine whether various computer models could accurately predict the arc that the head of an anthropomorphic test dummy would travel during a crash – as simulated on the CAMI sled track. Four modelers provided independent input data and computer scenarios in preparation for a simple crash test. The researchers found that seemingly small differences in the assumptions made by the individual modelers lead to significant differences in the model result. This emphasized the importance of establishing uniform parameters prior to the use of any computer simulation. Also, when compared to actual test results, models tend to under-predict head travel, and model-based predictions are being reassessed and revised accordingly.

Studying Medical Certification Requirements

The FAA is called upon to certify pilots with varying characteristics. The Agency recently conducted a large cross-functional study concentrating on how female pilots compare with males with regard to various other characteristics and performance. Researchers used the Aerospace Medical Research Scientific Information System (ARMSIS) to select from 7,911,739 records of medically certified, active male and female pilots, representing 1,427,223 individuals over the 1993-2003 timeframe. They also drew on information from the National Transportation Safety Board, and FAA Aerospace Medical Research Toxicology and Autopsy databases.

Of the 20,191 records used in the study, 0.26 percent were associated with accidents and incidents logged by the NTSB; 736 represented 717 individual female aviators. Ninety-five of these female pilots experienced a fatal accident as a pilot-in-command, and of these, 90 percent resulted from general aviation operations. The ages of the pilots at the time of the accidents ranged from 17 to 77 years, with an average age of 41. Twenty-four percent of the pilots held a 1st class medical certificate, while 24 percent held 2nd class certificates and 41 percent held 3rd class certification. In terms of the NTSB investigation of the 95 fatal accidents, investigators identified 327 causes and factors, and they attributed 55 percent of those factors to the pilot in command. Researchers found that the most common causes were the lack of airspeed (23 percent) and lack of experience (29 percent).

The researchers also looked at toxicological causes of events. Twenty-three percent of the pilots reported having taken medications, and females proved more likely to self-report medications than males. Only four cases were relevant in terms of the type of medication identified, including abused or disqualifying drugs (e.g., cocaine, sertraline, hydrocodone, and alprazolam). Investigators found a low use of alcohol, with only one pilot testing positive for ethanol. A total of 323 injuries resulted from the 95 aircraft accidents. Other findings included 310 fatalities, 11 serious injuries, and two minor injuries. In terms of autopsy findings, researchers identified 710 types of injuries: thorax (22 percent), lower and upper extremities (18 and 16 percent respectively). They found the distribution and severity of injuries by body region similar for males and females, except for the thorax, where the incidence of injury proved significantly greater for males (28 vs. 23 percent for females).

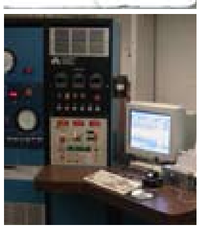
This study represents evidence-based medicine. It enhances the understanding of the civilian pilot population by implementing a cross-functional and integrated assessment through the AMRSIS process. It also provides the aeromedical community a history-based foundation to the medical certification decision-making processes. By understanding the past, we are better prepared for the future, and therefore can reduce risk, optimize research investment strategies, and enhance aeromedical education programs.

Aircraft Safety

"Our mission is to provide a safe global air transportation system by developing new technologies, tools, and practices."

Patrick Lewis,
Airport and Aircraft Safety R&D Program Director
Air Traffic Organization Operations Planning



Conducting Thermal Analysis of Polymer Flammability

Industry and academia have worked hard over the past few decades to relate laboratory analyses to the real-world flammability of polymers (plastics). Most thermal analyses relate a single property, such as char yield, (a noncombustible gas) and carbonaceous char (a noncombustible solid) heat of combustion, or thermal decomposition temperature to the fire test performance. Efforts to understand how fires really behave based on the study of individual material prop-erties have, however, met with limited success.

Recently, FAA researchers demonstrated the benefits of an experimental thermal analytical procedure known as pyrolysis-combustion flow calorimetry (PCFC). This technique allowed them to separate the effects of the condensed phase (pyrolysis) process, from those of the gas phase (combustion) process of flaming combustion. Through this new methodology, the FAA can now screen hundreds of very small samples (milligrams only) of new plastics and compositions for flammability.

This new capability has greatly accelerated the discovery of ultra fire resistant plastics for a fireproof cabin. The FAA has described its thermal analysis method and the underlying theory for measuring flammability parameters in “A Thermal Analysis Method for Measuring Polymer Flammability,” Journal of ASTM International, 3(4), 1-18 (2006).

Developing Ultra Fire Resistant DDE Polymers

In 1995, the FAA began a long-range research program to eliminate burning cabin materials as a cause of death in aircraft accidents. The technical objective of the program was an order-of-magnitude reduction in flaming heat release rate compared to current cabin materials. FAA criteria for commercial aircraft described in Title 14 of the Code of Federal Regulations, Part 25 were used to test all materials. Because plastics of a wide variety are used in aircraft cabin components, researchers drew from the insights of versatile, cost-effective polymer chemistry to satisfy both the technical and economic constraints on a fireproof cabin.

Previously, the FAA measured the microscale heat release rate of a polycarbonate containing the chemical group 1,1-dichloro-2,2-diphenylethene (DDE) and found it to be 13 times lower than conventional polycarbonate (LEXANTM) and four times lower than the polyetherimide (ULTEMTM) currently used in thermoformed aircraft cabin parts. Researchers had hoped to find a way to benefit from the low-cost and high fire resistance of DDE plastics synthesized from bisphenol-C (BPC), a potential building block for an entire family of plastics. But first they had to synthesize and evaluate over 30 different DDE plastics to identify the molecular mechanism responsible for their remarkable, shared fire resistance.

The research team found that DDE plastics are low-cost, easily processed, tough, and under normal conditions, have good mechanical properties. In a fire, the "fire smart" DDE functional group undergoes a thermally-activated molecular rearrangement that produces hydrogen chloride in quantitative yield. The flammability and mechanical properties of DDE containing polymers are described in an FAA Final Report DOT/FAA/AR-06/12, "Fire-Smart DDE Polymers," published in March 2006. This account will also appear in an upcoming review article to be published in the journal High Performance Polymers.

Studying Ignition Hazards in Aircraft Fuel Tank Electronics

FAA researchers recently investigated the ignition hazard presented when small fragments of steel wool and energized electrical circuits make contact in a flammable environment. The conditions set up in this study mimic those present in aviation environments and allow researchers to quantify the minimum ignition energy needed to ignite the flammable vapors in an aircraft's fuel tank.

The team used various types of steel wool and five different methods of shorting the tested circuit. A 28-volt direct current (dc) power supply simulated energized aircraft electrical wiring. Thin-film, non-inductive resistors limited the electrical current to appropriate levels. An additional ignition detection technique helped researchers to determine if a sparking or burning event could ignite a gaseous mixture with a known minimum ignition energy of 200 micro Joules (J) – the accepted minimum ignition energy of hydrocarbon fuel vapor.

The ignition detection technique employed a 36-liter cubic aluminum chamber with a blowout hole on top and a clear acrylic front panel with thermocouple and lever mechanism pass-throughs. The researchers introduced a standard flammable gas mixture into the chamber and used a standard voltage spark ignition source (SVSIS) to calibrate the mixture with a 200- J voltage spark. They recorded voltage and current traces and noted the temperature rise for each test. Then, they sealed the chamber blowout hole with a thin sheet of aluminum foil and defined ignition as a recorded rise in pressure that inflated or ruptured the aluminum foil sheet. At the end of testing, they recorded the electrical current at ignition to determine the minimum ignition current.

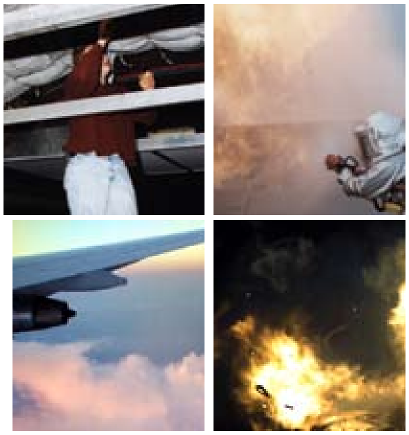
The tests showed that the lowest current causing the gas mixture to ignite was 99 milliamps (mA). In this instance, the researchers observed that a wad of superfine steel wool ignited and then caused the gas mixture to ignite. All further tests concentrated on igniting the steel wool. Although the ignition characteristics tended to vary with each wad of steel wool, testing showed that the lowest current that could ignite the material was about 45 mA.

The team concluded that the maximum allowable steady-state current limit of 10 mA root mean square, specified by the FAA in draft Advisory Circular 25.981-1C, does prevent ignition. The FAA published the test findings in DOT/FAA/AR-TN05/37, "Intrinsically Safe Current Limit Study for Aircraft Fuel Tank Electronics."

Determining Fire Hazards of Lithium Ion Batteries

Fire safety researchers conducted a series of tests to determine the flammability characteristics of single 18650 rechargeable lithium-ion batteries and of these batteries packaged for bulk shipment onboard cargo and passenger aircraft. They designed the tests to discover the conditions necessary for battery ignition, the characteristics of a battery fire, the effects of state of charge on igniting batteries, the potential hazard to the aircraft as a result of a battery fire, and the effectiveness of the standard Halon 1301 fire suppression systems in extinguishing a battery fire. Several serious fires on cargo pallets loaded with lithium batteries precipitated this study.

After a series of tests, the researchers determined that a relatively small fire source can heat the lithium-ion battery above the temperature required to activate the pressure release mechanism in the battery. This causes the battery to vent its highly flammable and easily ignitable electrolyte through the relief ports near the



positive terminal. Halon 1301, the fire suppression agent installed in transport category aircraft, is effective in suppressing the electrolyte fire and easily extinguishes any fire both at the five percent knock down concentration and at the three percent suppression concentration.

The release of an electrolyte caused by heating a lithium-ion battery produces a pressure pulse that can raise the air pressure within a cargo compartment. Cargo compartments are only designed to withstand approximately a one pound per square inch pressure differential. Thus, the FAA researchers also examined whether a fire involving a bulk-packed lithium-ion shipment might compromise the integrity of the compartment and cause the halon to leak out of the compartment. Fortunately, the results showed that such a cargo fire would not present any unusual stresses on the cargo liner material.

The FAA published these findings as DOT/FAA/AR-06/38, “Flammability Assessment of Bulk-Packed, Rechargeable Lithium Ion Cells in Transport Category Aircraft,” in September 2006 (http://www.tc.faa.gov/its/worldpac/techrpt/ar06-38.pdf).

Studying Flameless Ration Heaters

Flameless ration heaters (FRH) are used to cook self-heating meals known as Meals, Ready to Eat (MRE). Prepackaged meals have traditionally been used by the military to feed soldiers, but now they are also used by campers, boaters, disaster response teams, etc. When salt water is added to a combination of food grade iron and magnesium, an exothermic reaction creates temperatures of up to about 100°C in a relatively short time.

The potential use aboard commercial aircraft of FHRs has raised a concern because of the high temperatures involved, as well as the release of hydrogen that occurs during heating. Researchers have sought to measure this release of hydrogen to determine if it could pose an airborne fire safety threat. They tested the heating of individual MREs under varying conditions in an open area, as well as the heating of multiple MREs placed in a confined space. They also examined the potential of the accidental activation of FRHs in a confined area aboard the aircraft, such as in overhead storage bins or a cargo compartment. They observed temperatures in excess of 215ºF and violent ignition events, making it clear the release of hydrogen gas from the use of FRHs does pose a potential hazard on a passenger aircraft. The FAA published the results of this research in DOT/FAA/AR-TN06/18, “The Fire Safety Hazard of the Use of Flameless Ration Heaters Onboard Aircraft”) www.tc.faa.gov/its/worldpac/techrpt/artn06-18.pdf). The FAA has briefed the airlines on the potential hazards of flameless ration heaters so they can prevent passengers from using these heated meals.

Supporting Fire-Fighting Operations

Recognizing that U.S. Forest Service air tanker aircraft carry heavier loads than those anticipated in their original design and certification, the FAA initiated a loads monitoring research program to characterize the structural loads environment on these aircraft. In cooperation with the U.S. Forest Service, FAA researchers installed multi-channel load recorders on a P-2 and P-3 airplane used in fire-fighting operations. The research team collected data from approximately 400 flights during the 2005 firefighting season and expect to collect data on another 400 flights during 2006. The operators provided the data to the FAA-funded researchers at Wichita State University for analysis.

The team found that, contrary to the common assumption, the highest wing loads do not occur during the retardant drop, but while fully loaded and cruising to the drop zone. Because they need to get to the fire scene quickly, the pilots of these aircraft generally do not alter their route to avoid turbulence, a major stress factor on wing loading. During firefighting operations, the pilot drops retardant approximately 4,600 seconds into the flight. The associated wing strain at the time of the drop is considerable less than that experienced during the outbound flight cruise. Actually, there is only one peak load during the drop, while there can be multiple higher loads prior to the drop.

Based on these findings, it is recommended that the U.S. Forest Service develop a structural health monitoring program and undertake an engineering analysis to ensure the structural safety of firefighting aircraft. Also, it is recommended that these aircraft undergo a fatigue and damage tolerance assessment of critical structural areas. The FAA published its research results in DOT/FAA/AR-05/35, "Consolidation and Analysis of Loading Data in Firefighting Operations: Analysis of Existing Data and Definition of Preliminary Air tanker and Lead Aircraft Spectra" (http://155.178.136.203/eosweb/opac/index.asp).

Collecting Loads Data for the Boeing 777

FAA researchers have collected the operational loads history of the Boeing 777-200 in DOT/FAA/AR-06/11, "Statistical Loads Data for the B-777/200 Aircraft in Commercial Operations" (http://tc.faa.gov/its/worldpac/techrpt/ar06-11.pdf). This report provides analysis of Boeing 777-200ER aircraft operational usage data from 10,047 flights, representing 67,000 flight hours of a single international airline operator. It also contains statistical information on aircraft usage, ground and flight loads occurrences, and the operational usage of certain systems, as well as statistics on aircraft weights, flight distances, altitudes, speeds, and flight attitudes. Ground loads data include statistics on vertical, lateral and longitudinal load factors along with ground speed and aircraft weight during different ground operational phases. Flight loads data include statistical information on gust and maneuver load factors, derived gust velocities, and ground-air-ground cycles. Systems operational data include statistics on flap usage and engine fan speed.

Assessing Wire Separation and Segregation Arc Damage

At the FAA Arc Fault Evaluation Laboratory, researchers have developed a new method for quantifying electrical hazard damage. To develop this method, the research team used arc damage assessment data and separation and segregation of electrical systems data to quantify the damage electrical systems can impose on adjacent electrical and non-electrical systems. Using this new method, they can now determine minimum distances needed between certain electrical bundles to avoid catastrophic damage (loss of functionality of critical systems) and loss of system function. Data from this method will support the development of guidelines on safe separation and segregation distances.

Developing a Risk Analysis Tool

FAA sponsored research has led to the development and enhancement of an electrical systems risk analysis tool (RAT). Designed to perform risk analysis of an aircraft electrical wire interconnect system (EWIS), the new software

simplifies analysis of hazards that can cause damage to structures and cause fires. The tool can also be used to examine how potential failures in the EWIS could affect the functionality of the connected systems.

The tool combines routing and architecture data with an automated structured safety analysis. It considers common cause failures that can result in the functional loss of systems sharing a common wire bundle. The analysis logic considers all wire failure modes, including arcing faults occurring within a wire bundle and arcing to adjacent wire bundles or structure.

This new tool provides a simplified method of processing large quantities of EWIS design data through a powerful analysis process that will assess virtually all potential EWIS hazards. In addition, it can be updated with fleet data to reflect the latest effect of fault mitigation technology on wiring systems. It will also help to bring about greater consistency in the certification process and be of considerable safety benefit to the aviation community. The tool will provide advanced capabilities to help certification officials analyze EWIS designs.

Training Maintenance and Repair Personnel for Composite Structures

Working with Edmonds Community College, a member of the Joint Advanced Materials and Structures Center of Excellence, the FAA is developing a course to teach the maintenance and repair of composite aircraft structures. The FAA's latest developments in composite maintenance research will be incorporated into the course. The SAE Commercial Aircraft Composite Repair Committee (CACRC), which is chartered to establish airline industry consensus on standards regarding composite materials maintenance and repair, is also involved in course development and will provide continuing support through its Training Task Group. The course will blend distance (web-based) learning on composite maintenance and repair knowledge with work in regional laboratories, where students will receive hands-on training. A composite specialist from industry will teach the course and advise laboratory instructors.

In FY 2006, researchers held two workshops with industry to develop course standards. At these workshops, Airbus and Boeing, major aerospace original equipment manufacturers (OEMs), provided detailed internal reviews of the course content. The FAA gained industry consensus on items that must be addressed in composite maintenance training.

Evaluating Environmental and Aging Effects on Composite Structures

Because more composite materials are being used on aircraft structures, the FAA is evaluating environmental and loading effects on aging composite structures.

Currently, researchers are studying a composite stabilizer after 18 years of service. In August 1982, Boeing manufactured and certified five shipsets of 737-200 graphite/epoxy stabilizer as part of the NASA Aircraft Energy Efficiency (ACEE) program. Three shipsets have been retired, and two are still in service. This past year, FAA-funded researchers at Wichita State University's National Institute of Aviation Research (NIAR), a member of the Joint Advanced Materials and Structures (JAMS) Center of Excellence, performed an evaluation of one of the retired structures.

Researchers from NIAR, the FAA Airworthiness Assurance Nondestructive Inspection Validation Center, located at Sandia National Laboratories, and Boeing assessed the results of a number of standard and novel nondestructive inspection (NDI) methods performed on the stabilizer prior to teardown. These inspections included thermography, RapidScan, laser ultrasonics, pulse-echo ultrasonics, and photogrammetry. The research team compared the accuracy of the different inspection methods in detecting flaws, such as delaminations, disbonds, impact damage, moisture ingression, or corrosion of the aluminum lightning protection scheme.

After tearing down the stabilizer, researchers found it in good condition, with only a few corroded fasteners. Then they compared the results of the teardown with the NDI data obtained prior to the structure's disassembly. After that, researchers performed a complete destructive evaluation, including physical and mechanical testing, to confirm the structural condition of the stabilizer. This sequenced investigation resulted in better understanding the effects of aging on the composite structure and identified changes in the material properties over the service life. Ultimately, they found the structure had not degraded in its 18 years of service.

Developing Guidelines for Adhesively Bonded Aircraft Structures

The FAA undertook a number of activities in 2005 and 2006 to evaluate the adequacy of current certification requirements for adhesive bonded aircraft structures. Adhesive bonding is used in many manufacturing and repair applications for aircraft structures. The technical issues for bonding are complex and require cross-functional teams for successful applications. Researchers looked at bonding composite-to-composite, metal-to-metal, and composite-to-metal structures to acquire knowledge about these construction and repair methods. They conducted a survey to benchmark industry practices and collect information on the safety issues and certification considerations for bonded aircraft structures and repairs. Thirty-eight companies with experience and history in adhesive bond manufacturing and repair practices responded to the survey.
After reviewing the survey results, the FAA sponsored workshops to gather additional information. 142 representatives from industry, academia, and governmental agencies representing 70 companies, universities, and governmental agencies attended the first workshop.
A second workshop, held in Europe, provided international input about areas that need to be addressed to enable the safe and reliable application of adhesive bonding in manufacturing aircraft. This cooperative effort of industry, government groups, and academia led to the development of initial guidelines. Future joint efforts by the FAA, industry, and academia will lead to recommendations on standardization, engineering guidelines, shared databases, and focused research for bonded structures.

Keeping Acrobatic Aircraft Fleet Safe

To understand the fatigue and corrosion problems of aging acrobatic aircraft better, FAA-funded researchers at the National Institute for Aviation Research conducted a tear down inspection of a T-34A N141SW that had previously been involved in an accident. In their destructive evaluation, the researchers looked particularly for signs of cracks and corrosion in the right wing front carry-through lower spar, horizontal and vertical stabilizer attachment points, right wing rear spar lower cap wing station 66, and right wing rear spar lower bathtub fitting.

The researchers opened the cracks found on the aircraft and analyzed them to determine their responsible failure mode. They also inspected the surrounding structure microscopically for additional defects. During the destructive evaluation, the research teams found a total of 25 cracks on the right wing front carry-through lower spar, ten cracks on the horizontal and vertical stabilizer attachment points, two cracks on the right wing rear spar lower cap, and one crack on the right wing rear spar lower bathtub fitting. In the carry-through structure, overload caused three cracks, ranging in size from 0.15 to 5.28 inches. Sixteen cracks had fatigue origins with fatigue lengths ranging from 0.05 to 0.53 inch. These sixteen cracks then extended due to overload conditions. The cause of failure could not be determined in the other six cracks, which ranged in length from 0.10 to 1.17 inches.

The researchers found four cracks, resulting from overload, on the vertical stabilizer bulkhead; these cracks ranged from 0.28 to 1.4 inches. They also found six cracks, caused by overload, on the horizontal stabilizer bulkhead; these ranged in length from 0.13 to 1.13 inches. Two 1.187-inch-long cracks also appeared on the right wing rear spar at WS 66. Extensive metal smearing on the fracture faces made the cause of failure for these cracks difficult to determine. In addition, another crack, measuring 3.29 inches, was found on the right wing rear spar lower bathtub fitting. The failure mode of this crack could not be determined.

Due to the recent history of fatigue cracking and failure on T-34A aircraft, this research will aid the FAA in understanding and addressing T-34A concerns, and will help determine the condition of a high-time acrobatic category aircraft. A complete report of the teardown evaluation can be found at www.tc.faa.gov/its/worldpac/techrpt/artn05-57.pdf

Assessing Fatigue Crack Growth Methods for Rotorcraft Applications

Researchers at the FAA, NASA, and Mississippi State University are working to adapt fixed-wing aircraft damage tolerance technologies and techniques for rotorcraft applications. The phenomenon of fatigue crack growth is a major area of concern in this work. The stress that can be tolerated before small cracks begin to grow has been determined for many materials used in fixed-wing aircraft and researchers want to determine tolerable stress levels for materials used in rotorcraft.

Currently, the standard crack growth region is defined in American Standard Test Methods (ASTM) E-647. Using this standard, re-searchers computed and analyzed a substantial body of rotorcraft fatigue crack growth data and identified some problems with the standard test method. As a result, researchers are finalizing a new experimental method to replace or supplement ASTM E-647. The researchers informed the ASTM committee of their findings. Additional details about the FAA Fatigue-Crack-Growth research can be at: http://aar400.tc.faa.gov/Programs/agingaircraft/rotorcraft/RCDT%20FCG_Background.htm.

Ensuring Safety of Health and Usage Monitoring Systems

Increasing demands for safety improvement and the availability of new enabling technologies and sciences are driving advances in Health and Usage Monitoring Systems (HUMS) technologies and applications. These advances, however, present complex certification issues related to HUMS hardware and software. Both the airborne and ground-based parts of the new systems must be carefully studied. To collect and validate the data and processes needed to address these challenges, the FAA researchers have developed the HUMS R&D Strategic Plan and Roadmap. The resulting research effort will also support the development and revision of HUMS advisory guidance materials.

At a 2006 meeting, FAA researchers unveiled their plan and roadmap to approximately 60 representatives from the U.S and European rotorcraft industries, NASA, U.S. Department of Defense, Canadian Department of Defense, Australian Defense Science and Technology Organization, and United Kingdom Civil Aviation Authority. The FAA is now working with the U.S. Army, and the United Kingdom Civil Aviation Authority (CAA) on various HUMS research topics.

Evaluating General Aviation Alternative Fuels

A 1990 amendment to the Clean Air Act prohibited the sale of leaded gasoline, effective January 1995. Although the law exempted the aviation, marine, racing, and farming communities from this ban, the FAA is working with industry to develop alternative, unleaded fuels.

FAA researchers are leading efforts to bring industry, academia, and the aviation community together to find an alternative, unleaded, high-octane general aviation fuel. They have helped to establish two Coordinating Research Council (CRC) working groups under the Aviation Gasoline Subcommittee. Membership in the Unleaded Aviation Gasoline Development Group and the High Octane Rating Group includes aircraft owner and pilot associations, petroleum producers, specialty chemical companies, engine manufacturers, air-craft manufacturers, experimental aircraft associations, universities, and independent consultants. An FAA test facility is the leading independent laboratory providing spark ignition, reciprocating aircraft engine test data on unleaded fuels to the CRC Aviation subcommittee and the American Society for Testing and Materials.

In FY 2006, FAA researchers and colleagues at the South Dakota State University evaluated an ethanol-based aviation fuel at the FAA Small Engine Test Facility. They studied power performance, endurance, and detonation performance of Aviation Grade Ethanol 85 (AGE-85) in a Lycoming IO360-C engine. AGE-85 is a blend of at least 85% ethanol denatured with 2% automotive gasoline, less than 1% biodiesel, and pentane isomerate. Under the conditions of this test, the results indicated that the engine experienced normal wear except for the exhaust valve faces and stems, which showed a hammered effect. The research team found minimal combustion and fuel system deposits and a moderate level of intake valve deposits. The engine produced an average of 2.8% more peak horse power on AGE-85 than isooctane (ISO), but required an average of 56.5% more fuel mass flow. This resulted in a drop in efficiency at maximum power from 0.470 lb/hphr for ISO to 0.716 lb/hphr for AGE-85. The AGE-85 produced exhaust gas temperatures that averaged 20°F higher than ISO at best power mixture strength. Test results are published in DOT/FAA/AR-06//43, “Spark Ignition Aircraft Engine Endurance Test of Aviation Grade Ethanol 85” (http://tc.faa.gov/its/worldpac/techrpt/ar06-43.pdf).

FAA researchers also worked closely with their counterparts at the Cessna Aircraft Company to evaluate an ethanol derivative, ethyl tertiary butyl ether (ETBE), for endurance, power performance, and detonation performance when fueling a Lycoming IO360-C engine. Cessna has proposed ETBE as a potential stop gap fuel in the event of a supply disruption to the current leaded aviation gasoline, 100ll. The endurance test results indi-

cated that the engine experienced normal levels of engine wear after the 150-hour test. Researchers found minimal engine sludge and varnish deposits, combustion chamber deposits, and fuel system deposits. The engine lubrication oil analyses showed minimal fuel dilution, viscosity change, and acid content. There were no observations of difficulty with starting or material compatibility issues. Final Report DOT/FAA/AR-06/27, "Spark Ignition Aircraft Engine Tests of Ethyl Tertiary Butyl Ether," is available online at http://www.tc.faa.gov/its/worldpac/techrpt/ar06-27.pdf.

Developing Best Practices for Tool Calibration Program

With technological advances in aircraft design and manufacturing, airplanes are becoming increasingly sophisticated and complex machines. The safe and efficient operation of modern airplanes depends on a proper maintenance program, which requires the use of many precision tools. As mandated in Parts 43.13 (a) and 145.47 (b) of the Title 14 Code of Federal Regulations, the FAA requires aircraft repair station personnel to inspect and calibrate tools to ensure their reliable and accurate performance. A repair station typically develops and uses an internal program to perform and manage the calibration of tools. However, no single standard exists within the aviation community to provide uniform guidance for the development of an effective tool calibration program.

Under a cooperative agreement with the Wichita State University National Institute for Aviation Research, the research team developed calibration "best practices" that could help to establish an effective tool calibration program. Based on a literature review and an analysis of about 10,000 records of the FAA Program Tracking and Reporting System, the researchers identified and developed possible solutions to address major areas of concern. These areas include calibration due date, missing tags and stickers, lack of control, personnel errors, missing records, and traceability. The researchers also shadowed FAA inspectors visiting repair stations to gain field experience and assess the practicality of the proposed solutions.

In May 2006, the research team proposed a calibration management structure that incorporates guidance for best practices in areas such as environmental controls, calibration frequencies and intervals, calibration labeling, personnel and training standards, effective tracking and control, calibration subcontracting, the handling and storage of calibration instruments, calibration certificates, documentation, measurement traceability, and internal audits. The team developed two new checklists to help FAA inspectors in monitoring compliance with the tool calibration requirement. To provide the FAA with guidance on how to approve calibration of foreign-made tools, the research team recommended a path in which a source country's eligibility can be determined through its association with international accreditation bodies. The FAA plans to use these research results to develop advisory circulars applicable to the tool calibration program.

Assessing the Airworthiness of Commercial Aircraft

Airframe teardown inspections and extended fatigue testing are effective means to help determine the continued airworthiness of high-time operational aircraft – particularly those approaching their design service goal (DSG). Essential information and data needed to evaluate the kinds of airframe structures that are susceptible to widespread fatigue damage (WFD) are obtained from teardown inspections. While the expertise and knowledge base required to conduct teardown inspections are well established by the large commercial airframe original equipment manufacturers and military sectors, the broader aviation community lacks well-documented guidelines and data.

In a joint effort by the FAA and Delta Air Lines, researchers conducted a teardown inspection and extended fatigue testing of a fuselage obtained from a retired Boeing 727 revenue-service passenger airplane near its DSG. They removed eleven large fuselage sections, selected as representative of structure susceptible to developing WFD. Focusing on the lap joints, the research team used both conventional and emerging nondestructive inspection (NDI) methods before and after removing the fuselage sections from the airplane.

Using a destructive evaluation procedure developed for the study, the team performed fractographic examinations on each of the seven panels to characterize its state of multiple-site damage. They then used this confirmed information to assess the capability of 20 NDI methods to predict the presence of small hidden cracks. Later, the researchers used the FAA Full-Scale Aircraft Structural Test Evaluation and Research Facility to conduct extended fatigue testing on two of the panels, while continuously assessing damage of those panels through both conventional and emerging NDI methods.

The project collected and analyzed an extensive amount of data, which is documented in a five-volume report. The team developed a companion engineering database that contains the processed data collected from fractography, nondestructive inspections, and full scale testing of the crown skin panels. This database can be used to evaluate the sensitivity and effectiveness of standard and emerging NDI methodologies to detect small cracks hidden in assembled structures. It also provides for the efficient transfer of information to engineering organizations for the future calibration and validation of predictive methodologies for structural fatigue. Data from this project will continue to provide guidelines for future programs that help to ensure the continued airworthiness of the aging commercial fleet.

Graduating the First Doctoral Student in the FAA-Drexel Fellowship Program

The FAA-Drexel Fellowship Program is a collaborative effort established in 1998 to promote aviation safety research within academia and support ongoing research activities within the FAA's Aging Aircraft Research Program. Participating students are an integral part of the program and have the opportunity to work on real world problems that face the aviation industry. A goal of the FAA-Drexel fellowship program is to develop the next generation of engineers able to address aircraft safety issues.

On June 5, 2006, FAA-Drexel Fellow Abubaker Ahmed became the first Ph.D. graduate from the fellowship program. The research for his dissertation, entitled "Growth of Multiple-Site Damage (MSD) in a Fuselage Lap Joint Curved Panel," deals with widespread fatigue damage (WFD), a critical safety issue of aging airframe structure facing the aviation industry today. Conducted at the FAA's Full-Scale Aircraft Structural Test Evaluation and Research (FASTER) facility, this research rigorously tested a fuselage panel constructed to a major airframe manufacturer's specifications.

Dr. Ahmed studied how MSD formed and evolved in a panel within the airframe fuselage test panel. This research will provide key information that will be useful for the aviation industry in developing programs to prevent the occurrence of WFD in the aging aircraft fleet. Dr. Ahmed

accepted a position with the Damage Tolerance Group of Boeing Commercial Airplanes in Everett, Washington.

Updating of Default Probability of Detection Curves for Ultrasonic Inspection of Hard-Alpha Inclusions in Titanium Billet

The United Flight 227 accident in Sioux City, Iowa, in 1988 led to the incorporation of damage tolerance principles into the design and life-cycle management of the rotating components of aircraft jet engines. A key parameter in establishing damage tolerance is a quantification of the ability of inspections to remove flawed components from service based on the probability of detection (POD).

Traditional means for determining POD are based on empirical measurements made on samples containing known representative defects. However, using this method, it would be cost prohibitive to manufacture the number of samples required for the POD determination of rotating engine components. With these component flaws, mostly hard-alpha inclusions, an alternate approach is to estimate POD based on defects found during the manufacturing process. The FAA used such an approach to produce the 1995 Default POD Curves that appear in AC33.14-1, Damage Tolerance for High Energy Turbine Engine Rotors (ANE-110, 1/8/01). In FY 2006, a FAA research team used a small sample size with the addition of data readily available within the community to derive better estimates of the default POD curves. Besides drawing on alternative sources of data, such as physics-based models of the inspection process, they applied more powerful statistical analyses than had previously been used in estimating POD curves. Drawn from larger data sets that included multizone inspection data as well as conventional inspection data, and analyzed more rigorously through physics-based techniques, the new curves are more realistic than those previously available. This ability to quantify current performance and its variability will help shape the development of future damage tolerant design concepts of fracture-critical titanium alloy rotor designs.

Developing Nondestructive Inspection Technologies

The advantage of employing nondestructive inspection (NDI) technologies to evaluate the condition of underlying aircraft structures is clear: the aircraft does not have to be torn apart to see beneath its exterior. When FAA researchers can examine actual underlying aircraft structures to verify the accuracy of – and ideally strengthen their confidence in – NDI findings, they embrace the opportunity.

Recently, a collaborative research team had such an opportunity. While performing extensive destructive evaluation and extended fatigue testing of a fuselage structure from a retired transport aircraft, the researchers looked into the effectiveness of twenty NDI technologies that were applied to the aircraft prior to its being dismantled. They focused on the ability to detect cracks emanating from lower row fastener holes in the lower lap joint skins of a Boeing-727 aircraft. The Airworthiness Assurance Working Group had previously identified these longitudinal lap joints as susceptible to widespread fatigue damage, and the vulnerability of these parts is also the subject of Airworthiness Directives (AD) 99-04-22 and 2002-07-09.

Researchers from the FAA, Delta Airlines, and the FAA's Airworthiness Assurance NDI Validation Center assessed the readiness of conventional and experimental NDI technologies for use at airlines or maintenance, repair, and overhaul (MRO) facilities. The various NDI findings had indicated the test lap joint panels removed from the retired aircraft contained service-induced cracks. Destructive tests later confirmed these findings.

The conventional NDI technologies used in the study included directed visual inspection, external low-frequency eddy-current (LFEC) sliding probe, and internal medium-frequency eddy-current (MFEC) methods. All of these are called out in the Boeing NDI manuals. The emerging methods, designed to inspect the inner skins from the exterior fuselage surface, included a variety of advanced eddy current, ultrasonic, and radiography systems.

The research team evaluated each technique according to its sensitivity and reliability, ease-of-use, speed, and fieldability.

The study yielded useful results. The internally-applied MFEC methods reliably detected cracks longer than 0.090-inches, better sensitivity than that of any externally-applied NDI technologies. External methods that provided the best sensitivity were the Meandering Winding Magnetometer (MWM), Remote Field Eddy Current (RFEC), Giant Magnetoresistive Sensor (GMR), digital radiography, and RivetCheck. The LFEC sliding probe, Array Eddy Current, the Magneto Optical Imager (MOI), and Turbo-MOI Methods proved the fastest methods to deploy. Emerging methods determined to be ready for immediate implementation at airline or MRO facilities included the MOI, Turbo-MOI, and MAUS. All of these technologies are currently in use, but not on a widespread basis. The technologies deemed promising for implementation at an airline or MRO facility in the near future included MWM, RFEC, GMR, digital radiography, RivetCheck, and a high frequency ultrasonic array.

Results from this study will aid in the acceptance and adoption of these emerging technologies as alternate means to inspect for cracks in aircraft fuselage substructures without the need to tear the aircraft down.

Developing an Enhanced Life Management Process

The FAA is currently working with industry to enhance the current life management processes for aircraft engines. Based on probabilistic damage tolerance principles, the new process will address the threat of material or manufacturing anomalies in high-energy turbine engine rotating components. One existing process for detecting hard alpha (HA) anomalies in titanium rotors is documented in FAA Advisory Circular (AC) 33.14-1. Future revisions to AC 33.14 will address other materials and anomaly types. In FY 2006, researchers completed a multi-year research program and published their findings in "Turbine Rotor Material Design—Phase II." This work addresses data and technology requirements to support and enhance the AC and its implementation.

The team includes researchers from Southwest Research Institute (SwRI), GE Aircraft Engines, Pratt & Whitney, Honeywell, and Rolls-Royce Corporation. Together, they developed the DEFORM™ forging microcode, an enhanced predictive tool capability with supplementary material/anomaly behavior characterization and modeling. They used detailed nondestructive evaluation and metallography techniques to validate the tool, as applied to forgings with HA anomalies. They also used the microcode to characterize the conditions associated with cracking of HA

anomalies during forging. Studies of representative forging shapes indicated that ingot-to-billet conversion and component forging would, under common processing conditions, create cracks in all HA anomalies.

The researchers conducted additional experiments to understand the fatigue behavior of embedded HA. They performed fatigue tests on coupons machined from seeded forgings and conducted spin pit tests with material from earlier forgings containing HA anomalies. The total fatigue life observed was at least twice as long as the calculated life, based on the assumptions that crack nucleation life was zero and the initial crack size was equal to the core plus diffusion zone size. Analyses using the fracture mechanics module (Flight-Life) in the Design Assessment of Reliability with Inspection (DARWIN®) code indicated that initial crack sizes more nearly corresponded to core sizes than core plus diffusion zone sizes.

As a result of this work, researchers have improved the overall efficiency and accuracy of the DARWIN risk assessment computations. In addition, they developed an infrastructure for software management, code licensing and distribution, and support for users.

Releasing the Uncontained Engine Debris Damage Assessment Model

Hazards from uncontained engine failures must be mitigated during the design layout of the aircraft systems that will be used in turbine-powered aircraft. Uncontained engine failure events release high-energy fragments that can impact and disable critical systems and reduce the airworthiness of the vehicle. When multiple systems are disabled, the potential for an accident increases. The redundancy and separation of systems, coupled with the thoughtful location of components in the design of an aircraft, can make significant improvement in the vehicle's ability to survive a high-energy event.

In FY 2006, FAA researchers, working with their counterparts at the Naval Air Warfare Center, released an improved version of the Uncontained Engine Debris Damage Assessment Model (UEDDAM). This model is designed to support the certification process and has tailored outputs that match the certification package requirements. Although the model is not yet being used for commercial certification, the U.S. Air Force has been using the model for several years. In a 2004 description of its C5 re-engine program, the USAF reported: "In a unique approach to the problem, we were able to answer both LFT&E (live fire test and evaluation) and safety issues by using the latest Federal Aviation Administration endorsed methodology. The use of the Uncontained Engine Debris Damage Assessment Model (UEDDAM) allowed the program to realize large cost savings while answering vital questions about the safety and vulnerability of the upgraded engines due to cascading damage."

Version 3 of the Uncontained Engine Debris Damage Assessment Model, released in September 2006, incorporates several improvements, including the ability to support analysis of decompression hole size as a code output. Other significant improvements include the user defined material property inputs that make it possible for manufacturers with proprietary materials to insert their own material data within the code.

Evaluating Remote On-Ground Ice Detection Systems

Undetected ice remaining after the deicing process can cause dangerous lift loss during takeoff. This is a critical issue for all aircraft, but especially for hard wing regional jets. In 2006, FAA Flight Safety researchers, scientists in the FAA Human Factors programs, and personnel at the Transport Canada Transportation Development Center teamed to determine the effectiveness of two prototype remote on-ground ice detection systems (ROGIDS). Using a special camera, ROGIDS captures and interprets the infrared reflections given off by ice on critical aircraft surfaces. In preparation for future regulatory approval of a commercial version of ROGIDS, researchers first determined how well deicing personnel detected ice by traditional visual and tactile methods. Those results provided the baseline to evaluate the ability of the two ROGIDS prototypes to detect ice on an aircraft wing.

The ice samples used were beneath a residual layer of deicing fluid typical of what would remain on an aircraft wing after the deicing process is completed. The first study showed that deicing personnel can easily detect very thin ice by touch when the sample is contained in a small area, but they have a much more difficult time seeing clear ice on bare and painted aircraft aluminum surfaces. The study showed that despite the impressive sensitivity of human fingers to ice, the abilities of one ROGIDS prototype were significantly superior to those of experienced deicing personnel (who performed both the visual and the tactile inspections) in detecting ice patches of varying areas and thicknesses scattered on an aircraft wing. The other ROGIDS prototype, which had not had a significant amount of shakedown testing prior to this test, proved to be roughly equivalent to the deicing personnel. As a result of these tests, the FAA and Transport Canada Flight Standards organizations feel ROGIDS has potential to increase the level of safety in icing conditions with further work.

Two reports document these tests: Human Visual and Tactile Ice Detection Capabilities under Aircraft Post Deicing Conditions (DOT/FAA/TC-06/21) and Comparison of Human Ice Detection Capabilities and Ground Ice Detection System Performance under Post Deicing Conditions (DOT/FAA/TC-06/20). Both reports are available online at: http://www.tc.faa.gov/acb300/330_documents.asp. Researchers presented the results of these tests at the SAE Committee G-12 (Ground Deicing) annual meeting in Lisbon, Portugal, on May 24, 2006, and at the Human Factors and Ergonomics Society Confer-ence in San Francisco, October 19 and 20, 2006.

Providing New Guidance on Instrumentation for Icing Certification Flights

Federal aviation regulations, such as Title 14 Code of Federal Regulations (CFR) 25.1419, "Ice Protection," require flight tests in measured natural or simulated icing conditions for aircraft being certificated for flight in icing conditions. Different aircraft manufacturers have employed different types of instrumentation to measure the relevant icing cloud variables, primarily water content, droplet sizes, and temperature. The available instrumentation ranges from the simple to the complex, from the old to the new, and from the relatively inexpensive to the expensive. Most of the instrumentation comes from the cloud physics research community. The use of this technology requires a certain amount of knowledge and experience to ensure that the probes are properly installed, calibrated, and operated. In addition, all probe types can have subtle systemic errors that may be difficult for the inexperienced operator or data analyst to recognize.

As a result of these complexities, FAA Aircraft Certification

Offices (ACO) have either had to rely on the aircraft manufacturers to supply adequate instrumentation and technicians, or they have had to hire experienced contractors to install and operate suitable instrumentation and analyze the icing cloud data.

To provide advice to the ACOs and to help standardize policy and procedures for icing certification projects, research was done to provide technical data on the variety of instrumentation used to analyze and measure the properties of the icing conditions experienced during test flights. The result was the 2006 publication of a set of four technical notes:

- DOT/FAA/AR-TN06/29, "Cloud Sampling Instruments for Icing Flight Tests: (1) Icing Rate Indicators,"
- DOT/FAA/AR-TN06/30,"Cloud Sampling Instruments for Icing Flight Tests: (2) Cloud Water Concentration Indicators,"
- DOT/FAA/AR-TN06/31,"Cloud Sampling Instruments for Icing Flight Tests: (3) Cloud Droplet Sizers," and
- DOT/FAA/AR-TN06/32, "Cloud Sampling Instruments for Icing Flight Tests: (4) Large Drop Sizers."

These reports provide information on the suitability, procedures, and precautions for the most commonly used instruments for measuring icing rate, cloud water concentration, and droplet sizes in natural clouds or airborne tanker-sprays. They also include advice on the data quality assurance, data processing, and presentation of results.

The technical notes are intended to be a ready reference for ACOs, designated engineering representatives, aircraft manufacturers, and other interested parties. They can be found at http://actlibrary.tc.faa.gov.

Operating Aircraft in Ice Pellet Conditions

Under certain atmospheric conditions, precipitation falls on aircraft as pellets of ice. From 1992 to 2004 many air carriers were allowed to operate in ice pellet conditions provided the flight crew did a contamination check of the wings within five minutes of takeoff. For most passenger aircraft, this check was conducted from inside the aircraft, but for freighters, which generally have no cabin windows, it was done from the outside. Operations in the presence of ice pellets were incorporated into the deicing and anti-icing programs of many individual air carriers and were approved annually by the Principal Operations Inspector for those carriers.

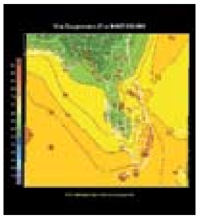
Recently, due in part to Agency and industry concerns, the FAA decided to reassess its policy with respect to operation in ice pellet conditions. At the request of Flight Standards Service, the Flight Safety Branch, in cooperation with Transport Canada, conducted relevant runway testing in Canada in March 2006. Using a turbine powered aircraft, they simulated ice pellet contamination in a specific type of anti-icing fluid on the wing. Type IV is the thickened (viscous) anti-icing fluid commonly used by airlines in North America. The aircraft was accelerated to rotation speed, and then stopped. Crushed ice from blenders was used to simulate ice pellets. The ice mixture was run through sieves to get a size distribution similar to natural pellets. Known quantities were distributed over the wing from modified hand held seed spreaders.

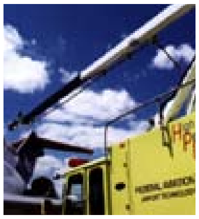
The results indicated that, when the aircraft was protected with Type IV anti-icing fluid, the simulated pellets would readily flow off prior to rotation. A review of the research indicated that a 25-minute allowance after anti-icing in light ice pellets afforded a large safety margin, and Flight Standards has since approved that allowance as sufficient to ensure a safe takeoff from most airports.

Airport Technology

“We are dedicated to developing scientific knowledge and technology to improve the construction, maintenance, and operation of airports.”

Satish Agrawal
Airport Technology R&D Program Manager
Air Traffic Organization Operations Planning





Evaluating the End-Around Taxiway (EAT) Screen

Because of the need to increase operational capacity, airports have added dual and sometimes triple parallel runways. Typically, departing aircraft use the inboard runways for takeoff while arriving aircraft use the outboard runways for landings. To increase operational capacity and to mitigate the risk of potential runway incursions, airports are considering, or are in the process of constructing, taxiways that go around the runway ends. These are usually called End-Around Taxiways (EAT). In some cases, since an aircraft taxiing on the EAT may look like it is actually crossing the departure end of the runway, a potential problem exists for aircraft taking off on a runway with an EAT. The pilot may perceive that there is a runway incursion and abort the takeoff, or perform an inappropriate maneuver to avoid what appears to be a possible accident.

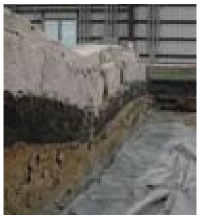
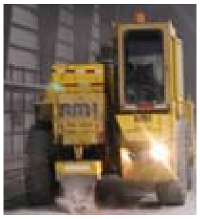
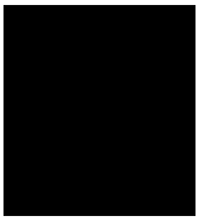
To mitigate this situation, the FAA Airport Obstruction Standards Committee (AOSC) Executive Steering Group directed that a visual, screen-type device be designed and installed at airports with EAT facilities. The basic design was to be based on simulator evaluations of a screen 13 feet in height and 700 feet in length. Screened images would help pilots, who were executing a takeoff roll, tell when another aircraft was actually crossing the active runway versus when it was simply operating on the EAT. (A possible exception might be where the EAT is shielded by natural terrain.)

FAA airport safety researchers investigated the most conspicuous configuration and combination of color and materials for the EAT screen. The results of this evaluation validated that the pre-specified minimum screen height of 13 feet was satisfactory, that the color and size combination of 12 feet wide red and white engineering grade reflective material in a diagonal pattern proved most effective, and that no additional external lighting was necessary to enhance screen visibility at night. Additional findings were made regarding effective access for emergency equipment, and no degradation of the screen's effectiveness resulted from tilting it at an angle of 14 degrees to avoid interference with radar systems.

On September 29, 2006, as a result of this research, the FAA issued change 10 to the Airport Design Advisory Circular 150/5300-13. This change adds design criteria for EAT Screens.

Installing the Next Generation High Reach Extendable Turret

Past research done by the FAA Aircraft Rescue and Fire Fighting (ARFF) Research Program determined the advantages and benefits of ARFF vehicles using High Reach Extendable Turrets (HRET) equipped with penetrator nozzles in aviation fire fighting. Since the introduction of HRETs in 1986, approximately 350 of the turrets have been retrofitted into

existing ARFF vehicles or purchased already on new ARFF vehicles. Some advantages and benefits of this technology include: increased throw range performance, increased range of motion of the turret, more efficient application of the agent by directing it to the seat of the fire, faster extinguishing of two-dimensional pool and three-dimensional flowing fuel fires, and the ability to penetrate inside an aircraft to cool the interior cabin and extinguish fire. Essentially, this technology increases passenger survivability, protects property, and extinguishes fire faster right after an aircraft crashes.

The December 18, 2003, aircraft accident at Memphis International involving a wide body DC-10 cargo aircraft demonstrated the importance an HRET outfitted with a penetrating nozzle can have at an accident. Upon landing, the failure of one landing gear caused the aircraft to skid on its fuselage and be consumed on one side by fire. While two ARFF vehicles concentrated on the fuel spill fire, the ARFF vehicle with the HRET penetrated the aircraft from the opposite side. Although firefighters were concerned that the fire would burn through the fuselage and create an interior fire, the HRET-equipped vehicle flooded the interior with foam. Ninety-nine percent of the cargo was spared fire damage. The saved cargo value estimate of $25 million was greater than the value of the aircraft.

This accident demonstrated the need and ability of a HRET at an aircraft accident, and the role it can play in protecting cargo and increasing survivability in passenger aircraft. Because the current HRET performance criteria have been in place for over a decade, researchers have begun work to develop new HRET performance criteria to meet the challenges posed by the new Airbus A380 and other New Large Aircraft soon to be manufactured. The distance from the front of the ARFF vehicle to the burning aircraft fuselage is commonly referred to as standoff distance. Current HRETs cannot reach a second level doorway of a Boeing 747 or Airbus A380 unless the ARFF vehicle is positioned right next to the aircraft fuselage. Unfortunately, this placement eliminates visibility of the operator controlling the HRET as well as requiring the operator to be positioned in the hazard area. Other challenges that NLA present to the firefighters are complex slide arrangement and engine pylon locations.

The ARFF Research Program has completed the installation of a Next Generation HRET on their research vehicle. Testing of this new technology has begun to further refine the performance requirements to meet the challenges of today's commercial aviation fleets as well as the fleets of tomorrow.

Deploying FAArfield 1.0 – Advanced Airport Pavement Thickness Design Software

Researchers completed a new computer program, FAA Rigid and Flexible Iterative Elastic Layer Design, or FAArfield 1.0, on September 28, 2006. The new program incorporates three-dimensional (3D) finite element structural analysis to compute stresses for rigid (concrete) pavement and rigid overlay thickness design. Previous FAA computer programs for thickness design (LEDFAA 1.3) estimated rigid pavement stresses based on layered elastic analysis (LEA). FAArfield is a significant advance in pavement design technology and represents the first time the powerful and accurate 3D finite element method has been used in a routine design procedure to compute the critical design stresses (stresses at the slab edges) for complex aircraft gears.

Previously, 3D finite element based procedures were considered impractical for PC–based design applications because of the excessive time it took to complete modeling. A combination of faster computer processors and innovative programming methods reduced run times to the point where FAArfield 1.0 can be used for routine pavement design. Some of the strategies employed by the FAA included optimizing the 3D meshes and using less accurate, less computationally intensive methods in initial iterations to reduce overall processing time.

The look and feel of FAArfield 1.0 is virtually identical to the LEDFAA 1.3, so users will have no trouble adjusting to the new program. However, researchers have incorporated many changes into the new software. The entire program uses the Microsoft Visual Studio.NET programming environment, making it more compatible with current PCs and operating systems. Engineers have completely revised the rigid pavement failure models to incorporate new full-scale test data for four- and six-wheel gears from the National Airport Pavement Test Facility rigid pavement tests. For flexible pavements and overlays, FAArfield incorporates all the changes made in LEDFAA 1.3 and adds automatic base layer design. Researchers also have completely rewritten the rigid overlay design procedures, making them more efficient than previous algorithms.

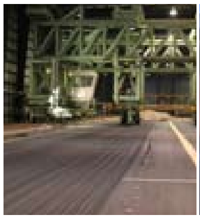
FAArfield 1.0 will be the basis for a major revision to AC 150/5320-6, expected in 2007. In anticipation of this change, FAArfield includes more run-time guidance. Also, the internal aircraft library has been revamped and expanded to include all current fleet aircraft and new models, including the A380.

Completing Full-Scale Flexible Overlay Tests

Asphalt overlays on concrete pavements often fail because the joints cause cracks in underlying concrete slabs that reflect through the asphalt to the surface. Rubblization is a relatively new pavement construction method in which a machine breaks apart an existing concrete pavement before the old surface is overlayed with a new asphalt one. The theory is that any remaining slab action within the concrete layer is destroyed, thus eliminating the risk of this “reflection cracking.” Rubblization was originally developed for highway pavements. In October 2005, the FAA completed a set of full-scale asphalt-on-concrete tests at the National Airport Pavement Test Facility. These tests provided performance data on both rubblized and unrubblized concrete pavements overlaid with asphalt. These data will help the FAA to update its current design guidance for overlays on rubblized pavements.

The National Airport Pavement Test Facility overlay tests were a follow-on to the full-scale rigid pavement tests, designated CC2, completed in December 2004. Researchers designated the overlay tests as CC2-O (for overlay). In these tests, engineers overlaid severely deteriorated slabs left over from the CC2 series with five inches of asphalt surface. They reduced the slabs on the north side of the centerline into rubble prior to overlay using the resonant-breaker type of rubblization equipment. They left the south side slabs in the deteriorated condition.

The research team then used the test facility load vehicle to traffic both sides with simulated aircraft taxi loads. Traffic loads began at 55,000 pounds per wheel, but were later increased to 65,000 pounds to accelerate the failure. The design allowed the researchers to conduct side-by-side tests on the rubblized and non-rubblized overlays. Each side contained three test items, which differed from each other in the type of base construction used. All test items were constructed on a medium-strength clay subgrade soil.



Test results on the rubblized side indicated that the overlays performed significantly better than the design prediction based on current interim FAA guidance (Engineering Brief 66). The researchers expected this outcome, because the interim guidance is known to be conservative. When failure did occur, it generally resembled failures associated with flexible pavements. Researchers did not observe any reflection cracks on the unrubblized side. They also expected this result, since they had not exposed these sections to the daily temperature cycling that contributes to reflection crack failures.

Reconstructing Rigid Pavement Test Sections At The National Airport Pavement Test Facility

In preparation for a new series of full-scale traffic tests on rigid (concrete) overlay pavements, engineers constructed three pavement test items at the National Airport Pavement Test Facility. In a project of the Innovative Pavement Research Foundation (IPRF), funded by the FAA through a Cooperative Agreement, the overlay tests were designated Construction Cycle 4 (CC4). These tests differ from previous studies conducted at the facility because, under the agreement, the FAA was required to reconstruct and prepare the subgrade soil to certain specifications, provide facilities for data collection, and operate the test vehicle.

IPRF designed the test sections and testing plan, and constructed the test sections above the subgrade. Quality Engineering Systems of Connaught Lake, Pennsylvania, the IPRF contractor, performed the work at the FAA test facility. FAA engineers completed reconstruction of the subgrade in January 2006, and completed construction of the test items in March 2006. The reconstructed sections consist of a jointed concrete overlay placed over a jointed concrete base course. The concrete layers are separated by a thin asphalt interlayer. Joint offsets, the initial condition of the base layer, and the thickness of the overlay relative to the base layer are among the variables considered in the experiment. The overlays are subjected to traffic simulating four-wheel and six-wheel heavy aircraft gear loads. Traffic testing is expected to continue through the end of 2006.

The CC4 series of tests provides full-scale test data on the performance of concrete overlays on concrete pavements to fill a gap in empirical knowledge. Previous tests on this type of construction are at least 35 years old and do not reflect current construction practices or aircraft loads. The present tests are intended to yield reliable performance data that the FAA can use to update the overlay thickness design procedures in its FAArfield computer program. The CC4 testing program largely follows a test plan that was prepared under a previous IPRF project, and is available at www.iprf.org.

Partnering for Airport Research

In December 2003, Congress authorized the Airport Cooperative Research Program (ACRP) as part of the Vision 100-Century of Aviation Reauthorization Act. The FAA sponsors the program, which the National Academies Transportation

Research Board manages. The purpose of the ACRP is to carry out applied research on problems shared by airport operating agencies. These problems, as well as some others that are too costly or complex for individual airports to solve, are not adequately addressed by existing federal research programs. In FY 2006, FAA research partners initiated 33 projects under the ACRP. Those projects include:

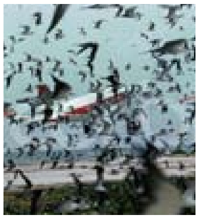
- Developing a guidebook for managing small airports – Management resources at small airports are usually very limited because many operate with small budgets. Airport managers have a wide variety of experience and educational backgrounds. Although some management guidance is available for their use, much of it is dated, focused on specific issues, intended for larger airports, or designed as a textbook rather than a practitioner's handbook. Research will provide operators and managers of small airports with current, comprehensive advice on resources and techniques that can be applied to meet their responsibilities.

- Studying the use of Light Detection and Ranging (LIDAR) in airport obstructions surveys – The use of airborne LIDAR data has been proven technically effective for obstruction analysis. Further research is needed to establish a cost-effective methodology that airports and their consultants can adopt to procure, process, and use these new data. This research is determining the requirements that must be met to use LIDAR data in aeronautical obstructions surveys and airport layout plan elevation surveys, recommending procurement specifications and procedures that could be used by airports or other agencies for procuring and using LIDAR data, and describing the technical bases that could justify acceptance of LIDAR-based obstructions surveys.

- Developing a guidebook for use with airport-user survey methodology – Airport-user surveys are the primary source of information for airport operators and other agencies on airport-user characteristics and airport ground access mode use. They play a critical role in airport planning and air travel forecasting. The planning, development, and conduct of airport-user surveys can be complex, expensive, and subject to a number of pitfalls. Surveys are often conducted at infrequent intervals by different contractors, and there is often a lack of continuity between successive surveys for the same airport. The lack of comparability between surveys at airports in multi-airport regions can be a particular problem for analyzing airport choice decisions or for performing studies of traffic "leakage" to airports in adjacent regions.

- Determining appropriate methods for using Lightning-Warning Systems at airports – Air carriers and airports are concerned with the potential hazards of lightning. Safety policies and practices require that ramp operations be discontinued when the potential for lightning exists. Ramp closures significantly affect all facets of airport operations, including landside, terminal, and airside operations – effects which ripple through the National Airspace System. The severity of these effects could be reduced if current airport lightning-warning systems were enhanced to more precisely identify the periods when ramp closures must be in effect. For example, this could be accomplished by integrating measurements from other weather-observing systems, such as radar, into the lightning-warning systems.

- Studying new design concepts for airport terminal landside facilities – Airport terminal landside facilities evolve in response to changes in travelers' needs and industry development. Increased passenger and baggage screening, provisions for self-service check-in, blast protection and chemical-biological threat mitigation, the need to improve intermodal connections among various ground transportation services, new technology, new legislation, and the special needs of an aging population and persons with disabilities are all making pressing demands on the limited airport terminal area. To address these demands, some airports have moved functions from their traditional locations, reallocated space within the terminal,



converted and reconstructed facilities, or created new types of facilities. Such changes have varied impacts on passengers' experiences, airlines' relationships with their customers, and airport revenues and costs. Research is underway to study the interface between various airport terminal landside elements (e.g., garages, roads, curbs, terminals) to identify improved ways of accommodating new airport terminal functions.

- Establishing guidelines for the collection and use of geospatially referenced data for airfield pavement management – The collection of data on pavement structure, pavement condition, traffic, climate, maintenance actions, testing and evaluation, and other items is essential for effective management of airfield pavements. While such data sets are regularly collected by many agencies and airports across the country, the information often differs greatly in definition and format, making it difficult for others to interpret and use it. Also, state-of-the-art technologies such as global position systems have typically not been effectively used in collecting the information. Guidelines are needed to make these collection efforts economical, compatible and effective.

- Developing alternative aircraft and airfield deicing and anti-icing fluid formulations – The discharge of spent aircraft and airfield deicing/anti-icing fluids (ADAF) to receiving waters is a growing environmental concern at airports across the United States. The presence of these fluids in storm water runoff creates a potential to elevate aquatic toxicity as well as creates a high biological oxygen demand (BOD5). Lower aquatic toxicity and BOD5 may reduce infrastructure costs to airports, provide greater operational latitude to aircraft operators and airports in deicing/anti-icing operations, and improve overall air transportation system reliability.

- Analyzing hazard mitigation for runway end approach lighting structures – Elevated approach lighting systems are in place at many airports throughout the country due to uneven terrain or close proximity to water. These high voltage structures are designed for longevity and sustainability; however, regulations also require these structures to be easily broken should a collision with aircraft occur. This research attempts to reduce the damage to aircraft caused from possible impact on elevated lighting structures, as well as improving the emergency rescue situation by reducing and/or eliminating the electrical hazards from these high voltage systems.

- Developing a guidebook for implementing airport Safety Management Systems - The airport Safety Management System (SMS) is a powerful tool for reducing the hazards and risks of aircraft accidents/incidents and runway incursions during approaches, takeoffs, and ground operations. This issue has been seriously considered in several parts of the world besides being an ICAO standard for the international airports since November 2005. The objective of this research is to produce a guidebook for developing an effective airport safety management system for different airport sizes based on FAA regulations that will be issued in the near future.

- Developing improved civil aircraft arresting systems-Currently, the FAA has approved a single civil aircraft arresting system, called an Engineered Materials Arresting System (EMAS). The system has been successfully deployed at a number of airports that have limited space for standard runway safety areas, and has demonstrated its value in several overrun accidents to date. However, expensive construction and maintenance requirements can make EMAS technology prohibitive for installation at small airports. The objectives of this research are to identify alternative candidate arresting systems that are comparable to EMAS and to identify alternative means of EMAS construction.

Foreign Object Debris Radar Detection System

The presence of foreign objects in the airport environment presents a major hazard to aircraft safety. Foreign object debris (FOD) is any substance, debris, or article alien to the vehicle or system that would potentially cause damage. The presence of FOD can be the result of the loss of parts from aircraft, pavement cracking, wildlife, ice and salt accumulation, and construction debris. Identification of FOD at airports requires regular observation of airport surfaces by airport personnel, or by chance recognition by aircraft pilots operating on airport pavement. Removal of such FOD is only triggered by those actual observations.

In 2005, the FAA in cooperation with the University of Illinois conducted a preliminary short term evaluation of a radar based FOD detection system at the John F. Kennedy International Airport. Through the use of millimeter wave radar, this system demonstrated that it was capable of detecting objects as small as a two-inch long bolt on the pavement surface. As a result, it was determined that this type of system could easily provide airport personnel with immediate FOD alerts, and even provide specific information on where the object is located. The conclusions from the preliminary research effort recognized successful detection of FOD under many operational and environmental conditions, but also identified a need to conduct further evaluation of the FOD radar at an airport on a longer term basis, under varying seasonal conditions.

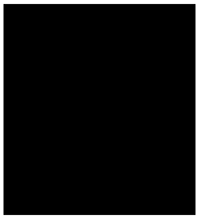
The FAA is currently developing plans for further FOD radar research at the Theodore Francis Green State Airport in Providence, Rhode Island. A total of two radar units will be installed at strategic locations on the airport surface that will collectively provide full FOD detection capability for the entire airport surface, including an alert mechanism to provide instant alert and location to airport personnel. Installation will be initiated in the early spring of 2007, and will be immediately followed by testing and evaluation throughout the remainder of 2007. Completion of the project is scheduled for early 2008.

Wildlife Mitigation R&D Program

The FAA's wildlife hazards mitigation R&D program consists of three main efforts aimed at reducing the risks of aircraft encountering wildlife on airports. The first main area is Wildlife Hazard Management research which focuses on techniques for managing the wildlife habitat on or in the vicinity of airports to make them less attractive for hazardous wildlife. The wildlife management area also includes the study of methods for controlling wildlife presence such as methods of deterring or scattering birds.

The second main area is aimed at detecting birds on or near airports to reduce the risk of aircraft striking the birds. The third main area is the development of a North American Bird Strike Advisory System (NABSAS). In all three areas, the current focus is on obtaining accurate and timely information that will ultimately lead to more effective management and reduced risks of severe and potentially catastrophic wildlife-aircraft strikes.

Wildlife Management and Control R&D Projects were carried out under agreements with the U.S. Department of Agriculture



(USDA). Studies conducted in 2006 included airport habitat studies which looked at the characteristics of water retention basins on airports that potentially attract bird populations. Researchers also studied alternative varieties of vegetation to identify bird foraging preferences and ultimately reduce their attractiveness for birds. Trash transfer facilities near airports can also be attractive to bird species. Studies continued to investigate the types and characteristics of trash transfer facilities that make them wildlife attractants. Potentially improved methods for assessing bird activity on airports were also evaluated. The ability to survey accurately bird activity is essential for habitat management and species population control.

In New York City, the USDA collared 300 resident Canada Geese and tracked their local movements. Data from this study will help airport wildlife biologists understand the nature of local bird movements and enable more effective control of airport avian hazards. The USDA also studied the use of avian effigies as a method to deter birds from controlled areas.

In 2006, the FAA established several cooperative agreements with key universities, agencies and airports as first steps toward the development of the NABSAS. The system is based on a strategic plan drafted in 2005 by the FAA, U.S. Air Force, and Transport Canada. The vision of the original draft remains to develop an advisory system for a variety of end-users that will provide near-real time information about bird hazards at North American Airports. Key cooperators include the U.S. Air Force, USDA, University of Illinois Urbana-Champaign, Embry Riddle Aeronautical University, and several commercial airports including Seattle-Tacoma, John F. Kennedy International, and Dallas/Fort Worth International as well as bird detection radar vendors. The FAA also serves as a participating partner in a similar effort being conducted by the U.S. Navy.

Through these cooperative efforts, the goal is to establish a national network of bird detection radars at airports known as “nodes”. Accurate and timely radar data from each node will be reported to a central repository and processing center where appropriate information will be generated for each end user. Field studies will begin at the first of several test nodes in the early 2007. The first test nodes will be established at Seattle-Tacoma International, John F. Kennedy International, and Dallas/Ft. Worth International Airports. This initial nodal network provides busy commercial airport environments in different regions with differing bird populations, wildlife control methods and different radar manufacturers.

Work began at the University of Illinois in 2006 to develop a protocol for calibrating bird detection radars prior to field evaluations. Additionally, Embry-Riddle Aeronautical University initiated efforts to develop a central repository and processing center for receiving, processing and distributing data from each airport node.

Aviation Weather

"Our mission is to provide accurate and accessible weather forecasts to improve system safety, capacity, and efficiency."

Gloria Kulesa
Aviation Weather Research Program Manager
Air Traffic Organization Operations Planning

Avoiding In-flight Icing Conditions

The formation of even a thin coat of ice on an aircraft surface can seriously affect an airplane's ability to fly by increasing drag, decreasing lift, and increasing aircraft weight. In many cases, the build-up of ice is so rapid that the pilot does not have enough time to take corrective action. National Transportation Safety Board records indicate that in-flight icing causes more than 25 accidents annually, with over half of these resulting in fatalities and destroyed aircraft. This equates to $100 million in injuries, fatalities, and aircraft damage each year.

To address this problem, FAA researchers developed the Current and Forecast Icing Potential products to alert users to areas of in-flight icing by displaying graphically the likelihood that icing will occur along their route of flight. During the year, the FAA upgraded the Current Icing Potential product. It also received a new name, Current Icing Product, to distinguish it from its preceding version. The upgrade provides more spatial resolution of icing conditions. Users can now see the finer details of weather structure contributing to potentially hazardous icing conditions. This improvement allows pilots to devise flight plans that more effectively avoid the icing hazard.

In addition, the upgraded product has another new feature, a severity index, to enable better decision-making by the user. Severity is needed to delineate where icing conditions are found, so aircraft can avoid these areas. While the previous version used an icing potential index, the upgraded software uses a relative scale calibrated to depict the true probability of encountering ice. The colors now change from cool (light blue) to warm (orange) and the vertical range has been extended to 30,000 feet. Additionally supercooled large drop regions (conditions outside current aircraft certification envelopes) are depicted. These improvements allow users to plan more effective routes of flight that will avoid hazardous icing areas.

Avoiding Volcanic Ash

Volcanic ash is a significant safety hazard to aviation that has caused more than $250 million dollars in damage to aircraft over the past 20 years. To address this problem, FAA researchers have developed a Volcanic Ash Coordination Tool to improve the timeliness, coordination, and accuracy of volcanic ash warnings and forecasts. The tool also enhances the efficiency of the national airspace system by enabling better identification of airspace that is unsafe to use.

The FAA and National Weather Service implemented this new tool in Alaska at the Anchorage Volcanic Ash Advisory Center, the Alaska Volcano Observatory, and the Anchorage air route traffic control center weather service unit. Most of the volcanoes that affect U.S. airspace are found in Alaska. This new tool allows the FAA, National Weather Service, and other national and local organizations with responsibility for detecting eruptions and issuing advisories and forecasts for volcanic ash to coordinate activities in real-time.

Assessing Quality

Because verification is critical to providing reliable information for improved weather forecasts, FAA-sponsored researchers are developing verification techniques and tools that allow forecasters, developers, and program leaders to generate and display statistical information in near real time. This past year, researchers developed critical enhancements to the Real-Time Verification System (RTVS). This system provides verification of research and operational weather products in real time via the Internet. It allows aviation decision makers to know how well any FAA forecast tool product is performing. When implemented at National Weather Service Headquarters early next year, RTVS will provide easier and faster access to statistical results and enhanced ability to verify turbulence, icing, convection ceiling, and visibility forecasts.

These enhancements are another major milestone in achieving full operational verification capability at the National Weather Service. Users of the system include the National Weather Service Aviation Weather Center, the FAA Air Traffic Control System Command Center, the FAA/National Weather Service Aviation Weather Technology Transfer Board, and several airline dispatch centers.

Mitigating the Effects of Convective Weather

Spring and summer thunderstorms account for a significant reduction in airspace capacity and are responsible for approximately 75 percent of weather delays from April through September. Similarly, winter storms create havoc throughout that season. While this raises a system capacity/efficiency concern, there also is a safety consideration. Turbulence induced by convective weather causes $22 million per year in injuries, fatalities, and aircraft damage.

To mitigate weather delays and improve aviation safety, the FAA is investing in new storm detection and nowcast capabilities to enhance safety and reduce weather-related delays. In June 2006, FAA-funded researchers began an effort to integrate existing capabilities into a single system that provides consistent storm forecasts (summer and winter). They anticipate that the Consolidated Aviation Storm Forecast System will eventually replace more than a dozen legacy forecast products. The research team has already met with stakeholders to determine user needs and is proceeding with development efforts.

During the fiscal year, the FAA delivered the Terminal Convective Weather Forecast product, which is designed to minimize terminal delays caused by convection. The new tool provides an animated one-hour forecast of thunderstorms, including growth and decay. It also provides a higher resolution (1 kilometer), long-range precipitation map for a more precise depiction of surrounding storms, and much better depiction of winter precipitation. This new software is currently being installed on the FAA Integrated Terminal Weather System (ITWS), with the debut deployment in New York this past summer. By the end of calendar year 2006, FAA deployed the tool on an additional 17 sites. The FAA estimates by the end of FY 2008 when all systems are deployed, ITWS will deliver an annual benefit of $524 million. This benefit will not be lost in the future consolidation work. The Terminal Convective Weather Forecast product will be incorporated into the Consolidated Aviation Storm Forecast System before the delivery of the final product.

Forecasting Turbulence

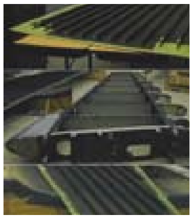
Although only 35 percent of its conditions are forecasted, turbulence accounts for 65 percent of all weather-related injuries, while only 35 percent of its conditions are forecasted. Because observations and forecasts are not accurate enough to predict the location, time, and intensity of turbulence, FAA funded the development of the Graphical Turbulence Guidance product. This tool produces easy-to-interpret depictions of turbulence. It is available on the web-based Aviation Digital Data Service, allowing anyone with an Internet connection access to the display. The output shows relative turbulence intensities at user-selected altitudes.

Using input from several numerical weather prediction models, the Graphical Turbulence Guidance product refines turbulence assessments by comparing the models with current pilot reports of turbulence. It produces turbulence forecasts out to twelve hours and clear-air turbulence forecasts for altitudes above 20,000 feet. Development has been completed on the next phase of this product, which extends forecasts down to 10,000 feet. This enhancement is anticipated to become operational in 2007. When fully developed, the advanced Graphical Turbulence Guidance product will provide forecasts for all altitudes and will have the capability to forecast mountain-wave and convectively-induced (regions involving thunderstorm activity) turbulence.

Center for Advanced Aviation System Development (CAASD)

"The mission of CAASD is to perform the studies, analysis and concept formulation for continued advanced aviation research for the modernization and development of the NAS."

Bob Bostiga
FAA CAASD Program Manager



Developing Performance-Based Air Traffic Management Operations for Improving Safety, Capacity, and Productivity

Aviation is a critical part of the U.S. economy. Yet increases in air traffic volume and complexity, combined with projected budget constraints over the coming years, will create challenges for our nation's air traffic management system. The safety, capacity, and productivity of the national airspace system can be improved by integrating enhanced automation technologies into it, enabling operational demands to be met in an efficient and safe manner.

The FAA's Center for Advanced Aviation System Development (CAASD), operated by the MITRE Corporation, developed an end-to-end concept for air traffic operations known as Performance-Based Air Traffic Management (P-ATM). The concept includes fundamental shifts in the use of automation capabilities across the national airspace system, while still maintaining a human-centered operation. It is a cross-domain set of air traffic capabilities, procedures, and new roles and responsibilities that will revolutionize the way the FAA operates its air traffic system.

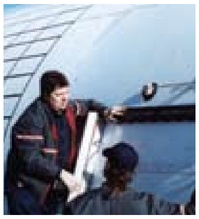
Under the concept, many routine air traffic control tasks would be automated, responsibility for problem prediction would move from controllers to automation, and controllers would resolve problems using automated resolution assistance. At the same time, airspace would be redesigned to optimize service and improve productivity, and additional routes would be designed to increase flexibility, efficiency, and capacity. In addition, automation would enable aircraft to fly accurate route and altitude profiles through the exchange of flight status and intent information between the aircraft and ground systems. This integration of technologies should provide vastly improved air traffic services that promote increased safety, capacity, and productivity. The P-ATM concept will transform air traffic operations and change controllers' jobs to safely and efficiently meet the future demands on the system.

In FY 2006, FAA-funded researchers at CAASD designed and conducted numerous human-in-the-loop experiments of this future environment. FAA en route and terminal front line managers from across the country assessed both the quantitative benefits and operational feasibility of this P-ATM concept.

The results of the work conducted thus far have had a significant impact in the FAA's plans for the next generation air transportation system. The P-ATM concept aligns very well with the core capabilities that are part of the future vision, but also represents a set of operational changes that can be achieved in a more near-term timeframe.

Estimating Runway Capacity at Complex Airports

An estimate of runway capacity can provide a key measure of the effectiveness of new technologies, procedures, and infrastructure intended to improve the air traffic control system. An accurate model for estimating runway capacity is a valuable tool for predicting the effects of new technologies on the system and for making decisions about building new runways. Accurately modeling runway capacity has become even more complex because today's environment consists of multiple decision support systems in the cockpit and on the ground, specialized separation rules for multiple approach and depar-



ture traffic streams, and interactions between nearby airports in major terminal areas.

To capture the dynamic effects of the interactions between traffic streams in runway capacity modeling, CAASD researchers developed a prototype simulation-based modeling system called *runway*-Simulator. In less than an hour, a trained analyst can configure this system to simulate the traffic streams for a set of runways at a single airport, or a group of nearby airports, operating under any set of air traffic control separation techniques. The simulation presents its results both as numerical measures of throughput and as an animation of the aircraft traffic streams that produced the numbers. The modeling system captures statistics describing runway usage, interactions between the traffic streams, and flow rates. These results are categorized in a variety of ways, including by the particular aircraft types and runways being used. Together, the statistics and animation provide increased insight into the most efficient way to operate a complex system of runways.

The new *runway*Simulator provides important advantages over the Enhanced Airfield Capacity Model that is currently used to calculate estimated runway capacity. The older analytical steady-state model estimates the average maximum sustainable throughput for a limited set of configurations using predetermined separation rules. The new system also estimates the average maximum sustainable throughput, but it can model any configuration and any set of separation rules. In addition, being a simulation, it also captures the dynamic interaction between traffic flows and produces much more detailed output that permits greater insight into why an airport is limited to a given capacity.

In FY 2006 the development team introduced the *runway*Simulator to the modeling experts within FAA. Together, they began a thorough evaluation of the model's capabilities to assess the potential effects of planned procedures, technologies, and infrastructure upon an airport's capacity.

Creating Clean Sheet Airspace Design Tools

Historically, airspace has been redesigned by air traffic controllers who were working to solve a problem like enabling a specific merge area to safely handle a large volume of traffic. Since many airspace design efforts cross facility boundaries, they can be costly and labor intensive processes. Controller teams often must spend extended periods of time away from their facilities to participate in detailed airspace design activities. Also, due to the size, complexity, and inter-connectedness of the national airspace system, the solutions controllers find to their local problems may have unintended ripple effects elsewhere in the system.

To make airspace redesign more efficient, CAASD researchers developed a prototype set of Clean Sheet airspace design tools. These tools feature a three-step, semi-automated process for airspace redesign that wipes the slate clean of preconceived notions about airspace redesign and produces completely objective solutions. Using repeatable and transparent methods, the tools allow faster, less expensive, more efficient airspace redesigns applicable to virtually any user input traffic flow, regardless of existing sectors or control facility boundaries.

The first step creates a map of geographically distributed traffic complexity (based on a specific set of metrics) in the area to be redesigned. Once a map is created, an automated Airspace Practitioner tool divides the airspace into areas of equal complexity. The target amount of complexity for each partition is adjustable and the tool can design sectors requiring one, two, or three controllers. The next step in the Clean Sheet process is a fast-time, dynamic simulation model, called Solution Option Manager (SOM), that tests the complexity regions and identifies operational problems that controllers might experience. The third step employs the Sector Evaluation Tool (SET), which uses a knowledge database of airspace design principles and best practices captured from air traffic control experts to suggest solutions to the problems identified in the second step. Work continues to enhance the SET knowledge database and to apply it earlier in the process.

In 2006, SET and SOM helped make airspace design decisions in Florida and Chicago (respectively). The whole Clean Sheet process was used to create a proposed redesign of all high altitude airspace west of the Mississippi River, taking into consideration future traffic levels and user-preferred routing. The proposed redesigns were presented to the FAA in late 2006 and are currently under consideration.

Developing Advanced Systems for Air Traffic Workforce Training

With a large percentage of the nation's air traffic controllers expected to retire over the next decade, the FAA faces the daunting task of training just under 12,000 new en route controllers. What makes this situation even more challenging is that training and certifying a controller requires a great deal of instructor resources and can currently take three to five years.

To help determine how to accelerate training to meet the anticipated demand for new controllers, and to improve the efficiency and effectiveness of the training program, a CAASD research team developed a new high-fidelity instruction prototype. Known as the *enroute*Trainer, this stand-alone system simulates the effect of winds, aircraft climb/descent rates, and aberrant conditions to provide students a realistic practice environment. The system's speech recognition and synthesis capabilities simulate pilot/controller interaction to enable self-paced training while still increasing standardization. The *enroute*Trainer simulates a variety of scenarios to familiarize the student with sector and area operations, procedures, and traffic patterns. Following a training session, the instructor can play back any scenario to assess the trainee's performance. To aid in records keeping, the instructor also can generate reports on significant measures, including operational deviations and student errors.

By encouraging practice and providing feedback, the technologies embodied in the *enroute*Trainer are expected to reduce the cost of certifying controllers and potentially could cut training time in half. Perhaps most importantly, they are expected to achieve these savings while improving the quality and consistency of training.

In FY06, an evaluation of the *enroute*Trainer began at the Indianapolis Air Route Traffic Control Center. Before beginning their on-the-job training with live traffic, a group of students were trained using this system during their final stage of radar simulation training. Both the instructors and the students were impressed with the fidelity of the simulation capabilities, improved training context, and streamlined processes. The qualitative and quantitative assessment of ongoing benefits is being measured as the students continue through their training. The project results will help to define training program changes and automation enhancements that will ultimately be incorporated into the En Route Automation Modernization (ERAM) system.

Modeling Improvements to the National Airspace System

The performance of the national airspace system, commonly measured by flight delays and traffic loads on airports and airspace, depends on the complex interactions of airspace users, air traffic service providers, aviation infrastructure, and weather. Analysts use simulations to capture these complexities when estimating the effects on the national airspace system of increasing traffic volumes, new fleet mixes, alternative route structures, new runways, and improved technologies, procedures, and operational concepts.

In 2006, CAASD researchers developed a new prototype fast-time simulation capability, *systemwide*Modeler, to help the Agency examine proposed improvements to the NAS more effectively and faster. The new tool simulates the progress of individual flights through airports, terminal areas, and en route sectors. Meanwhile, it considers airport capacities and traffic management initiatives while it models the delays and workloads caused by congestion and weather. Implemented in a state-of-the-art simulation language with a flexible architecture, *systemwide*Modeler simulates a day of operations in less than fifteen minutes and can report details for aggregate or focused analysis and visualization. The system has already provided a detailed analysis of the FAA's Operational Evolution Partnership and predicted airports that will have capacity problems.

The *systemwide* Modeler uniquely reflects differences associated with merging and spacing flows, resolving conflicts, and managing climbing and descending traffic in its analyses of en route controller workloads. Through its representation of traffic events and controller tasks, it goes beyond traditional traffic count-based models to help analysts understand the effects of new communications and automation technologies as well as new procedures and airspace design.

Simplifying New Aviation Concept Testing with AviationSimNet™

In the past, enabling laboratories at government agencies, commercial airlines, and universities to collaborate on evaluations of new aviation concepts required extensive funding, time, and communications resources. These difficulties limited opportunities for collaborative research. To overcome these difficulties CAASD joined with others in the aviation community to develop a new standard to facilitate distributed evaluations between simulation laboratories.

Known as AviationSimNet, the standard is a flexible, reusable technical specification for conducting real-time air traffic management (ATM) simulations over the public Internet. Building on proven simulation and communication standards like the Department of Defense's high-level architecture and FAA and International Civil Aviation Organization standards, AviationSimNet reduces the time and cost of fielding new capabilities.

The second version of the AviationSimNet standard, initially available to the public in August 2006, continues to be expanded to meet needs identified by the AviationSimNet community. The next release will include flight object and weather extensions, in addition to more simulation management capabilities.

Organizations participating in AviationSimNet include: the Air Line Pilot Association; The Boeing Corporation; the Center for Applied ATM Research at Embry-Riddle Aeronautical University; Crown Consulting; Lockheed Martin Transportation and Security Solutions; NASA Ames Research Center; NASA Langley Research Center; Raytheon; and UPS. In addition to building gateways that make their labs accessible via AviationSimNet, participating organizations are also hosting SimCenters, which are communications facilitators for the simulation environment that include labs at multiple organizations. The AviationSimNet environment was used to conduct a joint demonstration between Lockheed Martin and MITRE in September 2006. More information can be found at http://aviationsimnet.net.

Commercial Space Transportation

"Our mission is to ensure protection of the public property and the national security and foreign policy interests of the U.S. during commercial launches or re-entry activities, while encouraging, facilitating and promoting U.S. commercial space transportation."

Patti Grace Smith
Associate Administrator for
Commercial Space Transportation

Understanding the Physiological Challenges of Space Flight

The Commercial Space Launch Amendments Act of 2004 requires that spaceflight participants be informed of the health risks associated with short duration spaceflight. Although much is known about how young, healthy individuals withstand the rigors of long duration spaceflights, the medical risks of short duration microgravity exposure are not well understood. In addition, the typical space tourist who boards a suborbital flight will not always be ideally young and healthy. Hence, the regulatory community needs to understand better the physiological challenges of manned space flight to ensure optimal performance and safety for a wide range of passengers.

In 2006, the FAA Office of Commercial Space Transportation completed a research project that prepares it to collect voluntary medical data from commercial flight crew and space flight participants. Researchers defined the biomedical parameters recommended for pre-flight, in-flight, and post-flight monitoring to form a more complete understanding of the effects of suborbital flight on human physiology. The successful completion of this research project enabled the FAA to recommend to launch operators the specific types of biomedical data – along with methodologies for their proper collection and processing – needed to clarify the physiological effects of short duration spaceflight.

Analyzing Debris Risk

FAA researchers completed a milestone study on debris risk analysis. The Agency often uses computer-based models to anticipate public casualties related to commercial launch accidents. Researchers examined how well current computer models could predict the hazards to humans inside of buildings subjected to external explosive forces. They compared model predictions to the outcomes of historic real-world incidents and to the results of explosive debris and blast forces on uninhabited test articles. They found a correlation between predicted and actual results that reinforces the credibility of how insurance requirements and liability limits are currently established for commercial launch activities.

In a related 2006 project designed to further determine and refine the accuracy of debris dispersion models, FAA and NASA researchers studied characteristics of debris recovered from the Space Shuttle Columbia accident. As part of this study, researchers established a processing area and set up scales, cameras, computers, and other equipment for recording information into a database. Then they began to develop and optimize the procedures for the labor-intensive task of processing the large quantity of debris. The debris collection, stored in the Vehicle Assembly Building at Kennedy Space Center, contains over 84,000 items, most of which are associated with GPS latitude and longitude impact coordinates. The coordinates, along with physical measurements and aerodynamic features, such as shape and ballistic coefficient, can help researchers and analysts develop and refine debris dispersion models that are used for establishing safety requirements and evaluating public risk associated with space operations. The nearly complete procedure development phase of the study will help to determine process throughput and associated costs for a possible continuation of this project in 2007.

Separating Space Flight Traffic

The FAA is responsible for ensuring public safety as the commercial space transportation industry evolves. With a focus on the rapid evolution and complexity of new launch vehicles, Agency researchers are leading efforts to establish new processes to evaluate and approve the safety of critical launch vehicle components, systems, and space vehicle traffic. During FY 2006, researchers began a study to determine the separation requirements that will allow certain aircraft and commercial spacecraft to operate safely together within the national aerospace system.

Vehicle operators define the vehicle and space mission characteristics. General risk analyses determine initial separation requirements based on space vehicle and launch site characteristics. Fast-time simulations test the combination of mission and separation requirements within a high-fidelity model of the actual traffic environment. If the initial separation criteria and mission requirements result in unacceptable traffic impacts, then vehicle characteristics, mission characteristics, and/or risk analysis parameters are proposed that will mitigate those impacts.

The results of this process support development of the operational information needed in the field to conduct the mission, including operational procedures, agreements, and airspace design.

Environment & Energy

"We are developing methodologies and tools to better target and mitigate the effects of aircraft noise and aviation emission."

Dan Elwell, Assistant Administrator for
Aviation Policy, Planning and Environment

PARTNERing for Success

The Partnership for AiR Transportation Noise and Emissions Reduction is an FAA/NASA/Transport Canada-sponsored Center of Excellence. PARTNER fosters breakthrough technological, operational, policy, and workforce advances for the betterment of mobility, economy, national security, and the environment. The Center's operational headquarters is at the Massachusetts Institute of Technology; Professor Ian Waitz of the MIT Aeronautics and Astronautics Department is the director.

PARTNER comprises ten collaborating universities (with projects funded at three more), and approximately 50 advisory board members. One of PARTNER's strengths is the advisory board's diversity and inclusiveness. Its members include aerospace manufacturers, airlines, airports, national, state and local government, professional and trade associations, and non-governmental organizations and community groups. They are united in the desire to foster collaboration and consensus among some of the best minds in aviation so, together, they can advance environmental performance, efficiency, safety, and security.

Now entering its fourth year of operation, PARTNER has launched 18 research projects, including the Low Frequency Noise Study, Continuous Descent Arrival, Measurement of Emissions, Valuation and Trade-offs of Policy Options, Sonic Boom Mitigation, and Health Impacts of Aviation-related Air Pollutants. Much more on PARTNER, including information on all projects, is available at http://www.partner.aero/.

Developing Analytical Tools for Effective, Comprehensive Noise and Emission Mitigation

Aviation noise and emissions are highly interrelated phenomena that must be understood and mitigated together. This complex task requires analysis of substantive data on the interrelations of many seemingly disparate factors. FAA and NASA researchers are developing an integrated suite of analytical tools: the Environmental Design Space (EDS); Aviation Environmental Design Tool (AEDT); and the Aviation environmental Portfolio Management Tool (APMT). Each tool will provide a key component of an integrated decision making capability. EDS generates performance, cost, source noise, and exhaust emissions data within an aircraft design environment capable of simulating future aircraft properties. AEDT computes and identifies interrelationships among noise, fuel burn, and various emissions at the local, regional, and global operational levels both for base years and for future scenarios. Using data from EDS and AEDT, the APMT will compute economic and health impacts while assessing the cost-benefit of mitigation strategies.

Individually, these tools will provide critical data; as an integrated

set, they can help government and industry undertake operations and projects that more effectively target and control aviation noise and emissions. The toolset will also help the aviation community educate the public about how aviation noise and emissions interact to affect local, regional, and global communities.

PARTNER member universities are developing the EDS and APMT modules. This endeavor builds on past aviation environmental economic analysis tools, anticipates future international and domestic analysis needs, and encompasses best practice guidance. During the 2005 to 2006 period, design requirement research saw completion of the APMT requirements and architecture studies as well as development of APMT prototype Version 0.0. The prototyping effort focused on the construction of an APMT functional module, although one with more limited capabilities than is planned for the final versions. This enabled initial testing of APMT's abilities to address policy questions, assess uncertainties, and determine priority areas for future development and refinement. The 2006 assessment of the APMT prototype provided a roadmap for future development, and a preliminary evaluation of capabilities with respect to fidelity requirements. It also established a procedure for future assessment.

Describing APMT Modules

To help evaluate policy costs, APMT architecture uses aviation demand and policy scenarios to simulate producer and consumer behavior. Detailed operational modeling of the air transportation system provides estimates of the emissions and noise outputs. Then, a benefits valuation module puts a price tag on the health and welfare impacts of aviation noise, local air quality, and climate effects. Together, these modules produce a comprehensive cost-benefit analysis of policy alternatives.

The Environmental Design Space tool estimates source noise, exhaust emissions, performance, and economic parameters for aircraft designs under different technological, policy, and market scenarios. In 2006, a research team led by the Georgia Institute of Technology and the Massachusetts Institute of Technology, completed EDS Version 2.0. This version incorporates improved emissions calculations and flight performance modeling.

The development team, in collaboration with industry, is conducting a thorough assessment of the EDS tool. This will enable better understanding of the tool's accuracy, and will highlight any components needing improvement. The first phase of the assessment, conducted collaboratively with General Electric Aircraft Engines, and Pratt & Whitney, focuses on an engine-level tradeoff for systems offered on Boeing B777-200 and -300 aircraft. In addition to this development work, several capability demonstration assessments (i.e., sample problems) are ongoing (one completed in 2006) that will demonstrate to the international community the capability of the tool suite.

In 2006, a researcher team led by the Volpe National Transportation Systems Center with members from ATAC Corporation, CSSI Inc., and Wyle Laboratories, completed AEDT Version 1.0. This version includes most of the system's computational and database components.

Although the research that is anticipated to develop this analytical tool suite will last a decade, initial capabilities will come online between 2006 and 2009 – in time to influence the seventh and eighth meetings of the International Civil Aviation Organization's Committee on Aviation Environmental Protection (ICAO/CAEP). The FAA expects that when the EDS/AEDT/APMT tool suite is fully operational, it will help with regulatory decisions, and provide significant cost savings and other user benefits.

Demonstrating AEDT

During 2006, PARTNER used AEDT when conducting the NOx Demonstration Study for the FAA. Researchers integrated common databases, calculation methodologies, and performance-based modules that are currently in use as a part of aircraft noise calculations, to support the simultaneous calculation of aircraft emissions. The harmonization of noise and emissions assessment methodologies proved complex, but it yielded a landmark new capability. With these changes AEDT can now compute and identify critical interrelationships between noise and various emissions generated by generations at local, regional, and global levels.
The FAA benchmarked this new capability against a 2004 study by the ICAO/CAEP. The study had examined global emissions below 3,000 feet. The modeling demonstration included an airport queuing model so that the effects of the flight schedule could be captured in capacity-hindered airports.

Researchers extended the global coverage of aircraft activity by demonstrating the ability to incorporate radar data to assess emissions from scheduled as well as unscheduled aircraft and from certified and non-certified engines. The NOx demonstration also quantified emissions at and below 3,000 feet, below 10,000 feet, and over entire flights. It further refined the analysis process by allowing emissions value adjustment based on required aircraft thrust and meteorological conditions. FAA's NOx demonstration reproduced CAEP's global assessment of NOx stringency options in a fraction of the time it took CAEP to complete its original analysis.

Researching Aviation-Related Health Affects

Previously concluded airport assessment studies indicate that the health impacts of aviation emissions are not well characterized. There are uncertainties primarily due to poor characterization of aircraft engine emissions for hazardous air pollutants (HAPs) and particulate matter (PM), lack of comprehensive and reliable ambient measurement data within the airport vicinity, lack of suitable air quality modeling to determine atmospheric distributions of these pollutants, and lack of agreed methodology to conduct health impact risk assessment.

The FAA has taken research and procedural initiatives that will lead to fewer uncertainties and better assessment of aviation emissions-related health impacts. The Office of Environment and Energy (AEE) has prepared draft guidelines that will lead to nationally uniform methodology to inventory airport-related HAPs emissions. These guidelines will be based upon directly collected limited aircraft engine emission data, including measurement data obtained through the Aircraft Particle Emissions eXperiment in partnership with NASA and the EPA. AEE has also developed methodology for aircraft PM emission estimation. These two initiatives will lead to better characterization and estimation of aircraft emissions. In addition, through PARTNER collaborative research with NASA and the EPA, AEE is collecting data on ambient concentrations of aviation-released pollutants within airport boundaries.

Recently, AEE broadened PARTNER's scope of studies by tasking the Harvard School of Public Health to research health impacts of aviation-related air pollutants and the University of North Carolina-Chapel Hill to look into aviation emissions air quality impacts. These research

initiatives will provide substantive data with which the FAA can assess, with greater certainty, aviation emission health impacts.

The AEE has successfully included two major projects on aviation emitted PM and HAPs in the environment research section of FAA funded Airport Cooperative Research Program (ACRP), an ongoing effort managed by the Transportation Research Board of the National Academy of Sciences. Initially, these projects will focus on the identification and prioritization of critical needs in their respective areas, concerns which will subsequently be included in new calls for research proposals. The AEE and PARTNER will fully coordinate their activities with ACRP funded research to avoid any overlap while gaining from each other towards meeting the common objective. There are a number of similarities between the health effects due to pollutants released by aviation and non-aviation activities. Therefore, every effort will be made to benefit from similar research being performed elsewhere.

Remodeling the Emissions Dispersion Modeling System

The FAA's legacy air quality model, the Emissions Dispersion Modeling System (EDMS), underwent a redesign in preparation for its incorporation into the Aviation Environmental Design Tool. The most significant improvement in EDMS 5.0 is the ability to model multiple scenarios and analysis years and to assess airports within an integrated context. Users can now open multiple studies simultaneously, providing local, regional, and global capabilities.

A higher level of sophistication has also been added to factor details of schedules, existing and future airport layouts, and hour-by-hour weather data analysis, into changes in airport emissions and the contribution to the air quality within the vicinity of the airport. The EDMS 5.0 uses the World Wide LMI NETwork to estimate how the capacity constraints of specific airports and en route congestion impact the block-time of flights. The ability to depict increased airport operational fidelity down to 15-minute intervals (as opposed to hourly) means that airport delays can be more accurately quantified. The dynamic flight profile generator allows more specific takeoff and landing weight values to be entered, takeoff thrusts to be specified, and approach glide slopes to be defined. The emissions module is updated to use the Boeing Fuel Flow Method 2 to scale emissions according to thrust level. The EDMS 5.0 has been harmonized with the aircraft, airport, and meteorology databases - as well as with the same aircraft performance methodologies used in the Integrated Noise Model. The resulting structure lays the foundation for assessing interdependencies between aircraft noise and emissions.

Measuring Emissions

In FY 2006, the Measurement of Emissions Project undertaken by PARTNER and its member universities, NASA, and Transport Canada made great progress in characterizing engine emissions. Emissions data taken downstream behind aircraft engines in the open field differ from those taken at the exit plane during engine emissions certification testing. Under true operating conditions, an exhaust plume can age and chemically react with the ambient air. Valid health risk assessments depend on an accurate understanding of how the plume emitted by a stationary or taxiing aircraft is transformed after it exits the engine into a fairly stable collection of pollutants downstream. Recent field measurement activities have shed much light into this process.

Researchers collected substantial emissions data from large, medium, and small commercial, cargo, and government aircraft based at four airports and airfields across the country. This geographical spread aims to account for the effects of ambient conditions, such as temperature, pressure, and relative humidity on emissions. Measurement activities are complete and data validation is almost complete for all field measurement activities. A preliminary look at the data reveals significant new information on the behavior of pollutants – especially particulate matter (PM). The data also seem to confirm scientific theories on the relationship among pollutants, the emissions levels, and characteristics at different engine power settings.

The Society of Automotive Engineers is using this research to develop important new Aerospace Recommended Practices. These recommendations will help in selecting the proper instruments and measurement methodologies for quantifying levels of particulate matter emitted from military as well as commercial aircraft. In addition, the findings will support stakeholders, including both regulators and those they regulate, to progress under the FAA-sponsored PM Roadmap. The PM Roadmap serves as a foundation for promoting research coordination and collaboration to understand PM emissions from aviation. It defines work plans to conduct needed research resulting in information that can inform policy decisions.

FAA is also helping the Transportation Research Board to develop findings that can support existing and future requirements applicable to airports. This research organization has funded two proposals in FY 2006 that will supplement the PARTNER research.

Understanding Aviation Fuel Conservation and Emissions

The Energy Policy Act of 2005 required the Environmental Protection Agency and the FAA to initiate a joint study to identify:

- The impact of aircraft emissions on air quality in nonattainment areas,
- Ways to promote measures that allow aviation to enhance fuel efficiency and to reduce emissions, and
- Opportunities to reduce air traffic inefficiencies that both waste fuel and increase emissions.

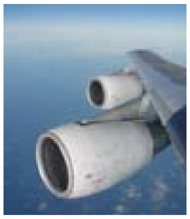
In response to this congressional mandate, EPA and FAA have agreed on an approach that will draw upon a variety of databases and computer models to:

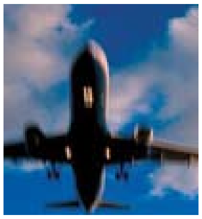
- Quantify aircraft emissions for 149 airports located in nonattainment areas,
- Estimate health impacts from aircraft emissions,
- Establish the relationship between congestion and delays – and their combined effect on emissions and local air quality,
- Estimate the potential of current FAA initiatives to relieve congestion and delays, reduce emissions, and improve local air quality in nonattainment areas, and
- Determine the potential benefits associated with improving ground and terminal operations.

The Massachusetts Institute of Technology, through PARTNER, is supporting the FAA and the EPA in conducting this study. As some deliverables from this effort overlap tasks already being fulfilled by CSSI, Inc., and Metron Aviation under pre-existing FAA agreements, these firms are also assisting within the study. The final report is scheduled for release in late 2007.

Assessing Aviation's Global Emissions

As the aviation industry continues its rapid growth, its potential effects on global air quality and climate change could increase. This concern is exacerbated by the fact that aircraft emit air pollutants directly into the higher





troposphere and lower stratosphere. The FAA Office of Environment and Energy has developed the System for assessing Aviations Global Emissions (SAGE) to predict aircraft fuel burn and emissions and assess various measures that could help mitigate emissions. SAGE dynamically models aircraft performance, fuel burn and emissions, capacity and delay at airports, and forecasts of future scenarios. The scope of the system's predictive data can range from all commercial (civil) flights globally in a given year to scenarios from a single flight, to airport, country, regional, and global levels.

In its 2006 Guidelines for National Greenhouse Gas Inventories, the Intergovernmental Panel on Climate Change cited SAGE as a tool that provides the highest fidelity method of estimating aviation emissions. Also in 2006, researchers used SAGE Version 1.5 to generate global inventories of fuel burn and emissions for years 2000 through 2005. They developed these historical inventories by modeling high-resolution gate-to-gate movements of all global commercial flights in each year. Files from the inventory report present the data in various forms, and provide derivative metrics and comparative assessments. In addition, the FAA published a series of SAGE documents with information on the model's methods and assumptions, revision history, and validation. Both the inventories and the information documents are available to all on the FAA Web site at http://www.faa.gov/about/office_org/headquarters_offices/aep/models/SAGE/.

Understanding Low Frequency Noise

While the level of aviation-associated noise that individuals can tolerate seems variable and personally determined, researchers need a generic, scientifically-based metric to assess the effects that aircraft noise impose on most humans. In its search for such a metric, the FAA funded PARTNER to study low frequency noise. The resulting study encompasses factors such as noise source level and spectrum, atmospheric propagation, and the impact on homes in the form of noise, vibration, and rattle. It includes subjective evaluations to determine the numbers and types of sound characteristics that are important, how they factor into noise annoyance, and the ability of metric calculations to predict their actual physical, as distinguished from perceived, impact. The researchers are exploring ways to measure and predict annoyance when people are faced with low frequency noise.

Over the past year, the team conducted psycho-acoustic testing of human subjects using noise data obtained from two houses inside Washington Dulles International Airport flight boundaries. These aircraft noise signature recordings, and recordings of aircraft noise from two airports in Florida, form part of a database that is being used in further psychoacoustic testing. This database contains sounds with and without strong low frequency components. In this study, groups of human subjects respond to the noise recordings. A crucial element of the research design focuses on

how their perceptions are affected by the presence of low frequency noise. The goal is to gain insight into how the perception of aircraft noise results in annoyance, and to identify metrics that correlate best with the subjective responses.
FAA-funded researchers also conducted a subjective study using sound signatures with and without an element they call "rattle" to see how much this element does to further annoy people. Acceleration levels measured inside houses at test airports compared well against previously used criteria at other airports. The results of this research will help to refine the metrics that may be used to quantify the impact of low frequency aircraft noise on communities. These metrics can then be used to influence noise-mitigating improvements in, and regulation of, technology, airport and aircraft operation, land-usage, and aircraft design.

Releasing Integrated Noise Model Version 6.2

With the recent release of the Integrated Noise Model Version 6.2, the FAA's standard tool for predicting noise impact in the vicinity of airports, many aircraft listings are new or updated. New airplane models include: Piper PA28-161 Warrior (PA28), Piper PA30 Twin Comanche (PA30), Piper PA31-350 Navajo Chieftain (PA31), Maule M-7-235C (M7235C), and Raytheon Beech 1900D (1900D). New helicopter models include the Eurocopter EC-130 (EC130), Robinson R-22 (R22), and MD600N (MD600). In addition, the new version included updated information for the following aircraft: Boeing 737-300 with CFM56-3B-1 engines (737300), Boeing 737-300 with CFM56-3B-2 engines (7373B2), Boeing 737-400 with CFM56-3C-1 engines (737400), Boeing 737-500 with CFM56-3B-1 engines (737500), Boeing 737-700 with CFM56-7B engines (737700), Boeing 747-400 with PW4056 engines (747400), Boeing 757-200 with PW2037 engines (757PW), Boeing 757-200 with RB211-535E4 engines (757RR), and Boeing 777-200 with GE90-90B engines (777200).

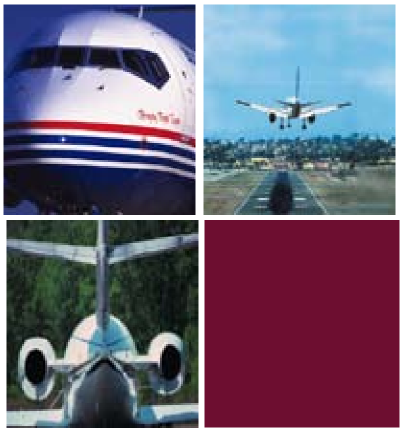
Statutory requirements for using the Integrated Noise Model are defined in FAA Order 1050.1E, Policies and Procedures for Considering Environmental Impacts, Order 5050.4A, the Airport Environmental Handbook, and "Airport Noise Compatibility Planning" of Federal Aviation Regulations (FAR) Part 150. The new model has many analytical uses, including assessing changes in noise impact resulting from new or extended runways or runway configurations, assessing new traffic demand and fleet mix, and evaluating other operational procedures.

Mitigating Sonic Boom

In April 2005, the FAA and NASA started the Sonic Boom Mitigation research project, through PARTNER, to understand sonic boom impacts. Pennsylvania State University and Purdue University are leading the project team. Research objectives are to assess applicability of existing noise metrics to sonic booms, determine annoyance associated with supersonic jets, assist in developing an acceptability metric, and provide guidance for supersonic jet design that minimize sonic boom impact. The team has surveyed existing sonic boom simulators, comparing their abilities to reproduce sonic boom sounds, and has begun to assess human opinions of the simulated sounds.

During this past year, the team compared three simulators. The team is using a mobile Gulfstream simulator, recently upgraded with a 24-bit system for reproducing low booms. Comparisons of the Gulfstream with NASA Langley and Lockheed Martin simulators and real booms were conducted at NASA Langley Research Center, Hampton, Virginia; Lockheed Martin Aeronautics, Palmdale, California; and NASA Dryden Flight Research Center, Edwards, California. The researchers found the three simulators compared well, and all can be used for subjective testing.

The researchers are also incorporating atmospheric turbulence in models for propagation from the aircraft to the ground. Data is recorded using a glider, and ground waveforms taken from the shaped sonic boom demonstrator field measurements. The team is analyzing documentation for atmospheric turbulence derived from a January 2004 Shaped Sonic Boom Experiment conducted to determine if a shaped sonic boom can persist to the ground through a realistic atmosphere. These data would



provide a better understanding of generation, propagation, and impact of a shaped sonic boom. Another collection of data for atmospheric turbulence was taken this past June at Edwards Air Force Base, California. The project's industrial partners will collaborate in a detailed analysis of the waveforms collected in these studies to create waveforms of a shaped boom design that have been propagated through realistic atmospheric effects. This will help designers consider realistic sonic boom impact in their work.

Working Toward Noise Certification Advancement

The FAA's Transport Airplane Directorate, in conjunction with the Office of Environment and Energy and the U.S. Department of Transportation Volpe Transportation System Center, conducted a three-day Noise Certification Workshop in Cambridge, Massachusetts, from August 29-31, 2006. The workshop provided updates of Aircraft Noise Certification regulatory processes and technical procedures. This is recurrent training for the noise certification focal points in each Aircraft Certification Office and for the assigned Noise Certification specialists. International certification authorities representing the European Aviation Safety Agency also attended.

Arriving in a Continuous Descent (CDA) Procedure

A PARTNER research team, led by representatives of the Georgia Institute of Technology – with collaborating FAA, NASA, and aviation industry members – is advancing the design, demonstration, and provisional use of Continuous Descent Arrival aircraft flight procedures within the national airspace system. A Continuous Descent approach provides advantages over current arrival patterns by reducing ground noise along much of the flight path, as well as saving time and fuel. The research team is currently developing operational procedures where environmental benefits can be effectively incorporated. They initially demonstrated the concept at Louisville International airport. There, a series of night-landing east-bound and parcel flights operated by UPS showed promising fuel and time savings, along with community noise and engine emission reductions. Given the positive environmental and performance findings, UPS has filed for approval with FAA to institute this procedure to capitalize on these CDA capability and benefits at Louisville International airport.

PARTNER researchers are also classifying the technical criteria to match moderate to higher traffic conditions at airports with the most efficient CDA implementation.

This ongoing assessment is looking at the major 35 U.S. airports recognized in the Operational Evolution Partnership plan and known as the "OEP airports." Identifying optimal candidate airports that could best adapt CDA procedures to reduce noise and emission as well as decrease fuel use will help us optimize our investments. Demonstrations applying CDA procedures to more extensive traffic conditions are planned for

Atlanta Hartsfield airport and the Los Angeles airport, the latter under the direction of the FAA Southern California Redesign development team. A technical challenge in the Atlanta project is adapting CDA for the significant use of downwind-based and final-leg traffic patterns. For the Los Angeles project, a better optimized, more comprehensive aircraft separation rule was developed to accommodate the broader mix of fleet traffic types.

Finding Alternative Fuels for Aviation

Soaring oil prices, energy supply security concerns, and the environmental impacts of aviation are motivating examination of alternative aviation fuels. The rise in fuel prices in the last year caused intense concern in the aviation industry. Fuel price volatility has strained the airlines, and, with oil more than $60 per barrel, some are concerned that jet fuel prices may escalate further.

In the fall 2005, the FAA Research and Engineering Development Advisory Committee advised the Agency to explore alternative fuels, and the FAA contracted with the RAND Corporation and the PARTNER Center of Excellence to look into the matter. The FAA also held two workshops with industry, government, and potential international collaborators to develop a national alternative aviation fuels roadmap. Participants explored the potential of using alternative fuels to ensure fuel supply, to improve operations, and to explore the potential to reduce environmental impacts.

Jet fuel kerosene is well suited to aviation because of its high energy density and thermal properties that allow it to remain liquid at high altitudes where temperatures are extremely low. The specific requirements of aviation, however, mean that substituting alternative fuels for kerosene must be done prudently. Given current airframes and engines, synthetic fuels converted from coal, gas, and biomass are promising replacements for kerosene. Some of these alternatives are in limited use today. Bio-fuels and hydrogen may provide long-term options, and will also be explored.

The aviation industry may be able to use alternative fuels to address certain local air quality issues, a problem near many urban airports likely to get worse as traffic increases. Synthetic fuels may have lower sulfur, particulate matter, and may enable design changes that reduce NOx emissions.

Lessons from the 1980s suggest caution. Researchers realize that much of the interest in alternative fuels is driven by the current high price of oil. Despite this, the potential for additional secure fuel supply and environmental benefit is justified. As the FAA seeks balanced and robust strategies to mitigate aviation's environmental impact while enabling future growth, alternative fuels may offer significant opportunities.

Understanding Aviation's Effects on Climate Change

From June 7-9, 2006, the interagency Next Generation Air Transportation System/Joint Planning and Development Office (JPDO) Environmental Integrated Product Team and PARTNER convened the "Workshop on the Impacts of Aviation on Climate Change," in Cambridge, MA. At the workshop, international experts explored aviation's impact on climate.

Attendees assessed and documented the current state of knowledge of climatic impacts of aviation, identified key underlying uncertainties and gaps in scientific knowledge, identified ongoing and further research needed to prioritize new funding to take advantage of on-going research programs, explored the development of metrics for aviation climate-related tradeoff issues, and helped to focus the scientific community on aviation-climate change research needs.

PARTNER has released a report and executive summary of the workshop findings and recommendations. Key findings are detailed in the areas of emissions in the upper troposphere and lower stratosphere and resulting chemistry effects. The findings also cover contrails and cirrus, climate impacts and climate metrics, and studies for tradeoffs among aviation emissions impacting climate. Attendees recommended coordinating the ongoing atmospheric and climate research activities funded by various federal research agencies to address the key research needs that are identified in the report. This coordination might entail expansion of existing research programs or even add a new focused research program. According to Dr. Mohan Gupta, the FAA host of the workshop, this report will serve as a cornerstone document to garner federal research support for such an initiative. The report and summary may be downloaded from the PARTNER Web site at http://www.partner.aero/.

Another PARTNER report, Aviation and the Environment - Report to the United States Congress, 2004, (also available for download) suggests that the effects of aircraft emissions on the earth's climate may be the most serious long-term environmental issue facing the aviation industry. There are large uncertainties in our current understanding of the magnitude of aviation-related climate impact. Extensive growth in the demands upon aviation is expected over the next few decades. It is imperative that timely action be taken to understand and quantify the potential impacts of aviation emissions so policymakers may realistically address climate and other potential aviation environmental impacts.
To ensure they understand tradeoffs when implementing engine and fuel technological advances, new airspace operational management practices, and policy actions imposed by national and international bodies, policymakers must be provided with metrics that correctly capture aviation emission climate impacts. The workshop was one of a number of PARTNER and FAA activities addressing these issues.

Managing Airport Land Use

A PARTNER research team, led by Purdue and Florida International universities, examined how community land use, on and adjacent to airports, can cause or reduce noise concerns and complaints. Researchers conducting this three-year project studied development around Denver, Fort Lauderdale, and Orlando-Sanford international airports. The team worked with airport administrators, civic leaders, and aviation organizations to collect data on the most prominent land use issues. Researchers used census and image analyses between 1970 to 2000 to evaluate demographic trends and socioeconomic factors in areas adjacent to the airports. In early FY 2007, the team will present a final report of its findings and recommendations to inform future policy. As the findings are expected to substantially impact important public policies and private sector decisions of high public interest, the Office of Management and Budget designated this research as "influential."

The study's findings have generated new research questions. Purdue University is undertaking a follow-on study to explore these issues in depth. Research scope will expand to include three non-hub airports, thus representing a different sector of the industry. In addition, the Transportation Research Board's Airport Cooperative Research Project is funding a project to develop means of protecting airports from incompatible land uses that impair airport and aircraft operations and safety, and constrain airport development. The FAA issued a call for proposals in May and selected the grant awardees in August. The project will begin in FY 2007.

Human Factors

"Our mission is to generate and apply new knowledge about human capabilities for effective performance."

Terry Allard, Ph.D.
Human Factors Research and Engineering Program Director
Air Traffic Organization Operations Planning

Developing a Handbook for Technically Advanced Aircraft

The FAA provides students, pilots, flight instructors, and pilot evaluators a technical handbook for almost any topic important to aeronautical proficiency. The Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25) is an example of such a publication and serves as the official source for knowledge and skills defining aeronautical proficiency. Handbooks are used as learning and teaching resources, but they also help to evaluate applicants for FAA certificates and ratings.

With the advent of technically advanced general aviation aircraft, pilots, instructors and evaluators must master a wide variety of new concepts and skills. During FY 2006, FAA researchers provided technical input to a draft handbook describing the knowledge and skills important for those who operate, teach, and test in technically advanced aircraft. The handbook was reviewed by industry stakeholders such as manufacturers, pilot organizations, and training schools. Accompanied by 108 color illustrations, the handbook covers technical aspects of using advanced cockpit systems and the human factors implications of those systems. Throughout the publication, human factors principles are introduced by a series of sidebars, each of which highlights a single human factors issue in the context of a typical flying scenario. All of the human factors principles are based on findings drawn from FAA- and NASA-funded research on pilot-system interaction done over the past 20 years.

Certifying Electronic Flight Bags

Human factors researchers are developing aircraft certification, operational approval, and training guidance to mitigate risks associated with integrating electronic flight bags (EFBs) on the flight deck. The main goal of this work is to identify, understand, and help the FAA address human factors issues related to EFB technology.

Current research focuses on standardizing and streamlining FAA evaluations through the development of practical EFB assessment tools. In FY 2006, researchers published a report of existing EFB tools to help users select, customize, and incorporate the most appropriate of these resources into emerging EFB technology at relatively low incremental cost.

The researchers continued to support the development of the draft EFB certification standards. Researchers incorporated industry comments into a December 2005 revision which, after review, they published online. The team disseminated information about the tools and the EFB project to a wide audience through talks and a conference paper. The researchers made several presentations to FAA management and field staff, as well as at industry meetings and international conferences. They also incorporated human factors considerations into a working paper on EFB guidance for the International Civil Aviation Organization.

Studying the Effects of Electronic Flight Bag Technology on Crew Performance

The transition from paper to electronic flight operating documents has substantially changed crew procedures. As a result, the FAA is examining a need to develop new procedures and training that redirect and enhance crew performance. Certification and operational approvals currently ensure that human factors considerations are designed into EFB technologies. Ultimately, however, the effective implementation of these systems will require the accurate measurement of crew performance.

The FAA and NASA researchers have partnered with FedEx and United Airlines to evaluate how EFBs affect flight deck performance in full flight simulation. They are comparing pilot performance in crews working with paper documents to crews working with the EFB. To date, the team has recommended the use of an improved in-flight cross-check of the flight management system, the resolution of certain abnormal in-flight situations, and the enhancement of situational awareness during taxi and runway navigation. The results of this study are also being used to develop better training for instructors and evaluators on pilot use of EFB systems.

Implementing an Aviation Safety Action Program (ASAP) for Aircraft Maintenance Organizations

An Aviation Safety Action Program (ASAP) identifies and corrects adverse safety events that are otherwise not likely to come to the attention of the FAA or industry management. Prior to this research, 28 air carriers had flight ASAP programs and only six organizations had maintenance ASAP programs. By September 2006, in part, as a result of this research, 27 airlines had maintenance ASAP programs.

The investigation process for a typical maintenance ASAP program (or "case") is best represented by a network whose central component, the Event Review Committee, works with various other organizational units to validate the program's original ASAP report. ASAP cases are usually rich in qualitative data, such as photographs, copies of logbook pages, and actual aircraft parts. A virtual walkthrough of 50 ASAP cases across ten organizations revealed variation in the data classification schemes used by various operators. Despite the differences, however, most operators use a customized version of Boeing's Maintenance Error Decision Aid to classify causal data.

In most cases, the researchers discovered ASAP networks classify corrective actions at a procedural or task level, an organizational level, and a policy level. Together with team partners from industry, the researchers developed a data classification scheme and a generic ASAP reporting form. This form is expected to facilitate mapping of ASAP data across multiple programs, both within the same company and across multiple companies.

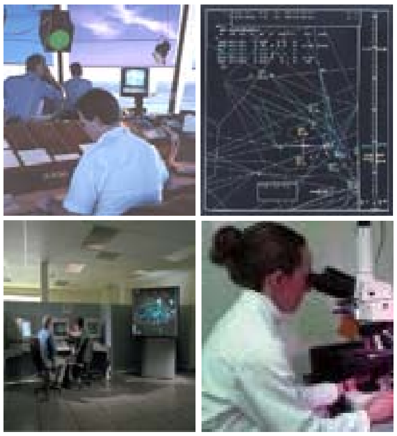
The researchers are completing field visits to partner companies to collect detailed ASAP case data. They are using the case data to determine: (a) the data collection tools used by each organization; (b) the data classification scheme used to classify ASAP case data; (c) the data classification scheme used to classify corrective action data; and, (d) best practices for disseminating the lessons learned or success stories resulting from the ASAP reports. In addition, the research team is developing an industry-level data classification scheme for maintenance data and surveying the status of maintenance ASAP programs.

Enhancing the Aircraft Certification Job Aid

Before the FAA can certify an aircraft for use in the national airspace system, human factors experts in the Agency must judge flight deck designs safe for use by current and future pilots. These judgments are not always easy to make, nor are they trivial. Experience has shown that design-induced human performance errors have contributed to many aviation incidents and accidents.

The FAA Aircraft Certification Job Aid is a computerized decision-support tool designed to help aircraft certification personnel ensure aircraft flight deck technologies are user friendly. This PC-based software has three major databases that address regulatory information, flight deck components, and human factors considerations. The Job Aid has been used by FAA certification team members for several years, and the content and functionality are updated annually.

In 2006, researchers continued development of the software-based decision-support tool and supported the deployment, instal-



lation, evaluation, and training on use of the tool within the FAA. They placed summaries of the Part 25 Transport Category Aircraft Advisory Circulars, Technical Standard Orders, and non-regulatory human factors research information related to design of flight deck equipment, tasks, procedures, and testing assumptions in the new Job Aid Version 7.0. Additionally, the FAA recently highlighted the Job Aid in a video-based training course and, as a result, the Agency has noted increased commercial interest in its use.

Improving Pilot Performance in Operating Automated Aircraft

Training pilots to safely and efficiently operate automated flight deck systems remains a challenge for regional as well as the major airlines. Collaborative FAA research is underway at the University of Central Florida, George Mason University, and Research Integrations, Inc. to provide airlines and FAA oversight offices improved training methods to address current flight deck automation problems and potential safety vulnerabilities. During 2006, researchers investigated various components of pilot performance related to automated systems. They evaluated pilot knowledge and understanding of system operation to determine the types of knowledge that facilitate a pilot's understanding of, and the subsequent performance of, flight deck automation. Information they collected provided the framework for design guidelines for training programs to improve human-automation interaction. These guidelines have been presented to industry for review. The researchers also examined current flight deck automation-related procedures to determine their effectiveness. They used the results of this work to design improved procedures, which regional airline pilots are now testing. In addition, they partnered with Boeing Aircraft to evaluate the impact of a proposed auto-flight panel on pilot performance. Researchers are currently gathering and analyzing industry safety data related to automation design, operational policies, flight crew procedures, and flight crew qualification and training. A report will be published in 2007.

Advancing Aviation Safety: Threats, Errors and their Management in Normal Operations

FAA-funded researchers at the University of Texas have developed the Line Operations Safety Audit (LOSA) methodology for monitoring and diagnosing normal airline flight operations. During a LOSA, a highly trained flight deck observer logs all threats and errors encountered by the flight crew. The observer notes how the crew detected the error, the crew's response, and the resulting outcome. Data collected include phase of flight narratives, threat and error management descriptions, threat and error coding, behavioral marker ratings, and pilot interviews. This information is then presented to airline management, providing a realistic view of their flight operations. Data is also archived for future analyses at the University of Texas. Several thousand line observations across 25 airlines are currently stored in the LOSA archive. Additionally, the LOSA methodology provides for a common framework across different airline safety departments and can be used for analyzing ground operations and pilot self report safety data.

FAA researchers continue to develop and promote the use of a threat and error management framework, including LOSAs, throughout the aviation industry. These are considered essential components of an effective proactive safety management system, and their use is encouraged by the Agency through the release of educational information. The FAA published an advisory circular on LOSA (AC 120-90) in 2006. Researchers presented the methodology to airline conferences, and conducted a formal workshop on threat and error management and LOSA at the FAA Shared Vision of Aviation Safety Conference in April 2006. Six hundred airline representatives attended this meeting. The research team is partnering with Boeing and Airbus to use LOSA data to study aircraft design, training, and procedural issues.

Designing the Future Air Traffic Control Workstation

The FAA Air Traffic Organization will face significant challenges in future years as the demand for air traffic services increases not only at the major metropolitan airports, but also at satellite and outlying airports that are convenient to concentrations of population and business. The mix of aircraft and the variable traffic patterns in the future may increase national aviation system complexity. Researchers are analyzing how tasks are performed today and how proposed changes to controller interface and introduction of automated functions might affect the use of controller resources. In FY 2006, the research team investigated the ability of controllers to perform air traffic control functions at 100, 133, and 166 percent of the 2004 traffic load.

The results of this work identifies limitations in applying the current mode to future higher demand levels. Research indicates that the current workstation in the en route domain will not support the processing of air traffic at the 133 percent level. The main barrier to achieving that level of traffic is the verbal communication workload of the controller. Increasing the use of data link together with an improved workstation design offers promise to alleviate a significant portion of this workload. But, this relief will handle only the anticipated 133 percent traffic level, not the future 166 percent level.

Future research plans include the search for other technologies and procedures that can reduce the communications and cognitive workload, both for the near-term and into the future, to provide the next increment in capacity. Research will determine limitations in the current concept of one controller providing service to individual aircraft as discrete units, and it will also determine the utility of grouping aircraft in a stream to increase controller productivity.

Testing Two Prototype Electronic Flight Data Interfaces

Electronic Flight Data Interfaces (EFDI) provide the potential for controllers to acquire, record, and track flight data more efficiently. EFDIs may also improve communication and information sharing with other controllers and enhance controller decision making. Efforts are underway to determine what it takes for a new user to learn the basics of the system, how the learner's level of performance may be assessed and enhanced, and how the trained user's performance may improve over time.

Combining electronic flight data with the airport surface detection equipment, researchers designed two EFDIs for use by local and ground controllers in airport traffic control towers. An airport surface map served as a perceptual-spatial anchor for the information. Both EFDIs provided a potential means to support the virtual tower concept. Researchers completed a simulation with four air traffic control tower supervisors to make an initial determination of the EFDI usability. Participants spent 1.5 hours learning to use each EFDI, and then monitored two thirty-minute airport traffic scenarios, one at the local controller position and one at the ground controller position. In both instances, the supervisors had responsibility for all flight data management. The research team observed usability

problems, counted the number of actions performed, and calculated error rates for each action. The participants provided feedback on questionnaires and during interviews.

Overall, the participants rated the EFDIs favorably. For the Integrated EFDI, the error rate was 16 percent during practice and 12 percent during the test. For the Perceptual-Spatial EFDI, the error rate was 7 percent during practice and 8 percent during the test. For both EFDIs, researchers identified several actions that made the largest contribution to the overall error rate. Afterwards, they redesigned those actions to decrease error rates. While the participants learned the EFDI functionality very quickly, longer training times are needed for users to become accustomed to the touch-sensitive interface hardware. The research team has submitted the EFDI designs for FAA consideration of a provisional patent application.

Developing Color Vision Tests for Air Traffic Control Specialist Applicants

People who have trouble distinguishing between colors are said to have a color-vision deficiency. Because of the increase in use of color in air traffic control displays, the FAA has undertaken research to update the 1980s-vintage color vision screening process it requires of those who apply to air traffic control specialists (ATCS).
The existing practical (job-related) color vision tests were based on air traffic control (ATC) criteria for routine tasks performed two decades ago. At that time, the primary color-related tasks of controllers involved identifying red and black text on paper flight progress strips, and red, green, and white signal lights used at airports. During the past decade, however, there has been a significant increase in the use of color in computer displays. Moreover, paper strips are being replaced as the User Request Evaluation Tool is introduced in en route facilities. One study indicated that the extent of color use in current facilities has moved far beyond that used in the current job-related color vision tests. Hence, it is necessary to re-examine color vision standards and develop new job-related tests adequate for today's air traffic control tasks.

Researchers developed a set of computational algorithms to compare the ATC task performance of individuals who have color vision deficiencies with that of personnel who have normal color vision. They identified a number of circumstances involving existing air traffic control displays where color use could be a potential problem for color-deficient controllers. The computational algorithms also factored the availability of redundant cues into the demands of color-related ATC tasks.

The results indicated that in 43 percent of occasions where redundant cues were available, they did not effectively draw users' attention. Thirteen percent of the color applications used to identify information categories did not have redundant cues, and the redundant cues for 34 percent of the color application proved ineffective in helping users identify information of a given category. Thirty-five percent of the color application used in text resulted in text readability lower than the threshold for error-free reading. Also, nine percent of the tasks offered no redundant cues at all. The research team concluded that having redundant cues is a necessary, but not sufficient, solution for ensuring task performance by color vision deficient operators.

Compiling Best Practices for Improved Air Traffic Safety

Operations supervisors are a key component to a safe and efficient air traffic system. These supervisors regularly provide leadership and oversight that positively influences the controllers' ability to manage air traffic safely and effectively. The FAA believes that there is a relationship between the use of operations supervisor best practices and the prevention of operational errors. In FY 2006, FAA-funded researchers studied the roles, responsibilities, resources, and tasks of these supervisors to identify the best practices related to prevention of operational errors.

The research team used a human performance analysis model in a front-end analysis that considered supervisor accomplishments in combination with instances of exemplary performance. At six Air Route Traffic Control Centers, the team interviewed and observed operations supervisors that facility managers perceived as being exemplary performers. They identified the major accomplishments and key tasks of the subject supervisors and documented the critical performance details for these tasks. In addition, they identified the barriers that prevented and facilitators that helped the supervisors achieve exemplary performance in each task.

The researchers organized their findings and recommendations into four categories:

- Selection and Assignment – Ensuring safety through the selection of appropriate staff and placing them in the best position for success;
- Skills and Knowledge – Training programs that equip supervisors with an ability to achieve safety objectives;
- Motivation and Incentives – Mechanisms that positively influence exemplary supervisor performance; and,
- Environmental – The policies, procedures, tools, and organizational climate that facilitate a supervisor in achieving safety objectives.

The research team developed and distributed to the participating Centers for feedback an operations supervisor Quick Reference Guide for managing controller performance. The team also completed a technical report detailing their analysis, findings, and recommendations.

Examining Human Error in General Aviation Accidents

The Human Factors Analysis and Classification System (HFACS) is a theoretically based tool for investigating and analyzing human error associated with accidents. Previous research has shown that HFACS can be reliably used to identify general trends in the human factors associated with commercial and general aviation accidents. In FY 2006, human factors researchers began a study to examine aircrew error in general aviation accidents that involved Visual Flight Rules (VFR) flight into Instrument Meteorological Conditions (IMC).

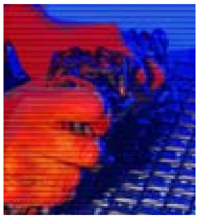
Researchers examined general aviation accident data from 1990-2004. The final dataset included 609 accidents where VFR into IMC was a factor, and 18,528 accidents labeled as the rest of general aviation. Researchers found that, similar to previous accident studies, the injury severity for VFR into IMC accidents graver than for the rest of general aviation and fatalities more prevalent in VFR into IMC (80 percent vs. 19 percent). More telling of the catastrophic nature of a VFR into IMC accident is the fact that for the 609 accidents there were a total of 954 fatalities. For the 18,525 rest of general aviation accidents there were 6,193 fatalities. Researchers also examined the human error causal factors that played a role within the accidents, both at the level of the unsafe acts of the operator as well as the conditions of the operator. Unsafe acts of the operator included: skill-based errors, decision errors, perceptual errors, and violations.

Study results point to the continuing need for pilots to be educated on the consequences of taking risks, the costs of overestimating their abilities in weather, and the importance of gaining a clear understanding of the weather within their flight path.

Information Technology

"Our goal is to provide IT policy to ensure effective information management, and security"

Dave Bowen
Chief Information Officer



Modeling Trust

FAA researchers are continuing to develop a new IT model that can assess multiple levels of trust in accordance with FAA and Department of Defense requirements. Until recently, only two types of trust assessment models were readily available: the binary models and the non-binary models. Binary models assign a trust value of either 0 (no trust) or 1 (complete trust). The non-binary models assign quantitative values in the range 0 to 1 or qualitative values like high, medium, or low. In either case, the values assigned tend to be subjective estimates. Both kinds of models have significant shortcomings that render them inadequate to guide short-turnaround decision-making processes that rely heavily on currently available information.

Neither model type specifies how trust values are to be determined, measured, compared, or revised over time. In contrast, the Vector Model of Trust now being developed at the FAA provides an objective decision support system, determines trust values, facilitates comparing trust values of two systems, negotiates and manages trust values, and computes the trust value of composed systems (given the trust values of the component subsystems). The model also provides a gap analysis tool to facilitate the development of more trustworthy systems.

The project has also refined the Trust QL language, completed a formal framework for expressing and reasoning about trust context and trust chains, verified and validated the model in different environments, developed security and privacy trust values in real-time, and completed a prototype of a user-friendly software application for this new model of trust.

Preventing Unintended Information Revelation

Documents generated by different individuals at different times can be combined to reveal information that is inconsistent with the overall goals and objectives of an organization and may inadvertently reveal sensitive information. A set of automated tools is needed, if not to reveal such links outright, at least to generate what IT specialists call plausible concept links or chains. The intersections of these “chains” then can be graphed to illustrate common links between the contents of what had seemed to be two unconnected documents. The specialists will sift through extensive collections of Agency documents first to find such chains and then to detect common scenarios that, by accessing or posting to these collections in their work and correspondence, might reveal sensitive information.

FAA funded researchers at the State University of New York at Buffalo have developed a prototype, using actual data, sets that can and automatically generate a semantic graph consisting of important concepts and associations. The prototype will permit users to discover concepts chains (including potentially hidden links) that span multiple documents.

Collaborating to Improve Information System Security

FAA and Air Force Research Laboratory specialists are collaborating on a project that will provide correlation and aggregation of Air Force Enterprise Defense (AFED) data with the FAA Computer Security Incident Response Center (SCIRC) database. AFED is a security management system that combines data from multiple types of sensors. Its aggregation capabilities allow analysts to view significantly reduced quantities of data from a single console. AFED components are configurable and flexible to allow them to be quickly modified to accept, aggregate, and display information from new data sources. Using AFED to correlate data resources at the FAA's central CSIRC site will optimize sensor signatures in the field and will reduce human workloads. The FAA goal is to reduce the number of alarm records by an order of magnitude.

This work is a follow on to an AFED/CSIRC proof-of-concept task funded by the FAA in Fiscal Year 2003. In this initial task, AFED analyzed recorded sensor data from SNORT, an open source network intrusion detection system. The results proved that AFED would be a valuable tool to apply in a real-time scenario to reduce instances of false alarms and lighten workloads for analysts.

Researchers have installed and tested AFED at the FAA William J. Hughes Technical Center. Current test results are encouraging researchers to update the installation to the latest version, which includes a more user friendly interface.

Preventing Cyber Attack

The FAA initiated the Adaptive Quarantine research project to ensure that the Agency is prepared to prevent and pre-empt active, passive, novel, insider, and outsider cyber security attacks against safety-critical and mission support networks and systems enterprise-wide. Researchers are working to develop an integrated solution that combines proactive behavior-based tools with reactive rules-based tools that cover the entire attack timeline and all layers of the protocol stack. This is the only such quarantine research project currently underway in the federal government, but because this technology relies on Commercial-Off-The-Shelf (COTS) products, it is transferable to other federal agencies.

Researchers plan a sequence of laboratory evaluations, proof of concept demonstrations, and field-testing in three-phase evaluation approach and will provide well-defined objective measures of success for each testing phase. Thus far, they have completed security test and evaluation of pattern recognition, anomaly detection, and behavior modeling proactive security appliances and submitted results and recommendations to the sponsoring Advanced Research and Development Agency. While these technologies offer novel approaches to intrusion prevention, they are still research prototypes. Usability, manageability, scalability, and product maturity issues remain to be resolved before they can be considered for use in the FAA environment.

Accelerating Deployment of Critical Technologies

FAA researchers continue to participate in the Federal Agency Administration of Science and Technology Education and Research (FASTER). A Community of Practice for federal officials involved with the administration of science and technology education and research programs, FASTER is organized under the Interagency National Science and Technology Council Subcommittee on Networking. This "community" was specifically created to support the use of advanced information technology systems. Participants collaborate to speed deployment of promising research technology, share information on protocols, standards, best practices, and coordinate technology assessments and testbed development.

Identifying New Biometric Technologies

The Center for Identification Technology Research (CITeR) is a National Science Foundation/ Industry/University Cooperative Research Center focusing on Biometric Identification Technologies. Applications of these technologies reveal vulnerabilities and perform socio-legal and business studies.

These technologies encompass, but are not limited to, working with multimodal systems, biometric modalities, biometric image coding and quality, performance frameworks, and system modeling. Participation allows the FAA to leverage R&D in the area of identification technologies that are funded by the National Science Foundation, industry and other federal government sponsors. FAA representatives met with CITeR members twice during the fiscal year to finalize and approve new projects and to receive updates on the status of the ongoing research of the Center.

Assessing Network Vulnerabilities

The FAA is working with the Air Force Research Laboratory and George Mason to develop an automated system to identify and mitigate potential attack paths to mission critical resources. Called Combinatorial Analysis Utilizing Logical Dependencies Residing on Networks (CAULDRON), this system will assess network vulnerabilities and then project the types of attacks that could occur because of them – down to the level of naming specific attack paths and specific mission-critical resources. The use of this application will speed detection and resolution of security events and will increase productivity levels of security personnel by:

- Providing context for total network security,
- Analyzing network modifications,
- Displaying prioritized lists of potential security incidents,
- Addressing insider and outsider threats, and
- Reporting only those vulnerabilities associated with possible attack paths.

FAA researchers are working with MITRE to provide network scans and complete an evaluation of CAULDRON. MITRE has made several recommendations on the user interface improvements, intrusion detection system integration, and network scan correlation mapping. This project will continue through Fiscal Year 2007 with enhancements to support recommendations and assessment.

Costing Secure Software Systems

FAA researchers are working with colleagues at the University of Southern California to add new information security extensions to the Constructive Cost Estimation Model (COCOMO) developed at that institution. The COCOMO II model will help to estimate the cost, effort, and schedule involved in planning a new software development activity. Determining these details has always been particularly difficult for the developers of emerging software–intensive systems that require a significant degree of security. A small number of pilot security projects are underway to assess the benefits of applying COCOMO II security extensions to refine traditional "rule of thumb" cost estimates of security cost–drivers.

Developing a Business Capability Model

Researchers are developing a view of the FAA to help its executives develop new investment priorities for portfolio management based on the analysis of competencies, assets, and resources that cut across organizational boundaries. In FY 2006, researchers completed a prototype capability model for FAA regulatory and administrative processes. The model will be used in strategic planning and portfolio management.

Assuring Real-Time Operating Systems (ARTOS)

The FAA participates in a National Coordination Office for Networking and Information Technology Research and Development program to define federal research goals in the area of certifiable systems. The program facilitates industry/government collaboration to define needs in the areas of aviation safety, medical devices, and power distribution networks. FAA researchers have participated in workshops in all three of these areas and, in the coming fiscal year, they will help to draft a "roadmap" needed for the federal government to meet its research needs in safe and secure systems. The results of this effort will help the National Science Foundation determine which projects to fund.

Creating Service Oriented Architectures

To be properly called "service oriented," a design philosophy must view individual applications as part of a collaborated approach to providing basic core services. A Service Oriented Architecture (SOA) is an ensemble of such services. Like many Fortune 500 companies, the FAA plans to migrate to a SOA to achieve platform-independent connectivity for a number of web services. In FY 2005-2006, the FAA held three Web Service workshops to get industry input and determine needs within the aviation community.

During FY 2007, planners will continue to focus on determining needed services and developing a responsive, enterprise-wide data exchange.

Moving Toward Internet Protocol version 6 (IPv6)

The FAA is committed to meet the OMB Guidance for the IPv6 backbone transition by June 30, 2008. During the past fiscal year, the FAA continued the planning and coordination necessary to transition the FAA's Backbone Infrastructure to an IPv6 compatible configuration and to ensure that the Agency's networks interface with this infrastructure. FAA planners also integrated IPv6 objectives into the Agency's Information Resources Management strategic plan and modified its Acquisition Management System policy to include language requiring IPv6 compatibility in future networking procurements.
In addition, the FAA IPv6 Steering Committee developed an IPv6 Transition Plan that includes an IPv6 transition strategy, impact analysis, and asset inventory. The Steering Committee is currently working to:

- Define the IPv6 address allocation/management process,
- Define security strategy for IPv6 Internet Access Points,
- Establish IPv6 test beds at major centers,
- Test IPv6 hardware/software products,
- Develop configuration guidelines,
- Demonstrate 4 to 6 tunneling between IPv6 "clouds," and
- Develop detail transition plan and schedule thru June 2008.

Research, Engineering and Development Advisory Committee (REDAC)

"We advise the Administrator on R&D matters and activities, and coordinate research and development efforts with industry and other government agencies"

Barry Scott, acting Director,
FAA Air Traffic Organization
Office of Operations Planning Research & Development
and REDAC Executive Director

Research, Engineering and Development Advisory Committee (REDAC)

FAA's Research, Engineering and Development Advisory Committee, established in 1989, advises the Administrator on research and development issues and coordinates the FAA's research, engineering and development activities with industry and other government agencies. The committee considers aviation research needs in air traffic services, airport technology, aircraft safety, human factors, and environment and energy.

Supporting Controller Workforce Transition

Over the next ten years, the FAA projects that a significant portion of the controller workforce will retire. Anticipating the need to fill many vacated positions, FAA Administrator Marion Blakey asked the REDAC Human Factors Subcommittee, chaired by San Jose State University Professor Kevin Corker, Ph.D., to assess and provide recommendations related to the skills, training, and needs of the next generation of controllers. Many FAA employees supported the Subcommittee activity by providing briefings and materials regarding recruitment, selection, screening, training at the FAA Mike Monroney Aeronautical Center Academy, and on the job training in the field. Additionally, some Subcommittee members visited the Academy's training facility as well as several field facilities. The discussions with the subject matter experts, managers, and controllers, as well as the visit to the Academy to see the training laboratories and simulators proved instrumental in providing the Subcommittee critical information on which to base their recommendations.

In a letter outlining their work, the Subcommittee members recommended improvements in seven areas: leadership; training processes; controller performance measures and training effectiveness; use of simulation; standardization of procedures; Collegiate Training Initiative school alignment; and the use of team training. In response to recognized needs and capitalizing on the Subcommittee recommendations, the FAA developed the "Controller Workforce Integrated Action Plan" to address controller workforce transition. In addition to the REDAC recommendations, the plan integrates inputs from the "Plan for the Future: the Federal Aviation Administration's 10-Year Strategy for the Air Traffic Control Workforce," with others drawn from MITRE and the Office of the Inspector General.

Transitioning ATM Research to Operations

The FAA also recently embraced many of the REDAC Air Traffic Services Subcommittee Transition Working Group recommendations. In its twelve month study, this working group, led by Ray LaFrey, identified and analyzed barriers to transitioning technology from research to operations.

Group members gathered information from relevant literature and over thirty briefings from industry, academia, government, national research centers, and aviation organizations. The Working Group subsequently developed a set of findings and recommendations that it presented to the FAA Administrator.

In her response to the REDAC, the Administrator agreed to a number of recommendations that would facilitate technology transition. The Administrator has created a Development Liaison Team to provide recommendations to the Vice President of Operations Planning on research technologies that should be pursued. The FAA is also working closely with industry to evolve toward a performance-based national airspace system concept that will allow operators to leverage existing aircraft equipage capabilities, while showing increased performance value as aircraft equipage capabilities are increased. In addition, the FAA is already working to establish guidelines for transitioning knowledge and data to industry. The Agency continually uses best practices from government and industry to improve its policies and guidance. New guidance is incorporated in the FAA's Acquisition Management System. The working group's full report can be found online at http://research.faa.gov/redac/reports/reports.aspx.

Financing the Next Generation Air Transportation System (NGATS)

To help the FAA determine financing options for the Next Generation Air Transportation System, a REDAC working group, chaired by Jerry Thompson of Jerry Thompson Associates, identified the level of resources required as well as available options for funding and financing research and development, capital projects, and the operations cost of NGATS. The effort focused on the FY 2006 - 2025 timeframe. The working group compared a reference status quo scenario to a NGATS scenario. For each scenario, they identified the best, worst, and baseline cases to determine a range of operating costs. Group members also considered opportunities to reduce costs through introduction of advanced technologies and techniques or outsourcing, but did not consider issues such as labor contracts, privatization, or major structural changes in the FAA organization. FAA Administrator Marion Blakey and Dr. John Hansman (REDAC, Chair) used this data to discuss NGATS funding with Congress.

Reducing Separation Standards

The REDAC's National Airspace System Operations Subcommittee established a Separation Standards Working Group, led by Sarah Dalton from Alaska Airlines, to examine what types of R&D activities would facilitate a reduction in separation standards without jeopardizing safety. The working group first examined the basis for current separation standards and reviewed past and ongoing studies of separation requirements. The members then considered improved methodologies for establishing separation standards, as well as changes that new technology may bring. The process resulted in recommendations that include the need to:

- Establish data needs early in NGATS development so all data collection opportunities are used,
- Develop consistent approaches for development of standards,
- Conduct research on human and automation roles in failure response and impact on required separation standards,
- Re-examine parallel and converging approaches, arrival/departure, and separation standards based on appropriate probability distribution using RNP-based navigation

The report is being transmitted to the Administrator, who will review the recommendations and provide a response.

Federal Aviation Administration
Operations Planning Research
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