Federal Aviation Administration's

R&D Review

special issue

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A Message from the Manager of FAA's Airport Technology R&D Program

Research Makes a Difference

This special issue of *R&D Review* focuses on the FAA's airport technology researchers and the work they are doing to ensure this nation's airports can accommodate projected air traffic growth safely and efficiently.

Air traffic is expected to reach 1 billion passengers by 2015. Since many of today's busiest airports cannot meet today's peek arrival and departure demands, future traffic increases will only exacerbate this situation. In many cases, construction of new runways will be feasible and helpful, but this approach alone is unlikely to resolve all future challenges. Expanded runway capacity must be accompanied by improvements in areas such as design standards, management strategies, decision support aids, and procedures that will allow greater capacity.

The airport technology R&D program is providing technology and procedural solutions that are helping this nation's airports accommodate traffic growth, while, at the same time, maintaining a safe operational environment. Our research focuses on airport pavement design and modeling, pavement materials, airfield design, rescue and firefighting, visual guidance, wildlife hazard mitigation, and runway surface technologies.

Our small research staff has made some incredible technological advances in the past decade. In partnership with industry we developed an engineered material arresting system that safely stops an aircraft that overruns an airport runway. We also conducted research leading to a new firefighting vehicle with an elevated boom that can penetrate an aircraft fuselage to spread water or firefighting chemicals inside an aircraft allowing more time for passengers and crew to escape. We are also setting international standards for airport pavement design and construction.

As you will read in this issue of *R&D Review*, we are working to meet tomorrow's challenges by continuously improving this nation's airport system. Our research and development efforts support new standards, criteria, and guidelines that the FAA and airport operators are using to plan, design, construct, operate, and maintain the over 5,300 public use airports, heliports, and vertiports in the United States.

I hope you enjoy learning more about this critical research program. If you would like additional information on our program, I invite you to visit our website at http://www.airporttech.tc.faa.gov/.

— Satish Agrawal, Ph.D.

Inside this Issue:

Critical Research for Aviation's Future

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For the Public Good

National Pavement Test Facility

National Airport Pavement Test Facility

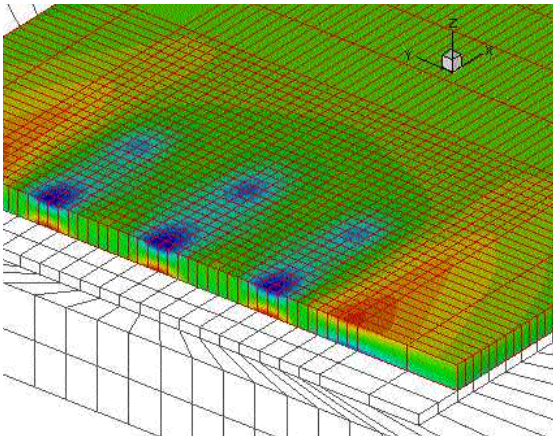
There are approximately 650 million square yards of runaway pavement surface in the United States with an estimated replacement value of over $100 billion. The Federal Government and the aviation community spend approximately $4 billion annually in replacing, repaving, rehabilitating, repairing, and maintaining these pavement surfaces.

The safe and efficient movement of aircraft is critical to an airport's successful operation. But, it is also important to ensure the cost effectiveness of aircraft runways, taxiways, and aprons, since they represent a large part of an airport's budget. Airports must plan for construction of new pavements, refurbishment and/or upgrade of existing pavements, as well as ongoing pavement maintenance activities. That is why durable, long-life pavements are critical to controlling the costs of operating the national aviation system.

The FAA funds airport pavement projects through airport improvement program grants. Through this program, the FAA provides grants to public agencies - and in some cases, to private owners and entities - for the planning and development of public-use airports. Eligible projects include those improvements related to enhancing airport safety, capacity, security, and environmental concerns, for example, runway construction and rehabilitation projects. Funds for the airport improvement program come from the Airport and Airway Trust Fund, which is supported by user fees, fuel taxes, and other similar revenue sources.

"Because the FAA wants to ensure that federal funds are being judiciously employed and that public investment in infrastructure is prudently managed," explains Dr. Gordon Hayhoe, manager of the FAA's National Airport Pavement Test Facility, "it has created a pavement technology research and development program that is working with industry to develop economical and durable pavements. This successful research program is expected to reduce the government's airport pavement expenditures by 10 percent by the year 2010."

Construction of new pavements can be a huge investment. The design and construction of economical and durable pavement requires an understanding of a variety of factors in



Color fringes of stress in a concrete slab loaded by 6-wheel aircraft gear

determining the type and optimum thickness of pavement layers. A critical means of understanding the behavior of pavement layers is through full-scale testing. Such testing involves the controlled application of simulated aircraft gears at realistic tire loads to a full-scale layered, structural pavement system. The purpose is to determine pavement response and performance under a controlled, accelerated, accumulation of damage in a compressed time period.

In April 1999, the FAA completed construction of the world's largest, enclosed full-scale pavement test facility dedicated solely to airport pavement research at the William J. Hughes Technical Center near Atlantic City, New Jersey. Built under a cooperative research and development agreement with Boeing, the facility provides high quality, accelerated test data from rigid and flexible pavements subjected to simulated aircraft traffic. Major features of the facility include:

- Fully enclosed instrumented test track 900 feet long by 60 feet wide.
- Computerized data acquisition system.
- Rail-based test vehicle capable of simulating aircraft weighing up to 1.3 million pounds.
- Twelve test wheels capable of being configured to represent two complete landing gear trucks having two to six wheels per truck.
- Wheel loads independently adjustable up to 75,000 pounds per wheel.
- Controlled aircraft wander simulation.

Researchers can accelerate damage by modifying loading conditions - increased loads and/or increased repetitions, imposed climatic conditions (e.g. temperature and/or moisture), the use of thinner pavements with a decreased structural capacity and thus shorter design lives or, a combination of these factors.

The test track can be divided into up to nine independent test items on three subgrade classifications low, medium, and high strength. Test items are trafficked to failure and then reconstructed. In this way, a variety of pavement structures can be tested, including both rigid and flexible designs incorporating unbound aggregate and stabilized bases.

Researchers assess damage by measuring the amount of rutting, cracking, roughness, and deflection at the surface and by multi-depth deflectometers, strain, and pressure gauges below the surface. Over 1,000 static and dynamic sensors are embedded in the test items to collect data. Static sensors monitor temperature, moisture, and crack status (resistance) on an hourly basis. Dynamic sensors measure quantities, such as strain and pavement deflection in response to the load, and are triggered by the vehicle operations. Sensor data collected during traffic test operations are processed and stored in a computer database maintained on-site. This database facilitates retrieval of the data for analysis.

The original installation consisted of nine "test items" or independent pavement test sections (six flexible, or asphalt, test items, and three rigid, or concrete test items). Each test item involved a different combination of pavement construction and subgrade strength, to give a range of the conditions that might be encountered in actual practice.

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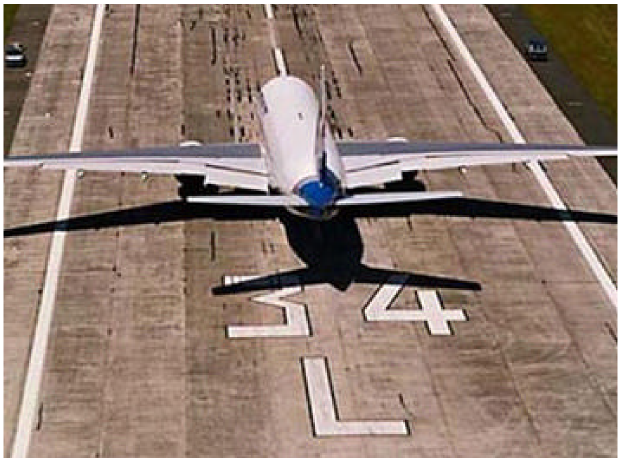
Test item trafficked to failure

Protecting a Critical Resource

Airport Pavement Design and Modeling Research



Boeing 777 landing

In 1927, the Ford Motor Company built one of the world's first paved runways at Ford Airport in Dearborn, Michigan. With no aviation experience and no airport pavement design specifications, engineers built this and other early runways using pavement thicknesses similar to those of early highways. In fact, until World War II, airport engineers based concrete pavement design on the anticipated loads imposed by the trucks refueling the airplanes, rather than the airplanes themselves.

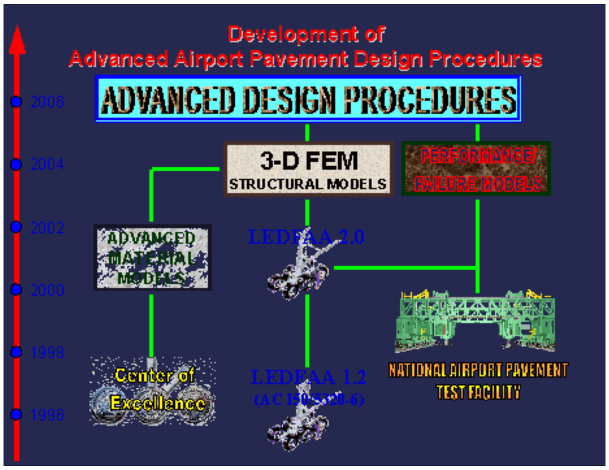
For many years after the war, airport pavement research and technology benefited from advances in highway research, as well as from Department of Defense research supporting military aircraft and airfields. However, by the 1990s, the largest civil aircraft exceeded the weight of military aircraft and exceeded the weight of the largest highway vehicles by an order of magnitude. Because of their proposed weight and landing gear configuration, these aircraft would have unique effects on runway pavement.

"During takeoff, landing, and taxiing, the aircraft pavement must support as much as 600 tons of aircraft, luggage, fuel, and passengers, all of which is concentrated on the relatively small contact points of the plane's tires," explains Dr. David Brill, FAA pavement research engineer. "The next generation of large civil aircraft will include models that will weigh up to 1.3 million pounds and have complex, multiple-wheel, multiple truck landing gear systems." The Boeing 777, which entered commercial service in June 1995, for example, has two 6-wheel landing main landing gears to support a gross weight of up to 660,000 pounds. The 6-wheel gear loads applied to airport pavements by the Boeing 777 and the new Airbus 380 (due to enter commercial service in 2006) are quite different from the loads applied by the older generation of commercial airplanes.

In engineering parlance, airport pavements (runways, taxiways, and aprons) may be either "flexible" or "rigid," depending on the type of material. Flexible pavements are constructed of asphalt, while rigid pavements consist of concrete slabs on a prepared subbase. At larger airports, both types of pavements generally include a stiffened, or stabilized, base layer to provide additional support. As aircraft get bigger and heavier, with new kinds of landing gear, added stresses and strains are exerted on airport pavements.

"Complex wheel load interactions within pavement structures can contribute to premature failure of the pavement structures, and must therefore be considered in pavement design analyses," says Dr. Brill. "When traditional, empirically-based pavement design methods are used to analyze loads from the new generation of landing gear, they require pavements that seem unrealistically thick. Hence, new heavy aircraft, such as the Airbus 380, may require airports to overlay, reinforce, or even rebuild runways to adapt to these new heavier aircraft."

To assess pavement requirements for heavier aircraft, and in an effort to create more cost-effective, longer lasting airport pavements, FAA researchers are developing criteria and methods for design, evaluation, performance, and serviceability of airport pavements. "Airport pavement can only serve its purpose when it has good load-carrying capability, good rideability, and allows safe operations of aircraft," explains Brill. "That is why FAA's airport researchers are working



Development of Advanced Airport Pavement Design Procedures

to ensure airports will be ready for any future aircraft."

Prior to the first flight of the Boeing 777, FAA Advisory Circular AC 150/5320-6D, the existing FAA design standard for airport pavements, had been used for over 25 years. This standard, however, could not accurately assess damage to airport pavement as a result of the complex gear loads of the Boeing 777. To better predict wheel load interactions and to provide the airport community with a pavement design methodology addressing the needs of new, heavier aircraft, FAA researchers developed the design program called LEDFAA.

A FAA-sponsored feasibility study of Layered Elastic Design (LED) methods for airport pavements demonstrated that the LED procedure for flexible (asphalt) pavements produces pavement designs that are compatible with conventional FAA design procedures for existing aircraft types. The LED method better predicted the wheel load interactions for the Boeing 777, because the landing gear configurations and layered pavement structures can be modeled using the LED procedure.

As a result of this research effort, in 1995, the FAA issued a new Advisory Circular, AC 150/5320-16, implementing LEDFAA as a new standard for design of airport pavements intended to serve the Boeing 777 airplane. To ease the difficulties of implementing the LED procedure, and to empower design engineers with the required computational tools to perform the numerical computations, FAA's researchers also developed the LEDFAA program package. This program automates the LED procedures and provides design engineers with user-friendly graphical interfaces. The program minimizes user input variables and contains built-in error checking procedures on all the input values to minimize errors. Once all required input values are specified, the design thickness of the airport pavement is automatically computed.

More recently, the LEDFAA program package has been completely updated to incorporate new aircraft types, including the Airbus 380, and to be more compatible with the latest computer operating systems. In addition, a recently approved change to AC 150/5320-6D makes LEDFAA 1.3 an alternative FAA design standard for airport pavements handling all traffic mixes, not just those intended to serve the Boeing 777. LEDFAA version 1.3 can be downloaded from the FAA's website at http://www.faa.gov/arp/engineering/software.cfm.

While the FAA continues to develop and improve LEDFAA for the airport community, researchers are also developing a new PC-based airport pavement design program that employs advanced structural models based on the three-dimensional finite element method (3D-FEM). These models are capable of more accurately simulating the structural response of airport pavements to complex loading configurations, including new large aircraft with 6 or more wheels per gear. While flexible pavements will continue to be designed using the existing LED models, the advanced 3D-FEM models will be incorporated in the design of rigid (concrete) pavements and overlays.

The new program, called FAARFIELD (for FAA Rigid and Flexible Iterative Elastic Layer Design) is currently in the Beta testing phase and will be ready for release in 2006. The Beta test version of FAARFIELD, called FEDFAA, is available for download on the FAA Airport Technology web site at http://www.airporttech.tc.faa.gov/naptf/download/index1.asp.

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Training the Next Generation of Airport Researchers

Center of Excellence for Airport Technology

Through its Center of Excellence Program, the FAA establishes partnerships with universities throughout the country. The Centers of Excellence provide a formal structure that facilitates research, education, training, and technology transfer. Participating universities benefit through funded research programs that enrich the educational opportunities for students by linking their learning to real world experiences.

"The Center of Excellence for Airport Technology plays an important role in the FAA's airport technology research and development activities," states Dr. Satish Agrawal, FAA Airport Technology R&D program manager. Established in 1995, faculty and students from the University of Illinois, Northwestern University, Embry-Riddle Aeronautical University, and North Carolina A&T State University conduct research in material characterization and modeling, non-destructive evaluation of pavements, structural behavior and modeling, airport pavement design concepts and procedures, and wildlife hazard mitigation.

Current research projects include:

- Analysis of Pavement Response Data from Denver International Airport
- Analyses of National Airport Pavement Test Facility (NAPTF) Pavement Response Data
- Fatigue Resistance of Airport Concrete Pavements
- Analysis of Flexible Overlay Systems for Airport Pavements
- The Greater Peoria Regional Airport Demonstration Project
- Model to Predict Fatigue Response of Concrete Airport Pavement
- Modification of Coal-Tar Rejuvenator Specifications
- Characterization and Design of Aggregate Interlock Joints in Concrete Pavements Using Surface Roughness Measurements

According to Dr. Agrawal, "This Center of Excellence not only serves as an important research partner, it also is training the next generation of aviation engineers. It supports a large number of graduate students, training to be the researchers of tomorrow." To date, students supported by the Center have completed approximately 20 Ph.D.s, and a significant number of master's degrees. Students have published over 150 peer-reviewed technical papers, technical reports, and other publications. Currently 15 students from four universities are conducting research under the auspices of the Center.

Students from the COE have been recognized as some of the best young researchers in the country. The FAA recognized **Daniel Sherman** as its **2003 Center of Excellence student-of-the-year**. The Department of Transportation has honored three students as its University Transportation Students of the Year:

1999 - Bill Vavrik
(University of Illinois, Urbana-Champaign)
2001 - Sean M. Smith
(University of Illinois, Urbana-Champaign)
2002 - Brent Brown
(University of Illinois, Urbana-Champaign)

At the 2003 Centers of Excellence Conference, the FAA and its university and industry partners recognized several students for their ongoing research. **Shihui Shen** (University of Illinois, Urbana-Champaign) received top honors in the student poster competition and **Alex Apeagyei** (University of Illinois, Urbana-Champaign) and **Farid Mugbil** (North Carolina A&T) earned fourth place honors. In the paper competition, **Jonathon Fisher** (University of Illinois, Urbana-Champaign) earned third place and **In Tai Kim** (University of Illinois, Urbana-Champaign) received an honorable mention.

Because the Centers of Excellence form flexible, multidisciplinary teams with other government organizations and industry affiliates, students get a wide array of experiences. The Center of Excellence for Airport Technology, for example, has teamed with Boeing, AvTurf, Inc., Trigon Engineering Company, among others. The team members coordinate research and development in areas of aviation technologies that are critical to the FAA's mission and long-term vision.

For additional information on the FAA's Center of Excellence for Airport Technology, please see http://cee.uiuc.edu/research/coeairporttech/. ■

Rethinking Airport Technology Research

2004 FAA Worldwide Airport Technology Transfer Conference and Exposition

Over 150 people from the United States, Bolivia, France, Israel, The Netherlands, and Taiwan recently attended the 2004 FAA Worldwide Airport Technology Transfer Conference and Exposition. The FAA and the American Association of Airport Executives, with additional support from the Airports Council International-North America, the American Concrete Pavement Association, and the Asphalt Pavement Alliance sponsored the symposium.

David L. Bennett, Director, FAA Office of Airport Safety and Standards, opened the conference. He noted that the FAA has issued over 100 advisory circulars on airport standards and development. "Research and development is critical to keep those standards and circulars updated," he explained. The conference, according to Bennett, makes "an important contribution" in providing a forum for industry to exchange ideas and work together to meet future airport needs.

Dr. Anne Harlan, Director of the FAA's William J. Hughes Technical Center, echoed Bennett's comments. She highlighted some of the critical research the FAA is conducting at the Tech Center, in particular, runway visibility, runway safety, airport rescue and firefighting, wildlife mitigation, and pavement. Through, and as a result of such conferences, she observed, the community is "working together to achieve aviation safety."

Dr. Satish Agrawal, manager of FAA's airport technology research program, pointed out that the FAA's airport technology research program is saving lives and critical resources. Through partnerships with academia and industry, technological advancements are occurring at a rapid pace, significantly improving safety.

Researchers from government, industry, and academia presented approximately 40 technical papers covering airport pavement technology and airport safety technology research and development at the 3-day conference. On the last day of the conference, attendees toured the FAA's National Airport Pavement Test Facility.

The FAA's airport technology researchers are succeeding in developing new technologies and procedures that are improving airport safety and efficiency. This research includes: airport pavement design, modeling, and testing; airport planning; airport rescue and firefighting; wildlife mitigation; visual guidance and runway incursion reduction; and runway surface technology. According to Dr. Agrawal, "by working with other government agencies, industry, and academia on key research projects, we are leveraging resources to ensure our work remains targeted on high priority activities that will benefit the flying public." ■

2004 FAA Worldwide A
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port needs."

David L. Bennett, Director
FAA Office of Airport Safety
and Standards

Getting Ready for the Super Jumbo Jets

Critical Research for Aviation's Future

"An airport is one of the most complex, carefully planned facilities that you can imagine, often designed around the types of aircraft and operations that use a particular airport," says Ryan King, a civil engineer in FAA's airport safety technology program. "Often when new larger aircraft and regional jets are introduced, existing airports do not meet all of the associated FAA design standards for that aircraft category, such as runway safety area dimensions, and separation between runways and taxiways."

To ensure FAA's airport guidance and standards remain up-to-date, the FAA has an active R&D program that focuses on airport planning. Researchers review the current widths, clearances, and separations of airfield operational areas, and consider the impact of air traffic control procedures, particularly queuing and spacing as it affects runway acceptance rate, making recommendations for policy and guidance changes, if necessary, to accommodate new aircraft.

Manufacturers are currently building super jumbo and stretch versions of their existing aircraft to accommodate increased passenger enplanements, which are expected to more than double over the next 25 years. The increased passenger traffic and larger aircraft could severely strain existing airports. The major areas of concern include terminal and gate configurations, runway and taxiway length and width, pavement strength, and the cost of updating these facilities.

The compatibility of aircraft and airport facilities is of critical importance to the process of planning and designing airports. Both the airport airside and landside planning are based on the operating characteristics of the aircraft that will be operated at the airport. On the airside, the type of aircraft will

about this issue...

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Please submit your brief responses online to: **http://research.faa.gov/aar/survey_info.asp** determine the runway length and width, the minimum separation between runways and taxiways, and pavement strength.

"The purpose of our R&D program," explains King, "is to advise operators and their consultants of appropriate dimensional standards for airport development and to provide planning guidelines for developing landside and airside facilities. Currently we are conducting the necessary research to assess the compatibility of new, super jumbo jets with existing airport facilities."

The Airbus 380, for example, is scheduled to start passenger service in 2006. Depending on its configuration, the plane will hold between 500-800 passengers (the standard Boeing 747, in contrast, holds approximately 416 passengers). With a length of 239 feet, the Airbus 380 will need over 2 miles of runway to takeoff and land.

The weight, wingspan, and performance characteristics of aircraft, in conjunction with site-specific conditions, determine an airport's geometry, in terms of runway/taxiway length and configuration. For example, because of the Airbus 380's 261 foot wingspan, the FAA recommends that taxiways at airports expected to serve this aircraft have a width of 100 feet. Most existing taxiways, however, are built to accommodate smaller aircraft and have only a 75 feet wide taxiway straight section.

In anticipation of the advent of super jumbo jets, in 1999 the FAA began a research program to determine if these new large aircraft could safely use existing 75-foot wide taxiways. In field studies conducted at New York's John F. Kennedy International Airport and Alaska's Ted Stevens Anchorage International Airport, researchers measured the wander rate of Boeing 747 airplanes from the taxiway centerline of 75-foot taxiways to help determine if it would be safe to allow the new jumbo jets to use 75-foot taxiways.

Based on the preliminary field study results, the FAA determined that it is possible for the super jumbo jets to use existing non-standard 75-foot-wide straight taxiway sections on an interim basis and under specific conditions. As a result, in August 2003, the FAA issued Engineering Brief #63, *Use of Non-Standard 75-Foot-Wide Straight Taxiway Sections for Airbus A380 Taxiing Operations*, (http://www.faa.gov/arp/engineering/briefs/eb63.doc), which allows FAA regions to approve modifications to standards for Airbus 380 taxi routes using 75-foot wide straight taxiway sections on existing taxiways only and only on an interim basis. New construction must adhere to the 100-foot standard.

Runway width may also be a concern with the introduction of new large aircraft. The FAA recommends a runway width of 200 feet for the new super jumbo jets. However, most existing runways at affected airports have a runway width of 150 feet. Airbus hopes to demonstrate the compatibility of the 380 on 150-foot runways. If the FAA approves, new construction of runways would still require 200-foot runways.

Runway and taxiway dimensions are just two of the compatibility issues FAA researchers are examining as the nation's airport get ready for the introduction of the next generation of large jets. FAA's Airport Technology R&D program plans to issue a report in 2005 on the Impact of *New Large Aircraft on Airports*. For additional information on the FAA's airport planning research, please visit http://www.airporttech.tc.faa.gov/planning/. ■

Laser measuring the distance of the nose gear from the centerline.

A Legacy of Success

Products that Save Lives

First EMAS emergency save, 1999.

"Although this issue of *R&D Review* focuses on our ongoing airport research and development activities, I think its important to highlight some of our past accomplishments," explains Paul Jones, FAA's airport safety technology R&D manager. "During the past ten years, our research and development program has provided products that have significantly enhanced the safety of aircraft operations in the United States and around the world. Among our many recent successes, we have developed and deployed a critical new technology that decelerates an aircraft in the unlikely event of an overrun, worked with industry to create an environmentally friendly system to deice aircraft, and have developed means to improve runway friction when snow, ice, water, and rubber deposits created slippery pavement."

Preventing Runway Overruns

Aircraft can and sometimes do overrun the ends of runways, sometimes with disastrous results. To minimize the hazards of overruns, the FAA requires a safety area of 1,000 feet in length beyond the end of the runway. Although this safety area is now a FAA standard, many runways were built before this standard was adopted.

For those approximately 350 airports locations in the United States that do not have the space for a full runway safety area, the FAA worked with Engineered Systems Company (ESCO) of Ashton, Pennsylvania, to develop an engineered solution to create the necessary margin of safety. The engineered material arresting system (EMAS), now being installed at airports across the United States, is made of water, foam, and cement. It deforms readily and reliably under the weight of an aircraft tire. As the tires crush the material, the drag forces decelerate the aircraft, bringing it to a safe stop.

EMAS is proven technology that saves lives," says Paul Jones. "On May 30, 2003, this key product of the FAA R&D program paid a huge safety dividend." On that day, a cargo MD-11 overran the runway at John F. Kennedy International Airport. The arrestor bed safety stopped the plane. Neither the crew nor aircraft suffered major damage. The airport returned to normal operations within a few hours.

Currently, 11 EMAS have been installed: Minneapolis-St. Paul International Airport, Minnesota; Little Rock Airport, Arkansas (2); John F. Kennedy International Airport, New York; Rochester International Airport, New York; Burbank Airport, California; Baton Rouge Metropolitan Airport, Louisiana; Greater Binghamton Airport, New York (2); Hyannis, Massachusetts; and Greenville Downtown Airport, South Carolina. Eight new systems are currently being planned for or installed at: Poughkeepsie Dutchess County Airport, New York; Yeager Airport (Charleston), West Virginia; Roanoke Regional Airport, Virginia; Ft. Lauderdale Hollywood International Airport, Florida (2); San Diego International Airport, California; Laredo International Airport, Texas; and LaGuardia Airport, New York (2).

Generally, the cost to install an EMAS ranges between $2 million and $4 million, plus site preparation, for U.S. installations. Airports can apply to the FAA for Airport Improvement Program grants to help defray the cost of the system.

Infrared deicing facility

Deicing Aircraft Safely and Efficiently

"In 1994 the FAA entered into a cooperative research and development agreement with a small Buffalo, New York, firm that had an idea for deicing airplanes that went against conventional wisdom, but proved very successful," reports Paul Jones. "Under a cooperative research and development agreement, the company, Process Technologies, Inc.'s (now Radiant Energy Corporation) funded development of an innovative infrared deicing system and the FAA provided expertise, advice, and instrumented test aircraft."

This system, called InfraTek, is an infrared radiant energy deicing system that deices aircraft with considerably less harmful effects on the environment than conventional chemical deicing. Operating similar to a carwash, a plane that has ice and/or snow adhering to it enters one end of a hangar-type structure, is pushed or pulled through the building where it is deiced by infrared heat, and then leaves the building "clean" or free of contamination. Anti-icing fluids are then applied as dictated by the existing weather conditions. Using conventional means, it can take hundreds of gallons of glycol to deice an aircraft depending on the type of aircraft and the weather conditions. The rising financial and environmental costs associated with glycol are a concern at many airports.

On February 15, 2000, Radiant Energy Corp. officially opened its third infrared deicing facility for Continental Airlines at Newark International Airport. This facility is large enough to deice the Continental fleet up to and including a Boeing 757.

Increasing Airport Visibility

Because painted markings on runway, taxiway, and apron surfaces are often obliterated when covered by even a thin layer of water, there is a need to provide a more effective method of marking or delineating critical areas and/or locations on the non-movement and possibly movement areas on an airport. Conventional in-pavement (semi-flush/inset) lights can be used; however, they are expensive and costly to install and maintain.

The Agency's visual guidance research is determining if more efficient and cost effective technologies can be adapted for airport use to improve safety. These efforts focus on developing performance specifications for visual guidance systems that will reduce acquisition, installation, and maintenance costs, while having enhanced visual cues necessary for safe airport operations. Some of the new technologies being examined include: fiber optics; metal halide lamps; and light emitting diodes (LED).

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Preventing Runway Incursions

Critical Safety Research

Any occurrence at an airport involving an aircraft, vehicle, person, or object on the ground that creates a collision hazard or results in a collision with an aircraft attempting to land, take-off, or taxi is called a runway incursion. Over the past few years, runway incursions have emerged as a major safety issue in aviation. Last year, the FAA reported 323 runway incursion incidents; there were 339 incidents the previous fiscal year.

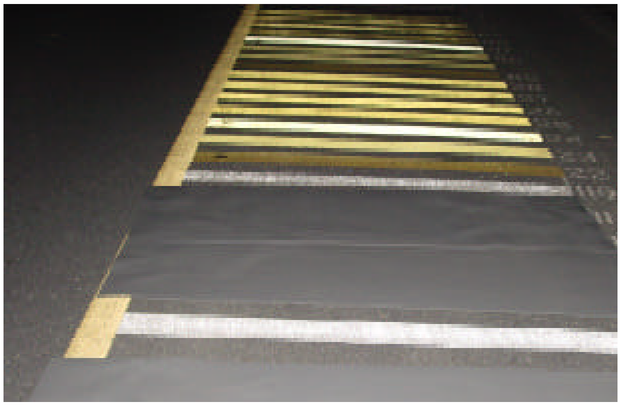
Increases in airport operations raise the risk of runway incursions. Some of the additional factors that contribute to the complexity of this safety problem are aircraft of different types and capabilities moving in close proximity, weather changes that impact visibility and conceal normal visual cues, unclear signs and surface markings, pilots unfamiliar with an airport, and complex and varied airport geometry.

Eliminating runway incursions is a FAA priority, and the Agency's airport technology researchers are helping to reach FAA's runway incursion reduction goals. Their research and development activities in the visual guidance program have improved runway and taxiway lighting, obstruction lighting, distance-to-go markers and signs, surface markings, and other aids.

"Providing unambiguous cues help reduce pilot/ground vehicle operator's disorientation and confusion and promote situational awareness, thus reducing the chance of runway incursions," explains Donald Gallagher, FAA's Visual Guidance R&D program manager. "This research is continually investigating new technologies and new airport applications for existing technologies to enhance the quality of the visual guidance cues provided."

Gallagher explains, "Surface markings and signs are the primary visual cue used by pilots/ground vehicle operators during the day in normal visibility. When markings become less conspicuous as in wet weather or lower visibility conditions, airfield lights and lighted signs become the primary cue. Lighting technologies, such as light emitting diodes, linear sources to replace point sources, fiber optics, and lasers are examples of what we have examined, along with different type of marking materials and coating such as photo-luminescent paint and such unusual concepts as 3D markings."

In a recent evaluation of pavement markings, researchers worked to reduce the potential of runway incursions and incidents by making pavement markings more visible to pilots and vehicular operators. During the evaluation, researchers compared the standard runway holding positions markings to 12-inch wide markings, which doubled the width of the standard ones. The results of the evaluation showed that the pilots preferred the wider markings because they provided improved distance recognition. Based on these results, the FAA's Office of Airport Standards revised the existing standards to require wider marking at runway holding positions. This research is summarized in *Airport Pavement Marking Evaluation for Reducing Runway Incursion* (DOT/FAA/TN01/2) and can be found on-line at http://www.airporttech.tc.faa.gov/safety/downloads/TN01-2.pdf.



Pavement Paint Evaluation

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

To improve inspections, the FAA developed a quick and accurate way to evaluate paint markings. Researchers developed a manual method that eliminated the subjectivity of the current process, and an automated method to evaluate larger surface markings over a vast airport area. The manual method uses three measurement tools to eliminate subjectivity. A retro-reflectometer is used to determine retro-reflectivity of the beads, a spectrophotometer for color measurements to determine whether or not the paint marking had faded, and a transparent grid to determine paint coverage. If any one of these three tests fails, the pavement marking fails.

Researchers also developed procedures for an automated method to evaluate larger surface markings using a commercially available van-mounted mobile unit to increase speed and sample size. This technique works well for large airports that have very long runway centerlines and threshold markings.

This research is summarized in *Development of Methods for Determining Airport Pavement Marking Effectiveness* (DOT/FAA/TN03-22) and can be found on-line at http://www.airporttech.tc.faa.gov/safety/downloads/TN03-22.pdf.

Currently, FAA's airport safety researchers are evaluating the effectiveness of a glass coating to prevent the deterioration of the runway paint and a new polyurea marking material. The glass coating material is called Adsil for anchored dendridic silicate interactive linkages. It is being evaluated with the Navy at Jacksonville Naval Air Station, Florida. This coating's purpose is to seal the surface to prevent damage from ultra violet light, fuel oil, and discoloration. The polyurea evaluation is being conducted at Liberty International Airport, Newark New Jersey in partnership with the Port Authority of New York and New Jersey. This is a different type of marking material that might be able to be used instead of conventional paints.

Runway incursions can result not only from aircraft to aircraft incidents, but also from the presence of unauthorized ground vehicles on the active runway. In many cases, air traffic control personnel can become confused by the great number of flashing lights on vehicles operating on the airport, unable to distinguish which vehicles are on the runway and which ones are on a parallel taxiway and/or holding short of the runway. It has been suggested that some unique configuration of vehicular lighting, supplementing the conventional yellow flashing

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Van mounted mobile unit

For the Public Good - *continued from page 3*

Aerial view of National Airport Pavement Test Facility under construction.

Researchers completed testing the first set of test items, known collectively as "Construction Cycle 1" in 2001. They completed a second series of flexible pavement tests, consisting of four test items on low-strength subgrade, in 2003. Results from those tests:

- Provided performance data for 4- and 6-wheel gears that was used in updating the failure models in LEDFAA 1.3, the FAA's airport pavement thickness design program; and
- Provided the data used by the International Civil Aviation Organization (ICAO) to determine the permanent Aircraft Classification Number calculation for 6-wheel gear aircraft including the Boeing 777 and Airbus 380.

Currently, traffic tests are underway on a third construction cycle, consisting of three rigid test items constructed on medium-strength subgrade soil. The three test items make use of different construction methods. In one section (the control), concrete slabs are placed on top of an unbound aggregate subbase in accordance with conventional pavement construction practice. A second test item includes an econocrete (stabilized) base layer, in accordance with required standards for airports handling heavy aircraft. A third section has concrete slabs placed directly on the prepared subgrade surface. A direct comparison of the results from the three test items is expected to give valuable information about the extra benefit provided by stabilized base layers in concrete airport pavements.

According to Dr. Hayhoe, "to date, researchers have collected over 63 gigabytes of data. The resulting technical data is helping us validate new design standards and assure compatibility between aircraft and airports throughout the world. The data is also providing the FAA an improved scientific basis for further development and refinement of the ICAO's pavement loading standards for aircraft." New international standards are expected in 2007.

These new standards will benefit the entire aviation community. The pavement design standards based on the empirical data will provide manufacturers assurance of the compatibility of their aircraft on airports throughout the world. It will also provide airport operators precise cost estimates to permit new aircraft operations on their facilities and allow airlines to plan for new equipment and routes. In addition, the data will give airport designers confidence in their designs. Finally, the data will ensure that federal funds for rebuilding or strengthening runways are being used prudently and the $100 billion investment in the infrastructure is protected.

Because of the critical need to understand better pavement properties, the FAA has made its test data available on-line at http://www.airporttech.tc.faa.gov/naptf/. Further information on the National Airport Pavement Test Facility can also be found on the same web site. ■

A Legacy of Success - *continued from page 13*

As part of this effort, Agency researchers discovered that LED lighting strips can be readily imbedded within, and virtually flush with, the pavement surface to provide a continuous light strip. Properly installed, these lights are compatible with snowplow operations and, being sealed or encapsulated, require only a minimum of maintenance. The strips require comparatively low levels of power and have demonstrated minimal failure rates in service.

To test the effectiveness of LED strips to enhance airport pavement pain markings, FAA airport safety engineers installed a test LED lighting strip configuration in the form of a parking location "T" at the number one parking spot on the apron area of the agency's William J. Hughes Technical Center. The configuration comprised five 3-meter (10-foot) sections, or strips, forming the crossbar of the T and an additional nine sections forming the "tail" of the T.

Experienced pilots and lighting personnel participated in a subjective evaluation of the strips, showing the technology promised a significant increase in pavement visibility at airports. Operationally, the LED light strips do enhance airport pavement markings and, except for snow conditions, improve nighttime visibility when standing water covers the pavement.

The results indicate that while the light LED have potential to further enhance visual aids, when installed in the pavement they do not remain operational for long in an airport environment. Industry must develop these technologies further before they can be considered for airport use.

Researchers continue to examine the usefulness of LED devices for a number of airports uses. They are evaluating a number of applications, and are also considering LEDs for use as taxiway edge lighting and runway thresholds.

Ensuring Runway Safety Through International Collaboration

In spite of advances in technology and operational procedures, safer winter operations remain a challenge for airport operators, air traffic controllers, airline personnel, and pilots who must coordinate their efforts in rapidly changing weather conditions. Ice or snow on a runway presents significant safety challenges.

Within the past decade, the continued introduction of new chemicals, equipment, instrumentation, and aircraft/airport operational procedures for adverse weather operations has reinforced the need for additional runway tests and evaluations. With steadily increasing traffic volume and greater mix of aircraft types at many airports, combined with harsh winter conditions, the complexity of potential runway problems are great. That is why the FAA is undertaking a comprehensive, multifaceted program that will address all factors influencing aircraft ground operational performance during severe winter conditions.

As part of an international effort, FAA's researchers are working with their counterparts at NASA and Transport Canada to create a system that will reduce the number of accidents attributed to snow and ice on runways. Research conducted under the Joint Winter Runway Friction Measurement Program is increasing the safety of all aircraft ground operations under winter weather conditions.

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Mitigating the Hazard

Wildlife Abatement Research

Between 1990 and 2002 there has been a 260 percent increase in the number of reported aircraft wildlife strikes. This increase reflects a number of factors, including a rise in the percentage of strikes reported based on awareness of the problem, an increasing number of aircraft movements, and mostly increasing populations of wildlife around airports. In particular, Canada geese, which are extremely hazardous to aviation because of their size and weight and because they travel in large flocks, have significantly increased the strike risk in recent years.

10/6/99 - American bitten struck wing (Inboard view), Atlantic City, New Jersey.

"Compounding the problem of wildlife strikes is the fact that aircraft have fewer and quieter engines," explains Dr. Michel Hovan, FAA's wildlife strike mitigation research program. "This creates two potential conflicts. One, a bird is less likely to hear the aircraft until closer in range, which does not provide substantial time to flee the hazardous area. Second, if a four-engined aircraft takes multiple strikes and looses power on two engines, it still has two remaining engines to provide power. If a two-engine aircraft loses two engines, there is no remaining power, thereby, placing the two-engine aircraft at greater risk than the four-engine aircraft. In addition one must consider that aircraft, in general, are not specified nor tested to resist the impact of a large number of large birds at once."

It is estimated that over $500 million is spent annually by the aviation industry as a result of wildlife strike damage. Besides cost concerns, wildlife strikes also constitute a safety risk. Large bird strikes can result in engine failure, airframe penetration, and potentially, crash. Unfortunately, this was demonstrated in 1995 when a U.S. Air Force AWACS aircraft encountered a flock of Canada geese and crashed shortly after take-off at Elmendorf AFB, Alaska. All aboard perished. General aviation is also concerned by the issue. As recent as July 2003, a Cessna 172 was lost near Dallas after reporting a bird strike.

To quantify the scope of the problem, the FAA has established the FAA National Wildlife Strike database. This database is available on-line and provides pilots, air traffic controllers, mechanics, and others in the aviation with the capability to report strikes at http://wildlife.pr.erau.edu/strikeform/birdstrikeform.html.

From 1990-2004, 60,000 bird and about 500 deer strikes to civil aircraft were reported in the U.S. (Reporting is not mandatory and it is estimated that less than 20 percent of strikes are reported.) Data from the wildlife strike database are analyzed and published annually. (See, *Wildlife Strikes to Civil Aircraft in the United States, 1990-2002* at http://wildlife.pr.erau.edu/Bash90-02b.pdf and FAA *Wildlife Strikes to Civil Aircraft in the United States* at http://www.aphis.usda.gov/ws/nwrc/field/sandusky/strike.html.)

To reduce wildlife strike risks at airports, the first strategy consists of reducing the actual numbers and density population of wildlife at the airport. This is done by understanding and modifying the airport as a habitat to the species in question, and by developing specific wildlife management techniques to control problem species. Most of this research is conducted by the U.S. Department of Agriculture under long-term agreements with the FAA.

Alligator on runway.

The FAA is developing the National Bird Strike Advisory System to reduce in real-time the bird strike risk to aircraft near airports. This new system is visionary with the goal of providing bird strike risk information to pilots and airports in a real-time mode. Risk assessment will be performed in real-time by using bird radar data in conjunction with historical data from the airport and from the FAA National Wildlife Strike Database.

As part of this long-term vision, the FAA and the U.S. Air Force Research Laboratory have been sponsoring the development of a small bird detection radar for airports. Researchers have completed building an experimental unit and have successfully conducted preliminary tests at wildlife refuges and at the JFL airport. Additional tests are planned at the Dallas Fort Worth International Airport.

The U.S. Air Force has its own Bird Strike Advisory System that is already operational. It is called the Avian Hazard Advisory System. It is a risk assessment tool that provides the user with a standardized measure of bird strike risk for low-level routes. It also provides an on-line, near real-time, geographic information system for bird strike risk flight planning across the continental United States. The system incorporates historical weather radar data and predictive models to determine current bird activity. The system can forecast up to 24 hours ahead of time the activity of 12 species considered to be a serious hazard and provide advisories for critical aviation areas, monitor in near real-time all species detectable by the radar, and provide advisories for all low altitude areas. Users can access the system on-line at http://www.usahas.com/.

In the future, it is envisioned that the FAA 's and the Air Force 's Bird Strike Advisory Systems will be integrated under one North American Bird Strike Advisory System.

In 2003, FAA researchers also began using a prototype geographic information system at the Dallas Fort Worth Airport to map historical and current bird observations, reported bird strikes, observed bird routes, seasonal land use, and aircraft approach and departure corridors. As an operational tool, the system provides the airport with the ability to analyze bird density maps to estimate the risks to aircraft created by these various hazard levels. As a research tool, the system is flexible, allowing users to research, identify, and analyze correlations between various pieces of data. For instance, researchers are able to study seasonal land use against bird population density. At the regional planning level, the airport can then use the information to influence land use planning and development so that bird strike risks are mitigated over time. Similar GIS-based systems are being developed for the John F. Kennedy and Seattle International airports.

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DID YOU KNOW?

- Over 195 people have been killed worldwide as a result of bird strikes since 1988.
- Wildlife strikes cost U.S. civil aviation over $500 million per year, 1990-2003.
- The U.S. Air Force reported over 4,300 bird strikes in 2003.
- U.S. civil aircraft operators and pilots reported over 5,900 bird strikes in 2003.
- An estimated 80% of bird strikes to U.S. civil aircraft go unreported.
- Waterfowl (32%), gulls (28%), and raptors (17%) represented 77% of the reported bird strikes causing damage to U.S. civil aircraft, 1990-2003.
- Over 600 civil aircraft collisions with deer were reported in the U.S., 1990-2003.
- A 12-lb Canada goose struck by a 150-mph aircraft at lift-off generates the force of a 1,000-lb weight dropped from a height of 10 feet.
- The North American non-migratory Canada goose population increased 3.6 fold from 1 million birds in 1990 to 3.6 million in 2003.
- About 90% of all bird strikes in the U.S. are by species federally protected under the Migratory Bird Treaty Act.

A Legacy of Success - *continued from page 17*

- Improving designs of aircraft systems to meet ground-handling requirements.

Last winter, tests at Chitose Airport near Sapporo, Japan, focused on wide body aircraft. Researchers are using the data to correlate the runway friction index against various types of aircraft braking coefficients. As in previous winters, the researchers also conducted tests at the Jack Garland Airport in North Bay, Ontario, Canada. To date, data on over 300 valid test runs with aircraft and nearly 40,000 runs with 44 ground friction measuring vehicles have been collected.

Originally begun as a 5-year program in 1995, initial tests at North Bay, Ontario, Canada, included braking tests with a variety of instrumented aircraft and various ground friction measuring devices. While work continued at the North Bay location, subsequent winters have seen the testing move to a series of international locations, including the NASA Wallops Flight Facility in Wallops, Virginia; Oslo, Norway; Gwinn Sawyer Airbase, Michigan; Munich, Germany; Erding Army Airbase, Germany; and Prague, Czech Republic.

Over the past several years, international interest in the project has grown, and it is now supported by more than 30 organizations from 12 countries. This cooperative effort allows sharing of data and leveraging of resources to further understand the complexities involved with accurate measurement and reporting procedures for winter contaminated runways. Current research focuses on:

- Reducing traction-related aircraft accidents;
- Providing airport operators better runway surface friction monitoring tools and more cost-effective techniques for obtaining acceptable runway operating conditions; and

Researchers are integrating data from manual contaminant analyses, friction tester measurements, and aircraft instrumentation. Analysis of these data sets is showing the effects of aircraft and ground vehicle braking friction under various winter conditions. Researchers are harmonizing this data to create a consistent friction value, or index, for contaminated runway conditions. This index will help pilots with "go/no go" runway decisions based on

readings taken by a ground friction measuring device. It will also help airport operators determine whether their runways are suitable for aircraft operations and maintenance procedures.

Data and test results will be shared at the Third International Meeting on Aircraft Performance on Contaminated Runways in Montreal, Canada, on November 3 to 5, 2004. For information on this conference, please see http://www.tc.gc.ca/tdc/events/imapcr2004.htm.

Improving Airport Firefighting and Rescue Operations

The analysis of aircraft accidents involving external fuel fires has shown that, although external fires are often effectively extinguished, secondary fires within the fuselage are difficult to control with existing equipment and procedures. Large amounts of smoke-laden toxic gases and high temperatures in the passenger cabin can cause delays in evacuation and pose a severe safety hazard to the fleeing passengers.

Recognizing the need to improve post crash interior fire survivability through better cabin interior fire suppression techniques, several years ago the FAA, along with the United States Air Force and the San Antonio Fire Department, successfully tested an elevated waterway system with a boom-mounted cabin skin penetration system.

"This firefighting vehicle," explains Paul Jones, "is one of the most innovative products ever designed for the aviation fire safety industry. Firefighters can use this penetration system to pierce the aircraft hull and deliver fire extinguishing agents directly into the aircraft cabin. Earlier control of the internal fire provides critical additional minutes of evacuation time for passengers." At present, more than 250 airports in the United States and worldwide have upgraded their firefighting and rescue fleets with elevated boom-type devices.

In another research and development success, the agency worked with industry to develop and evaluate new infrared technology that is helping airport rescue and firefighting crews safely and quickly respond to emergency situations at night and in adverse weather conditions.

The FAA requires airport rescue and firefighting vehicles to reach the mid-point of the furthest runway in 3 minutes or less. In low visibility and adverse weather conditions, however, meeting that challenge can be nearly impossible. To meet this challenge, the FAA worked with industry to develop the driver's enhanced vision system. This system combines satellite navigation, digital data link, and infrared technologies with easy-to-use software and onboard displays. The system lets emergency crews see through fog, rain, sleet, and snow, as well as through smoke and flames. Using this technology, rescue teams immediately get critical information, such as the condition of the aircraft, location of passengers and crew, presence and location of spilled or burning fuel, and the position of other emergency personnel at the scene.

Boston Logan International Airport was the first airport to employ this safety system. Logan's system, operational since September 1996, includes five mobile rescue vehicles, two in-water rescue boats, two airport management vehicles and one airport security vehicle. A command center contains vehicle tracking and communications installations in the airport tower emergency management

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Recent Success

Recently, the FAA's high- performance research vehicle with elevated boom proved its worth for fighting non-aviation fires. In June 2004, the FAA's fire vehicle was put into action to help fight a large junkyard fire. This truck proved critical to extinguishing the fire because of its ability to flow large volumes of water through its unique elevated waterway and high volume bumper turret. Local officials credited the vehicle with assisting in the save of three large buildings during the operation. The truck remained on the scene for 8 hours, continuously pumping water and foam into the burning piles of automobiles and scrap metal.

Mitigating Hazard - *continued from page 19*

Guls near airport.

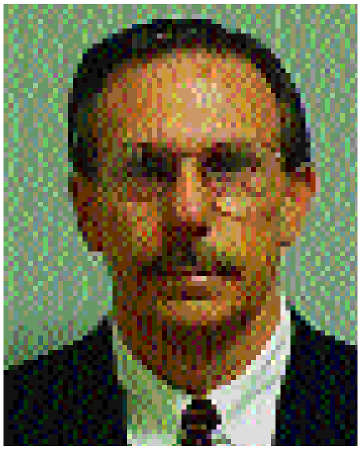
Knowing the size and behavior of the birds and mammals is key to prioritizing, planning, and implementing effective preventative measures. Identifications provide baseline data needed to implement habitat management plans on airfields and build avoidance programs that issue warning to pilots of bird strike hazards. This data also assists engineers and aircraft developers in designing windscreens and engines that are more resistant to damage from bird strikes.

"Because even the smallest piece of feather or fuzzy down can provide clues to the identification of the species responsible for the strike," explains Dr. Hovan, "the FAA and U.S. Air Force are working with the Smithsonian Institution's National Museum of Natural History to identify bird strike remains. Identification is important because, although commercial aviation reports about 6,000 strikes per year, very few of the remains are identified to determine what species of bird is causing problems."

Working with the Smithsonian, the FAA is developing a DNA-based, or forensic approach, to identifying bird strike remains. Researchers are currently working to conduct DNA-sequencing on the 300 species of birds commonly involved in aircraft accidents/incidents. In doing so, they are creating the necessary scientific protocols for extracting DNA from highly degraded samples. They also hope to develop and test a user-friendly DNA collection kit that can be used by pilots and airline and airport officials. From this work will come a national bird DNA database.

For more information on the FAA's wildlife strike mitigation research program, please visit http://wildlife-mitigation.tc.faa.gov or contact, Dr. Michel Hovan at michel.hovan@faa.gov. ■

Visit http://research.faa.gov/publications
for the latest on-line copy of the
2003 R&D Annual Review
A Fiscal Year Report of the FAA Research & Development Program.



New Airport & Aircraft Safety R&D Manager

Pat Lewis

Patrick Lewis is the new manager of the Airport and Aircraft Safety Research and Development Division, which manages the FAA's Airport and Aircraft Safety R&D programs. Pat has extensive FAA experience, serving previously as the acting manager of the Aviation Research Division, acting manager for the Innovations Division, and Program Director of the Software Engineering Resource Center. He has also done work with the Joint Planning and Development Office. He holds an MBA and has a B.S. in computer science and information systems. ■

2004 Harry T. Jensen Recipient

Dy Le

In recognition of an outstanding contribution to the improvement of helicopter reliability, maintainability, safety or logistics support through improved design or technical achievement.

Dy Le, program manager for the Rotorcraft Structural Integrity and Safety Issues in the FAA's Research and Development office, recently received the American Helicopter Society International's 2004 Harry T. Jensen award. Le, representing the FAA, was recognized as part of the National Rotorcraft Technology Center/Rotorcraft Industry Technology Association Damage Tolerance Program Team. In addition to the FAA, other members of the National Rotorcraft Technology Center include the National Aeronautics and Space Administration and the U.S. Army and Navy. Rotorcraft Industry Technology Association members include Sikorsky Aircraft Corp., The Boeing Company, and Bell Helicopter Textron, Inc.

This honor, bestowed at the American Helicopter Society International - Vertical Flight Grand Awards Banquet Program, held in Baltimore, Maryland, June 9, recognized the team's "outstanding contribution to the improvement of helicopter reliability, maintainability, safety or logistics support through improved design or technical achievement.

Since 1986, the American Helicopter Society has given the Harry T. Jensen Award in recognition of an outstanding contribution to the improvement of helicopter reliability, maintainability, or safety through improved design brought to fruition during the preceding year. The team earned the award for their contribution to the advancement of rotorcraft safety, reliability, and economics through research on rotorcraft structural integrity. In collaboration with academia, the team has successfully advanced the state-of-the art in specific rotorcraft technology areas. Some of the technologies developed under this program have been successfully applied in the design and certification of the Sikorsky S-92, and to address field service issues that cannot be handled by safe life analysis. ■

Protecting a Critical Resource - continued from page 5

Over the next year, researchers will:

- Complete testing and validation of the new design program for all types of airport pavement designs. This includes both flexible and rigid pavements, and new construction and overlays.
- Update the traffic models and failure criteria using full-scale test results from the National Airport Pavement Test Facility.
- Finalize the treatment of new large aircraft types including the Airbus 380, Airbus 340 -500/600, and Boeing 777-300 ER.
- Prepare detailed written documentation of all program modules that will facilitate future maintenance and upgrades.

For additional information on the FAA's pavement design research program, please see http://www.airporttech.tc.faa.gov/pavement. ■

A Legacy of Success - continued from page 21

center. The system uses computer displays driven by a differential Global Positioning System, a Geographic Information System, and a forward-looking infrared sensor mounted in the vehicle for locating and navigating to emergency sites. A central data and command radio link lets vehicles receive and transmit vital messages. ■

Preventing Runway Incursions - continued from page 14

warning lights, would help better identify vehicles operating within the active runway area, as well as to aircraft and/or other ground vehicles operating within the area.

FAA researchers conducted an evaluation at the William J. Hughes Technical Center, Atlantic City International Airport, New Jersey, in which they fitted numerous vehicles with modified light bars in an effort to determine if unique color configurations would enable air traffic controllers to differentiate runway movement from taxiway movement.

Researchers determined that the supplemental lighting concept, while very intriguing, would not be feasible, because they found no color configurations unique enough to identify the vehicles on the runway since all of the colors available for vehicle lighting already used elsewhere in the airport environment.

For additional information of the FAA's visual guidance research, please see http://www.airporttech.tc.faa.gov/safety/visual.asp. ■

upcoming events...

6th Workshop on Risk Analysis and Safety Performance Measurements in Aviation. The FAA and NASA are sponsoring the 2004 Annual International Workshop on Risk Analysis and Safety Performance Measurements in Aviation August 16-19 in Arlington, Virginia. Speakers from the aviation industry, the FAA, NASA, and academia will come together to discuss System Safety Processes and Risk Management. The theme of this year's workshop is *"Building a Safety Management System."* For more information, see http://aar400.tc.faa.gov/AAR424/Workshop2004/.