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SPECIAL ISSUE ON AIRPORT TECHNOLOGY RESEARCH AND DEVELOPMENT

Federal Aviation Administration

R&D REVIEW

Building a safe, secure, efficient, and environmentally compatible aviation system

Inside This Issue

A MESSAGE FROM THE MANAGER, AIRPORT TECHNOLOGY R&D BRANCH

There are more than 5,300 public use airports, heliports, and verti-ports in the United States, and traffic demand in these landing areas is steadily increasing. As early as 2013, U.S. enplanements are projected to reach nearly 1.1 billion passengers a year - 50 percent more than carried in 2001. Because the possibilities for expanding or building new airports are limited, Federal Aviation Administration (FAA) researchers are evaluating new technologies that will result in new and improved safety standards, criteria, and guidelines for those who use, design, construct, operate, and maintain the nation's airports, heliports, and vertiports. Partnering with industry and academe, the FAA is working to accommodate the projected traffic growth and establish an operational environment that is free of accidents and fatalities

The recent Airport Technology Transfer Conference--- Trends in Airport Technology for the New Millennium -- provided a unique opportunity for the aviation industry and the research community to interact and exchange critical information that will help assure safe and efficient airport operations into the future. Co-sponsored by the FAA, American Association of Airport Executives, the American Society of Civil Engineers, Airline Pilots Association, Airport Consultants Council, Airports Council International - North America, American Concrete Pavement Association, Asphalt Institute, and Helicopter Association International, this conference focused on the development of technology and its application to airport safety, efficiency, and mobility.

Approximately 200 attendees from various fields in aviation, technology, research, concrete pavement, design and construction, environment and safety, and aircraft rescue and firefighting shared their expertise and research findings, working together to meet today's aviation challenges.

The Honorable Marion Blakey, Chairman of the National Transportation Safety Board, pointed out this need for partnership in her keynote address, "With the oversight, resources and know-how of government - - and the

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MESSAGE (CONT.)

tools, technology, and dedication that many organizations in this room provide - - we can find solutions to address those areas that pose the most significant risks in aviation."

The conference's two tracks, Airport Pavement Technology and Airport Safety Technology, highlighted critical ongoing research and new technologies. The pavement technology presentations showcased the work being accomplished at the FAA's National Airport Pavement Test Facility, built by the FAA in partnership with the Boeing Company. This is the only such facility in the world and is being used to validate new methodologies for designing, constructing, and evaluation airport pavements. Researchers discussed pavement modeling and design methods, construction materials and methods, pavement evaluation, analysis, maintenance, and management, computer applications to airport pavements, and full-scale pavement testing.

In the airport safety technology presentations, panelists presented new concepts and ideas for aircraft rescue and firefighting, runway surface technology, runway incursion reduction, visual guidance, wildlife hazards, and airport planning and design. In her keynote address, Arlene Feldman, FAA's Eastern Region Administrator, explained that new safety technologies are making airplanes safe for people in the air as well as on the ground. "One has only to dream about technology and it will happen."

Other internationally recognized keynote speakers included The Honorable Frank A. LoBiondo, Member of the U.S. House of Representatives (NJ Second District), Dr. Anne Harlan, Director of the FAA William J. Hughes Technical Center, and Spencer Dickerson, Executive Vice President of the American Association of Airport Executives.

This 3-day conference proved an invaluable forum for the exchange of ideas. This special edition of *R&D Review* showcases some of the cutting edge research being done by the FAA in partnership with industry to enhance safety and efficiency at this nation's airports.

For additional information about our research program, please visit our website at http://www.airporttech.tc.faa.gov or call us at (609) 485-5250.

-- Satish Agrawal, Ph.D.
Manager, FAA Airport Technology R&D Branch

AIRPORT PAVEMENT TECHNOLOGY

PREPARING FOR THE FUTURE

Durable, long-life pavements are important in controlling the costs of operating the National Aviation System. The United States has approximately 6 billion square feet of airport pavement surface, with an estimated replacement value of $100 billion. In addition to annual expenditures of approximately two billion dollars on pavements - a significant portion coming from the Aviation Trust Fund - pavement outages and downtime for maintenance and rehabilitation contribute to the costs associated with aviation system delays.

New large aircraft can enhance airport capacity only if their introduction does not cause excessive pavement outages. While current pavement design standards have worked well, they may not accommodate the dramatic changes associated with the next generation of airplanes currently being planned. The next generation of large civil aircraft is expected to include models that will weigh up to 1.3 million pounds and have complex, multiple-wheel, and multiple-truck landing gear systems.

The question of whether these aircraft will damage airport pavements cannot be answered using existing data because very closely spaced tandem landing gears have never been tested for their effect on pavement life. It is unclear at what point current runway pavement will no longer be able to withstand the increasing weight and speed of such aircraft. Hence, while the next generation aircraft are still on the drawing board, researchers want to determine whether existing runways or taxiways will be able to support the kind of weight envisioned, or whether major pavement improvements will be required.

To help determine pavement needs, the FAA is testing airport pavement structures at its National Airport Pavement Test Facility (NAPTF). The NAPTF, built under a cooperative research and development agreement between the FAA and the Boeing Company, opened on April 12, 1999.

The facility is providing the full-scale testing information urgently needed to investigate the performance of airport pavement subjected to the complex gear loads of the new generation of aircraft. The technical data obtained will help validate new design standards and assure compatibility between aircraft and airports throughout the world and will supply an improved scientific basis for further development and refinement of the International Civil Aviation Organization's pavement loading standards for aircraft.

The test machine, the only such machine in the world, is located in a fully enclosed building, which is approximately 1,200 feet long, 100 feet wide, and 40 feet high. Pavement test sections are constructed using conventional construction equipment and techniques, thus representing actual field construction. The pavement test section area is approximately 900 feet long and 60 feet wide. This size permits simultaneous testing of 9 different pavement cross-sections.

Movable wheel module assemblies permit wheel groups to be moved up to 20 feet laterally and longitudinally, thus simulating a variety of landing gear configurations. Sensors are embedded in the pavement structures to monitor pavement conditions under loads.

In the current NAPTF config-

AIRPORT PAVEMENT TECHNOLOGY (CONT.)

uration of nine test pavements, data are acquired, processed, stored, and disseminated from over one thousand individual sensors using three data collection systems interconnected by wire and wireless local area networks (LANs). These sensors provide data on pavement performance that can be used to investigate the relative effects of four- and six-wheel aircraft gear loads, and to develop reliable failure criteria that can be used for development of mechanistic design procedures for airport pavements.

During 2001, the FAA completed the first set of full-scale tests at the facility. The FAA worked closely with the Boeing Company and an international working group in planning these tests, which involved subjecting nine test pavements to simulated B-747 and B-777 loading. Test speeds were 2.5 and 5 mph and the wheels were "wandered" side-to-side over a distance of 7 feet. The wander position was changed for every trip up and back along the test pavement according to a prescribed pattern over a 66-repetition cycle. Instruments embedded in the pavement structure automatically recorded the responses to the load.

The medium-strength subgrade conventional pavement was the first flexible pavement test item to fail at the NAPTF. The structure consisted of 5 inches of dense graded asphaltic concrete meeting the FAA specification P-401, 8 inches of P-209 crushed aggregate base course, and 12 inches of P-154 subbase course placed on a clay subgrade having a nominal (target) California Bearing Ratio (CBR) of 8 percent.

Researchers applied six-wheel traffic to the north wheel track and four-wheel traffic to the south wheel track. The test item was 60 feet wide and 62.5 feet long. The condition of the pavement structure was monitored during the tests by measuring the surface properties (rut depth, transverse profiles, and cracking). These measurements were used to determine when failure had occurred.

In the paper, "Subgrade Strains Measured In Full-Scale Traffic Tests With Four- And Six-Wheel Landing Gears," presented at the Airport Technology Transfer Conference, Gordon Hayhoe, FAA's Airport Technology R&D Branch, and Navneet Garg, Galaxy Scientific Corporation, discussed the significance of this test. Among other things, they concluded that according to the test data, a realistic theoretical model of flexible pavement response to airplane loading should include permanent deformation, moving loads with wander, repeated loading, and representations of structural parameters as functions of temperature and accumulation of damage.

Edward H. Guo, Galaxy Scientific Corporation, and Gordon F. Hayhoe and David R. Brill, FAA's Airport Technology R&D Branch, reported on tests of three types of Portland cement concrete pavements at the NAPTF in the paper, "Analysis of NAPTF Traffic Test Data," presented at the Airport Technology Transfer Conference. These test items were constructed on subgrades with various strengths (low, medium, and high).

Traffic loads consisting of four- and six-wheel carriages at 45,000 lbs. per wheel were applied on two lanes of the pavements along the longitudinal joints. After trafficking, researchers observed corner cracks in all three items. A total of 462 strain gages recorded the strain time history for most tests, and more than 90% of the sensors provided meaningful results. Analysis of a portion of the strain gage data yielded information about when, where, and how the observed corner cracks developed.

The data from the initial and follow-on NAPTF tests should result in new pavement design standards by 2006. To obtain more information on the NAPTF, including test data, see http://www. airporttech.tc.faa.gov/naptf/.

BUILDING BETTER PAVEMENTS

MODELING FUTURE NEEDS

It's a scene we've all seen many times: A plane is coming in for a routine landing at an airfield. Gear down, flaps extended, nose tilted slightly up, the aircraft continues its graceful descent until, with puffs of smoke from the tires, the main gear touch down, followed in a few seconds by the nose gear. The pilot applies the brakes and the plane slows down until it reaches about five mile per hour, the speed at which the plane can safely taxi to its hangar or gate.

We are often amazed at a plane's structural ability to withstand the stresses of takeoff, flight, and landing, but we rarely think of the pavement the plane is taxiing on, taking off from, or landing on. During takeoff and landing, and especially during taxiing, the airport pavement must support as much as 400 tons of aircraft, luggage, fuel, and passengers, all of which is concentrated on the relatively small contact patches of the plane's tires. And it must do so repeatedly, day in, day out, without significant distortion or damage that would compromise the safety of airfield operations.

And, in the economic spiral fueled by increased operational costs, planes keep getting bigger and heavier to carry more passengers or cargo. Yet, the pavement that a Boeing 727 can land on may not be suitable for the considerably greater weight of a 747 or an Airbus A310. How can airport engineers and designers be sure that airport pavements can support the weight of the planes intended for it? That's the province of people like the engineers at the FAA's National Airport Test Facility (NAPTF) at the William J Hughes Technical Center. They use sophisticated mathematical tools like Finite Element Analysis (FEA) and Finite Element Modeling (FEM) to examine the stresses that aircraft cause in pavement and predict how those stresses will affect the pavement's structural integrity.

There are many variables that can affect the behavior of airport pavement under stress, including the temperature, the weight of the plane, the configuration of the landing gear, the inflation pressure of the tires, the thickness of the various layers of pavement, the composition of those layers, and the elasticity of the pavement slab, to mention just a few. Such complex and interdependent calculations, some involving the solving of as many as 12,000 simultaneous equations, would take years for humans to perform, but can be solved in a matter of minutes by computer. Therefore, much of the engineering work involves the devising of computer programs to do the actual work of solving such complex FEA problems.

In addition to simply being able to crunch numbers quickly, computers give pavement engineers the ability to play "What if?"- in other words, to make small changes in the parameters and see quickly how those changes affect the final analysis results. As planes get bigger and heavier, and landing gear configurations become more complex, however, new programs have to be written that take into account the greater number of variables these situations involve.

A series of papers was presented at the recent FAA Airport Technology Transfer Conference in Atlantic City, NJ, that dealt with the issues of pavement evaluation and analysis, modeling and design

BUILDING BETTER PAVEMENTS (CONT.)

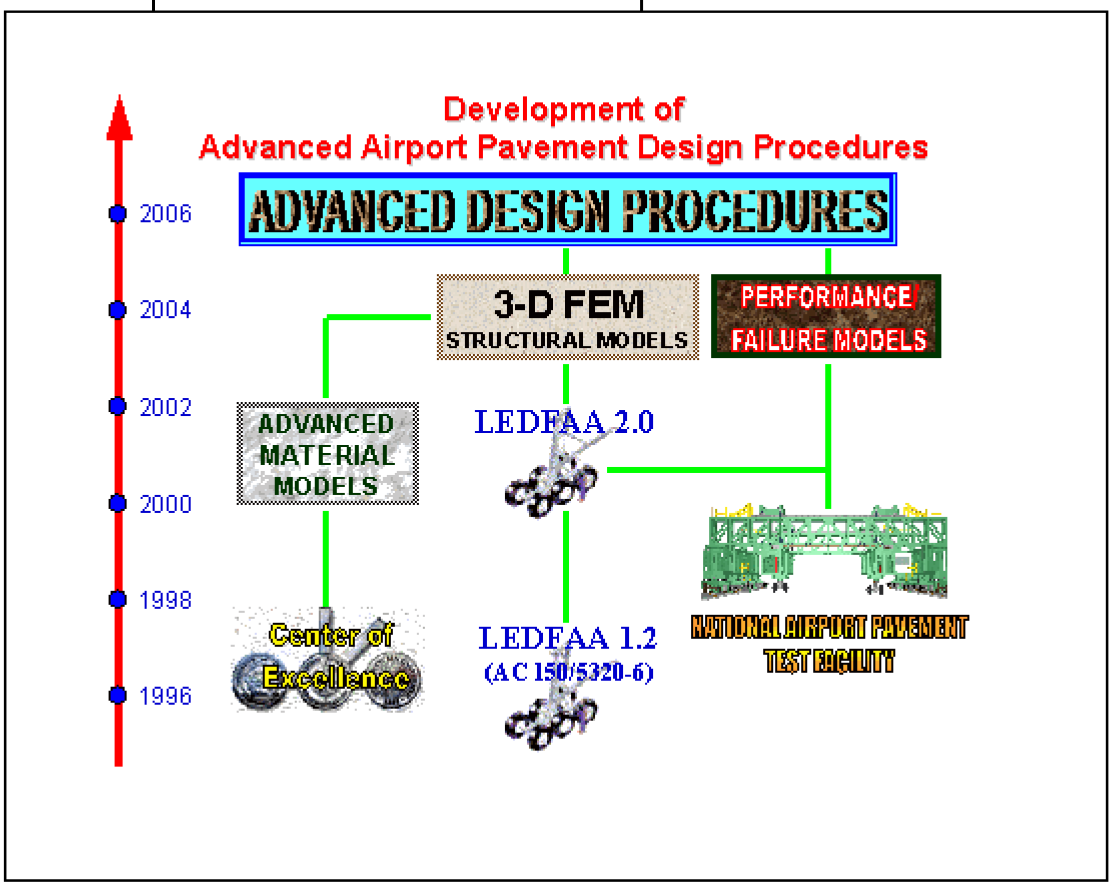
methods, and computer applications designed to perform the analysis and modeling.

In 1995, as part of Advisory Circular, AC 150/5320-16, the FAA introduced Layered Elastic Design - FAA (LEDFAA), a computer program for the design of airport pavements. Built around an earlier program designed by the U.S. Army, LEDFAA bases its pavement designs on critical pavement responses, such as stresses and strains, that it evaluates using a form of FEA, Layered Elastic Analysis (LEA), which is particularly well-suited to dealing with pavement slabs, which comprise several layers of pavement, subgrade and substrate. However, since its introduction, engineers have discovered that LEDFAA had certain limitations, particularly with regard to how it determines the stresses that occur at the edge of a pavement slab, and have written newer programs to compensate for these limitations.

LEAF, a new layered elastic computational program for pavement design and evaluation is one such program. In a paper presented at the conference, Dr. Gordon Hayhoe, of the FAA's Airport Technology R&D branch, explained that LEAF's objectives are to improve the efficiency of the layered elastic pavement responses of LEDFAA, and to provide a well-documented methodology and implementation suitable for further development. The program is written in Visual Basic 6.0, and is compiled as a dynamic link library. A sample application incorporating the dynamic link library is available as source code and as an installable executable file on the FAA Airport Technology web site, www.airport-tech.tc.faa.gov. Program documentation is also available at the web site.

Using programs like LEAF, LEDFAA, and others, pavement engineers are working to ensure that airport pavements are being designed to safely support the Boeing 777, the Airbus A380, and the other members of the new generation of people and cargo carriers.

For additional information, please contact Dr. Gordon Hayhoe at gordon.hayhoe@tc.faa.gov or visit the website at http://www. airporttech.tc.faa.gov/pavement/.



WILDLIFE STRIKE MITIGATION R&D PROGRAM

ENSURING SAFETY AT AIRPORTS

Introduction

The presence of wildlife on and near airports creates a serious hazard to operating aircraft. In recent years, the increase in passenger traffic, the introduction of much quieter engines on newer planes, and a very large increase in wildlife population, have all contributed to a significant increase the risk of collisions between aircraft and wildlife.

In the year 2001, over 6,000 strikes were reported. Annually, aircraft collisions with birds and animals cost the U.S. civil aviation industry almost than $400 million in aircraft damage and associated cost and almost 500,000 hours of aircraft down time.

The FAA has an aggressive research program, which is helping to mitigate wildlife strikes with aircraft by providing practical solutions as well as real-time critical information to pilots and airport managers. The ongoing research can be categorized into the following areas:

- Wildlife Habitat Management of Problem Species at Airports
- Dispersion of Problem Species at Airports
- Development of the FAA National Wildlife Strike Database
- Development of a Real-Time Radar-Based Bird Strike Advisory System

Wildlife Habitat Management of Problem Species at Airports

At airports, long-term management of problem species can be attained through habitat management. Under this approach, researchers are studying the habitats of problem species at airports. Once a specific habitat is understood, habitat modifications are undertaken to make it less desirable to the problem species. For instance some airports actively manage vegetation type and vegetation height. This makes airport grounds less attractive to some types of birds. Over time it is expected that the overall population of the problem species will diminish. The main advantage of this type of approach is that it provides a foundation for understanding the airport environment from a scientific and ecological perspective. The main disadvantage is that solutions are long-term in nature and, hence, these solutions take a long time to implement.

Dispersion of Problem Species at Airports

When wildlife becomes a source of danger to aircraft, immediate remedial techniques need to be used. Researchers in this area are focusing on developing and testing tools to actively harass and disperse problem species. Techniques for the most part depend on the use of noise, visual effects or other sensory effects. One example of a promising technique is the use of lasers. Various types of eye-safe lasers are being

Continued on page 10

SCENES FROM THE AIRPORT TECHNOLOGY TRANSFER CONFERENCE

Wildlife Strike Mitigation (cont.)

(continued from page 7)

investigated, and preliminary tests have shown that these are effective at dispersing Canada Geese at dusk and dawn. Other dispersion techniques that have been tested and evaluated by the FAA include the use of strobe lights, noise makers, and microwaves.

Development of the FAA National Wildlife Strike Database

The FAA has been collecting wildlife strike data since 1965, and through the year 2000, about 33,000 strikes had been reported, verified and filed in the FAA National Wildlife Strike Database. In 2001, the FAA made it possible to report wildlife strikes online.

As of December 31, 2001, over 49,000 incidents were reported and filed into the database. In 2002, the FAA is migrating its National Wildlife Strike Database into a more versatile format and is developing tools to let authorized users query the data over the internet.

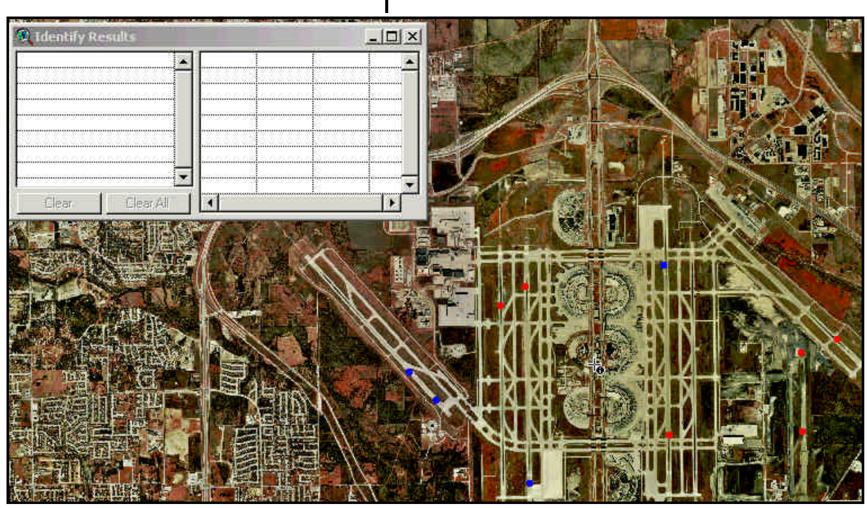
Development of a Real-Time Radar-Based Bird Strike Advisory System

The FAA, in conjunction with a National Safety Transportation Board (NTSB), recommends investigating the use of radar as the most promising and reliable bird detection technology.

In 2002, the FAA, in partnership with the U.S. Air Force and private industry, is developing and testing a small portable radar dedicated to the detection of birds at airports and military airfields. The prototype radar will be tested at a major commercial airport. The unit will be placed at the end of a bird-prone runway and will scan the departure and approach path.

Data from one or multiple radar units will be screened and mapped to a detailed Geographic Information System map of the airport. All data will be forwarded onto an airport server which can be accessed by pilots doing pre-flight, airport personnel, airlines, and FAA Air Traffic Control.

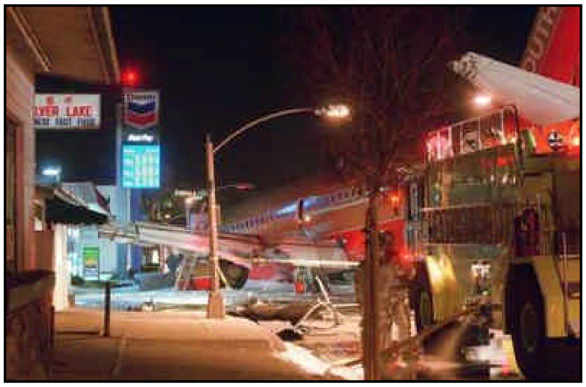
For additional information about this research program, please visit our website at http://wildlife-mitigation.tc.faa.gov or call at (609) 485 -5250.



Strike Information is available for birds and mammals from airport records. Airport radar will be positioned to cover critical airspace.

RUNWAY SURFACE TECHNOLOGY

ENHANCING SAFETY AND CAPACITY


A Boeing 737 overrun at Burbank, CA.

A critical safety concern at airports is the runway surface condition. Snow, ice, water, and rubber deposits can result in slipperiness, causing an aircraft to lose control during braking, and making surface movements hazardous. Although the advent of grooved runways to control surface water has greatly reduced hydroplaning in recent years, aircraft accidents from overshooting or veering off a runway remain a problem.

During the last 15 years, there have been 130 accidents involving aircraft overruns and veer-offs. The accidents involved runway surfaces, which were covered with water, ice, snow, or slush. In particular, three major aircraft accidents, at Washington National Airport on January 13, 1982, at Boston Logan International Airport on January 23, 1982, and at John F. Kennedy International Airport on February 28, 1984, resulted in the complete loss of all three aircraft and a total of 80 fatalities, focused national attention on the question of runway slipperiness and loss of control during landings and takeoffs. The National Transportation Safety Board identified runway slipperiness and an inadequate "safety area" beyond the end of the runway as factors contributing to these accidents.

At the recent Airport Technology Transfer Conference, researchers shared information on new developments, technologies, and techniques to improve runway surface conditions. In particular, scientists from organization such as NASA, Transport Canada, and the University of Nebraska-Lincoln shared data on a variety of research programs encompassing runway friction testing, airport pavement deicing and deicing alternatives.

The Conference also provided a forum to highlight the FAA's runway surface technology R&D program. As part of the agency's overall goal to reduce commercial aircraft accidents, the FAA's runway surface research program is working to eliminate runway slipperiness as a cause of accidents, and to stop all aircraft within the extent of the runway . To achieve this goal, extensive research, testing, and evaluation are being conducted to develop new techniques to remove ice, snow, and rubber deposits efficiently, and methods to prevent ice and snow accumulations on runway surfaces by using anti-icing chemicals and coating systems.

Equally important is an effort to harmonize the manner in which winter runway surface conditions are measured and reported to pilots. The Joint Winter Runway Friction Measuring Program is spearheaded by NASA, Transport Canada, FAA, and at least 10 other countries that face the challenges of winter operations. Testing has been conducted in the northern U.S., Canada, Germany, and the Czech Republic over the last six years. In addition, new materials and methods are being investigated to decelerate aircraft safely should there be an overrun. Some of the FAA's R&D successes are outlined below.

Soft Ground Arrestor System

Aircraft can and do overrun the ends of runways, sometimes with disastrous consequences. To minimize the hazards of overruns the FAA requires a safety area 1,000 feet in length beyond the end of the runway. Although this safety area is now a FAA standard, many runways were constructed prior to its adoption. For those locations that do not have the

RUNWAY SURFACE TECHNOLOGY (CONT.)

space for full safety area, soft ground arrestors provide an engineered solution to restore a margin of safety.

"Soft ground" means any material that will deform readily and reliably under the weight of an aircraft tire. As the tires crush the material, the drag forces decelerate the aircraft. This FAA research program began in the early 1990s with the development of a mathematical model of the wheel/ground interface and ended with the installation of the world's first soft ground arresting system in 1996.

On May 8, 1999, this key product of the FAA R&D program paid a huge safety dividend. That day, an American Eagle flight ran out of runway while trying to land at John F. Kennedy International Airport. The Saab 340 commuter aircraft overshot the runway, stopping 248 feet into the 400-foot long arrestor bed, only 200 feet from the waters of Thurston Bay. All 30 on board walked off the aircraft. Damage to the aircraft was minimal; damage to the bed was restricted to a section 30-feet wide and 250-feet long.

Ironically, an accident on the same runway at JFK in 1984 served as the impetus for developing the arrestor system. A DC-10 aircraft overshot the runway in February of that year and landed in the water. More than 170 passengers had to swim ashore in the icy waters. That accident produced parallel research efforts by the agency and the Port Authority of New York and New Jersey, which oversees JFK, into materials that could slow the momentum of aircraft.

The American Eagle flight stopped in the arrestor bed at JFK Airport, May 8, 1999.

"The idea to use soft material to slow down a runaway airplane builds upon the laws of physics. As the wheels of the airplane crush or push aside the soft material, the energy of the moving airplane is absorbed by the arrestor bed," explained Jim White, civil engineer with the FAA Airport Technology R&D Branch that specializes in airport safety systems. "Our job in airport safety research was to develop and test a system that could slow down a half-million-pound airplane quickly and in a predictable way."

Using sophisticated modeling techniques that predicted the resistance characteristics of different materials, FAA researchers worked from 1986 through 1993 to test the concept, eventually developing a foam that could halt the agency's Boeing 727 test aircraft. The next step was to identify a material that could stop a larger aircraft, such as a DC-10. In a bit of fortuitous timing, the FAA had just begun its technology transfer initiative, which encourages agency organizations to share their research with companies to develop new and safer products for aviation use.

One such company was ESCO, based in Aston, PA. The FAA signed an agreement in which ESCO worked side by side with the FAA to develop and test a practical system. ESCO provided the industrial might; the agency matched their contribution with a wide variety of resources. Realizing that testing would eventually have to be completed at an operating airport, the FAA also signed a cooperative agreement with the Port Authority.

The result of the cooperative efforts was a form of concrete that can be crushed by hand. This crushable concrete comprises three remarkably basic elements: water, cement, and something akin to soap bubbles. In this case, however, very fine amounts of cement, rather than soap, were used in the film that entrained - or captured air. Maintaining the consistent size and distribution of these delicate "cement bubbles" throughout the material is the key in producing a substance that is dense enough to slow a fast-moving aircraft, but not so dense as to cause an aircraft to bounce off or skim over its surface.

The arrestor bed was put in place at JFK in 1996, at a cost of approximately $2,600,000. LaGuardia joined JFK with the installation of an arrestor bed in 1998. Now, dozens of airports around the country are negotiating with private companies to install similar beds at their facilities. Recent innovations have improved the durability of these systems to withstand severe jet blast forces generated during during takeoff. Jet blast resistant beds have been installed at Rochester, NY, and Burbank, CA, the scene of a dramatic (but non-fatal) overrun by a Boeing 737.

Improving Runway Friction

In spite of advances in technology and operational procedures, safe winter operations remain a challenge for airport operators, air traffic controllers, airline personnel, and pilots who must coordinate their efforts under rapidly changing weather conditions.

Ice or snow on a runway is a significant factor in airplane accidents. Inaccurate, incomplete or confusing runway surface information has been a contributing factor in a number of cases in which airliners have slid off the end of the runway upon takeoff or landing or have been dangerously slow in reaching liftoff speed because of the slowing effect of snow, ice or rain. According to the National Transportation Safety Board, an aircraft's loss of traction has been a factor in approximately 30 airplane accidents between 1983 and 1995.

On an airport runway, friction is indispensable. Airport operators monitor runway conditions for friction and contaminants. A runway that has a surface condition other than bare and dry is termed "contaminated," and any amount of contaminant may reduce friction. To maintain acceptable operating conditions, airports use plows, brooms, and blowers to remove loose contaminants from pavement surfaces, and chemical agents to reduce the effects of runway ice and compacted snow.

As an aircraft approaches for landing, the control tower relays information to the pilot about these surface conditions as well as information about current wind, visibility, precipitation, and air traffic. The responsibility for the decision to land or not to land (the "go/no-go" decision) ultimately rests with the pilot. The pilot makes the decision based on the information supplied by the control tower and the pilot's knowledge of the aircraft. The pilot also takes into consideration factors such as the available landing distance and accessibility of alternate landing sites in making the go/no-go decision.

As part of an international effort, the FAA is working with NASA and Transport Canada to create a system that allows airport operators to get a better handle on winter weather conditions to reduce the amount of accidents attributed to ice and snow on runways. The Joint Winter Runway Friction Test Program, which just completed its seventh year of testing, focuses on advancing safe operations of aircraft when winter contaminates are

Runway friction test, using the FAA Boeing 727.

Runway Surface Technology (cont.)

present on the runway surface.

In particular, the test program is carefully examining the interface between the aircraft's braking performance and reported friction data to predict accurately the aircraft stopping distance requirements on winter contaminated surfaces. The results are expected to enhance safety for all ground operations and help relieve airport congestion during bad weather. Additionally, the research will help industry develop improved tire designs, better chemical treatments for snow and ice, and runway surfaces that minimize bad weather effects.

Although not required, many airports do evaluate runway friction by means of vehicle-mounted or trailer-mounted friction testers. Because different airports use different friction testers, however, values applied to runway friction conditions have not been consistent from one airport to another. And, because different types of aircraft behave differently on a given runway friction condition, identifying the stopping capability of an aircraft once the friction value is obtained has not been a clearly defined process.

Complicating the winter weather picture is that, for a given contaminated runway condition, criteria for safe operations differ from airport to airport because of differences in runway dimensions, pavement materials, and textures. A step toward decreasing ground handling difficulties is to standardize and harmonize friction tester values so airports can provide pilots with uniform and reliable runway condition information that is independent of the type of measuring device.

To achieve this goal, FAA, NASA, and Transport Canada researchers are comparing friction measurements from ground-friction-measuring vehicles and research aircraft in different winter runway conditions. They are integrating data from manual contaminant analyses, friction tester measurements, and aircraft instrumentation. Analysis of these data sets shows the effects of many parameters on aircraft and ground vehicle braking friction under various surface conditions. Researchers are harmonizing this data to create a consistent friction value, or "index" for similar contaminated runway conditions.

The index -- probably in the form of a simple chart -- will help pilots with "go/no-go" runway decisions based on readings taken by a ground-friction-measuring vehicle on the same runway. The index will help airport operators determine whether their runways are suitable for aircraft operations and maintenance procedures.

Data obtained during 1996 and 1997 helped define the methodology for an International Runway Friction Index (IRFI) to harmonize the friction measurements obtained by the different testers. Researchers used selected data from the first three years of testing to establish a Canadian Runway Friction Index (CRFI), an abbreviated version of the IRFI. Data from testing in 1998-2000 refined and improved the IRFI methodology. Data analysis in progress will further improve the harmonization of friction tester measurements for the IRFI.

Testing thus far has used nine instrumented aircraft and 15 friction testers from Austria, Canada, France, Germany, Norway, Scotland, Sweden, Switzerland, and the United States at test sites in Canada, the United States, Norway, and Germany. Friction tester manufacturers, aircraft manufacturers, airports, airlines, and government agencies of eight countries have participated.

For further information on the FAA's runway surface research, please contact Jim White at jim.white.@faa.gov or visit the http://www.airporttech.tc.faa.gov/Safety/surface.asp.

AIRPORT SAFETY RESEARCH

IMPROVING RUNWAY SAFETY

Improving runway safety at our nation's airports is one of the highest priorities of the FAA. The United States has the largest, most complex, and busiest air transportation system in the world. On any given day the National Airspace System handles more than 175,000 takeoffs and landings.

Though the system is quite safe, mounting evidence indicates that safety may be jeopardized by events on the airport surface known as runway incursions. A runway incursion is defined as an occurrence at an airport involving an aircraft, vehicle, person, or object on the ground that creates a collision hazard with an aircraft taking off, intending to take off, landing, or intending to land.

In an effort to improve runway safety, FAA researchers and engineers are working with the aviation community to eliminate runway accidents from happening. The recent Airport Technology Transfer Conference highlighted some of this work, such as visual guidance and signage.

As Donna Speidel, President of Speidel Construction, aptly pointed out at the conference, "airfield markings have been identified as part of the cure for runway incursions . . . as long as there are airplanes and airports, there will be a need for clearly defined, standardized, accurate airfield markings, distinctly visible under all weather conditions which will continue to play a vital role in safely guiding traffic on and off the AOA."

Visual Guidance

The agency's visual guidance research is determining if more efficient and cost effective technologies can be adapted at airports to improve safety. These efforts focus on developing performance specifications for visual guidance systems that have reduced 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).

As part of this effort, Agency researchers have 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,

AIRPORT SAFETY RESEARCH (CONT.)

except for snow conditions, improve nighttime visibility when standing water covers the pavement.

Another new technology being developed by the FAA is the Advanced Taxiway Guidance System (ATGS). This system provides an improved airport surface guidance to aircraft during night and or low visibility operations, using an automatically controllable taxiway lighting system to provide improved surface visual guidance to pilots. In addition to receiving taxiing instructions from air traffic control, the automatic lighting feature provides the pilot with a visual confirmation of the assigned route by illuminating only that particular path. By illuminating only the taxiway segments that are needed to comply with the air traffic clearance, the possibility of pilot route deviations and inadvertent runway incursions will be reduced.

The FAA established an ATGS test bed at the Atlantic City International Airport. The FAA-developed prototype ATGS incorporates relatively inexpensive non-radar-based sensors to provide aircraft identification and location on the taxiways. A host computer controls the entire system. It includes a processor that receives aircraft location, identification, destination, and direction of travel information from sensors located within the taxiway test bed. Based on the input from the sensors, the host computer determines which groups of taxiway lights need to be illuminated to provide the necessary visual guidance to the aircraft's destination. The host computer also detects potential runway incursions, taxiway routing conflicts between aircraft, incorrect aircraft turns, and any abnormal system operation.

A major subsystem of the ATGS is the lighting control computer equipment that is located in the airfield lighting vault. This computer acts on command from the host computer. After the host computer analyzes which groups of taxiway lights need to be illuminated for a particular aircraft, it then issues an electronic command to the lighting computer. Based on the input from the host computer, the lighting computer equipment sends signals over the appropriate taxiway power cables to illuminate the correct groups of lights. The lighting computer equipment also monitors all of the lights and aircraft location sensors within the test bed and informs the host computer of any malfunctions with these components.

The other major components of the ATGS are all located within the taxiway test bed. There are twelve microwave barrier detectors located throughout the test bed. As an aircraft taxies past each microwave detector along the intended route, the groups of taxiway lights behind the aircraft will be automatically turned off assuming that there are no other aircraft in trail that would need those lights

for guidance. The microwave detectors are also used to immediately trigger an alarm if an aircraft makes an incorrect turn.

A radio frequency identification system (RFID) is installed within the test bed area and is used to uniquely identify aircraft without the use of radar. The RFID system consists of four reader units, four antennas, and the identification tags that are installed on the FAA test aircraft. Each test aircraft is equipped with an identification tag on each side. As the tagged aircraft approaches a reader antenna, it interrupts the stream of radio frequency signals that the antenna is broadcasting. When the reader interrogates the tag, it modifies a portion of the signal and reflects it back to the antenna. This reflected signal carries the identification code of the aircraft. The antenna transmits the reflected signal to the reader unit that interprets the identification information.

Tests of the system the Atlantic City International Airport proved successful and pilot comments on the system were very positive. Although FAA researchers successfully evaluated the prototype ATGS, further in-service testing at a major airport is needed to validate the concept. Additional research for an upgraded ATGS will include the feasibility of integrating automatic taxiway lighting systems with ASDE and AMASS. This will demonstrate that automatically controllable lighting can be added at airports that already have these systems.

Airport Signs

Airport signs at certain critical locations at major U.S. airports are being sheared off their mountings by aircraft jet engine blast and/or wake turbulence forces. This damage to signs increases the chance of foreign object damage to aircraft as well as the loss of visual guidance for other aircraft.

To help understand how to remedy this challenge, the FAA conducted a study to investigate the forces exerted on airport runway signs caused by aircraft jet engine blast and wake turbulence. The project comprised four individual tests. Researchers conducted two laboratory tests to determine the elastic/plastic limitations of the frangible couplings of an airport sign and to determine the strain on the sign (specifically the couplings) at various wind speeds with and without turbulence.

Researchers also conducted two field tests using the current design criteria at the Chicago O'Hare International Airport to investigate the load at which airport signs were structurally failing in the airfield environment and to measure the maximum forces experienced by these airport signs.

A supplemental test was conducted to compare the effects on signs installed at the FAA maximum setback distance of 35 feet from the runway edge and at the International Civil Aviation Organization (ICAO) outer limit of 49 feet from the runway edge. Since the end of March 1999, informal field tests have been conducted at Chicago O'Hare International Airport using a slightly different sign design and stronger frangible couplings. To date, these signs have not failed.

The results of these tests indicate that the current frangibility design criteria on airport signs installed at the FAA maximum setback distance is not adequate for signs installed on airports that service large transport aircraft; whereas the current frangibility design criteria is acceptable for the ICAO setback distances.

Additionally, preliminary tests indicate that a more stringent frangibility requirement would accommodate the FAA maximum setback distances. Therefore, a modification to the frangibility requirements or maximum setback distance would appear to be a satisfactory solution to mitigate sign breakage. The former is recommended since it would appear to have no impact on the operational characteristics of the aircraft movement area.

The FAA's Visual Guidance R&D Program has an on-going commitment to seek out new technologies, which may be applicable to airport visual aids. For more information contact Paul Jones at paul.jones@tc.faa.gov.

AIRPORT RESCUE AND FIREFIGHTING

RESEARCH THAT SAVES LIVES

It is estimated that forty percent of aircraft accident fire fatalities can be attributed to smoke and toxic products combustion from burning cabin materials and jet fuel. Unlike in-flight fires, which originate from relatively small ignition sources and usually take some time to develop, postcrash fires are extremely severe from their onset. In most cases, the fire originates from the ignition of large quantities of spilled jet fuel. The main concern is the spread of the fire into the aircraft and the effect of burning interior materials on passenger evacuation and the creation of untenable conditions.

Aircraft fire issues are unique when compared to fire safety issues in buildings, residences, and ground transportation. During an aircraft crash, impact energies, coupled with the highly flammable aircraft fuel load, result in a high potential for exterior fuel fires and injuries or fatalities. The survivability of crashes or other incidents occurring on the airport surface can depend on the speed and effectiveness of airport rescue and firefighting actions.

To improve survivability, FAA researchers are working with the aviation community to improve airport firefighting capabilities. Together, the FAA and industry are making great strides in improving survivability under the extreme conditions of a postcrash fire.

many different models of the existing commercial aircraft designs have been easily penetrated with the boom-mounted cabin skin penetration system. Currently, numerous national and international airports are using these specially designed firefighting vehicles in their fleets.

Heavy Rescue Aircraft Firefighting (ARFF) Vehicle Operations

An important part of firefighting response at an airport is ensuring rescue vehicles make it safely to the accident site. Forty-eight airport rescue and firefighting vehicle rollovers have occurred since 1977. This is an alarming number of occurrences considering the few miles and operational hours that the rescue and fire services use these vehicles each year.

To understand why such vehicle accidents occur and to help prevent future incidents, the FAA is currently conducting a heavy rescue vehicle rollover study. This is a dynamic study of performance specific requirements of the heavy rescue airport emergency vehicle and their dynamic stability requirements as well as the development of an online reporting system.

As part of this safety effort, the FAA upgraded vehicle performance testing requirements. New testing requirements of ARFF vehicles include a constant turning radius standard and the ability to demonstrate 90 degree J-turns at a simulated rescue response speed. All of these new test procedures are contained in the 150-5210-10C

Advisory Circular, published in March 2002.

It is also important to ensure ARFF vehicle operators are fully trained. In addition to basic airport driver familiarization training, specialized operational skills must be taught to those individuals who drive emergency response vehicles and other vehicles, such as snowplows and maintenance dump trucks on airfields.

A possible solution may be one proposed at the recent FAA Technology Transfer Conference. Joseph A. Wright, of Crash Rescue Equipment Services, Inc. of Dallas, Texas, presented a paper describing Training Wheels, a mobile rescue vehicle driver trainer/simulator. Using computer-generated virtual reality technology, Training Wheels provides a completely safe, realistic substitute for vehicle operational training. Contained within a 44-foot mobile air-conditioned trailer with portable classrooms and two driving positions simulators, operators are presented with challenging driving situations.

Training Wheels is capable of providing numerous training scenarios, which present drivers with challenging situations. These scenarios can be adjusted and changed based on the driver's skill level. The computer interactive software allows environmental conditions to be changed as necessary. Drivers are provided the opportunity to drive on the airfield, around the airport vicinity, on highway or in city driving conditions.

The Rescue Vehicle of the Future

The FAA's ARFF Research Program has been conducting a study on the feasibility and demand for an Interior Intervention Vehicle (IIV). The primary function of this new concept vehicle will be to aid fire fighters in making rapid entry into an aircraft fuselage, as well as aid in the exit of passengers, while still maintaining adequate fire fighting capability.

There are inherent hazards in using extension-type ground ladders to gain access to the cabin of an aircraft. These hazards are further complicated by slippery surfaces caused by a blanket of fire-fighting foam and the mass of panicked passengers trying to escape the accident scene. The varying dimensions of the different aircraft that may need to be accessed, in combination with the above hazards, create a serious hazard for fire fighters, and a potentially equal hazard to the evacuating passengers.

Many innovative fire departments have taken the initiative to utilize readily available airport equipment to assist them in these types of situations. Such equipment includes both mobile and portable air stair units. While this type of equipment will work in certain situations on certain aircraft, it will be of limited benefit responding to a large aircraft like a B-747 or any of the proposed new large aircraft with a second level flight deck and passenger seating. These vehicles also have little or no standalone fire extinguishing capabilities. Some departments have plumbed a dry standpipe system into their air stair units with a host reel on the platform. This allows for a more rapid entry into the aircraft, but the vehicle is still limited by its need to be supplied by another piece of fire apparatus.

TECHNOLOGY TRANSFER

PARTNERING FOR SUCCESS

Center of Excellence for Airport Technology

The FAA has established a Center of Excellence (COE) for Airport Technology at the University of Illinois at Urbana-Champaign (with academic affiliates at Northwestern University, Chicago, IL, and Embry-Riddle University, Prescott, AZ). Started in 1995 as the Center of Excellence for Airport Pavement Research, the Airport Technology COE is the oldest of four currently active FAA Centers of Excellence, and was the first COE to be selected through a competitive proposal process. Currently, there are COE research projects in such major areas as: concrete fatigue, modeling asphalt overlays for runways, advanced materials characterization, and analysis of instrumented airport pavements.

In 1999, the COE's mission was expanded to include an airport safety component - airport wildlife hazard mitigation. Research in this area will help reduce the future risk of damaging bird strikes. To date, the FAA has supported the COE with approximately 3 million dollars in research grants.

At any given time, the COE supports a large number of graduate students, including about 8 doctoral candidates. To date, the COE has completed 18 doctoral dissertations, in addition to over 150 peer-reviewed papers, technical reports, and other publications.

A program in place since 2001 provides 12-week summer internships for students from Historically Black Colleges and Universities, designed to increase the number of underrepresented minority students pursuing Ph.D.-level studies in civil engineering studies related to airports. In FY-2001, 6 students participated in this program.

COE faculty and graduate students were well represented at the recent FAA Airport Technology Transfer Conference in Atlantic City. The COE contributed five papers to the conference on research in concrete and asphalt airport pavement modeling and in bird strike hazard mitigation technologies. A number of these papers were presented by the student authors.

Cooperative Agreement with the Innovative Pavement Research Foundation

One of the goals of the AIR-21 legislation was to improve the "design, construction, rehabilitation and repair" of concrete airport pavements. In fulfillment of this, the FAA Airport Technology R&D Branch is currently in its second year of a cooperative agreement with the Innovative Pavement Research Foundation (IPRF).

IPRF, based in Falls Church, VA, is a non-profit research foundation sponsored by the American concrete industry, and devoted specifically to concrete pavement research and technology transfer. In fiscal year 2001, the FAA provided 2.0 million dollars for concrete research through IPRF, including such innovative projects as developing a "best practices" construction manual for airport pavements and investigating ultra-thin whitetopping (UTW) as a rehabilitation option for light-load airports. In fiscal year 2002 additional 2.0 million dollars are available for concrete research.

The activities of the FAA-IPRF cooperative agreement are guided by a Program Coordination Group (PCG), which includes representatives of industry, government contractors, airport owners and operators, and other airport stakeholders.