Federal Aviation Administration

R&D Review

News Source for the FAA Air Traffic Organization's Operations Planning Research & Development Office

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Applauding Excellence

in this issue

A Message from the R&D Director

R&D Fiscal Year Highlights

Congratulations to our FAA scientists and researchers. Last year their successes included new programs and products that are improving the safety, efficiency, and environmental compatibility of aviation for years to come.

We have accomplished major improvements in aircraft safety. The FAA Full-Scale Aircraft Structural Test Evaluation and Research facility tested the strength of fuselage rivets to detect – and eventually even predict – cracks in airplane skins. In addition, FAA specialists are analyzing how to inspect aircraft without disassembling them. Since more new aircraft are being made of composite materials, our researchers at the FAA Airworthiness Assurance Center of Excellence worked with their Iowa State University counterparts to develop an important new nondestructive ultrasonic inspection technique. Similar research involves rotorcraft at the FAA Airworthiness Assurance Nondestructive Inspection Validation Center at Sandia National Laboratories, where researchers are working with industry to help inspectors discover small cracks hidden under fasteners.

You will find aviation technical manuals upgraded and easier to read thanks to an FAA project with aircraft manufacturers and the Wichita State University National Institute for Aviation Research. Researchers developed this online Evaluation Toolbox for Aviation Technical Writers: http://www.niar.twsu.edu/humanfactors/toolbox/default.htm.

We have perfected a new technology to prevent in-flight fuel tank explosions. This onboard fuel tank inerting system generates nitrogen or nitrogen-enriched air to displace the air above the tank's remaining jet fuel. You may read the final report at http://www.fire.tc.faa.gov/pdf/05-25.pdf. FAA experts are also developing new fire test methods for thermal acoustic insulation, while seeking alternatives to a mandate to replace insulation blanket.

Last year, our researchers acquired a new vehicle to help them determine more sophisticated Aircraft Rescue and Fire Fighting (ARFF) procedures and practices. The new, larger ARFF truck will help adapt fire protection standards for large aircraft, such as the Airbus 380 that will be introduced this year. Engineers at the FAA National Airport Pavement Test Facility are evaluating the impact of heavy aircraft on airport surfaces. They will update the FAA's thickness design standards for the concrete pavements now being installed, as well as for rehabilitating existing pavements.

By reversing the configuration for centerline lights of taxiway approach, Visual Guidance specialists found a cost-effective way to alert pilots that they were moving from runways to taxiways. Our researchers also demonstrated a redesigned Runway Obstruction Warning System in which a network of sensors embedded in runways and taxiways are monitored in the control tower.

We also are working to increase capacity. A cost analysis is underway to see whether we should invest further in a new surface traffic management system that we demonstrated, jointly with NASA, last year at Memphis International Airport. The FAA also installed a surface traffic management that United Parcel Service controllers are now using to monitor the loading, unloading, and refueling of cargo jets.▶

The FAA will decide soon about nationwide deployment of Automatic Dependent Surveillance – Broadcast. Our leading "technology opportunity," ADS-B sends a radio message every second giving an aircraft's identification, position, velocity, and other information. Under the Safe Flight 21 program, ADS-B will expand to Pennsylvania and Tennessee from its current use on the lower two-thirds of the East Coast and parts of Ohio, North Dakota, and Arizona. The similar program in Alaska, Capstone, has resulted in safer skies for areas lacking radar coverage.

Our human factors researchers developed a web-based tool to help planners and construction engineers make informed decisions on air traffic control towers. They also are developing a modular concept for building towers, and are designing a future en route workstation to increase productivity of air traffic controllers. Together with NASA, Boeing, FedEx, passenger carriers, airline labor unions, and St. Louis University, we released a simplified "Operator's Manual for Human Factors in Aviation Maintenance." FAA human factors specialists are also improving training for aircraft inspectors.

Over the past year, the FAA refined the Human Factors Analysis and Classification System (HFACS), which examines human error associated with commercial and general aviation accidents. Our researchers have integrated HFACS and other traditional situational and demographic variables into a single database that the National Transportation Safety Board has made available on its web page.

Forensic toxicologists at the FAA Civil Aerospace Medical Institute are making significant advances in aerospace medicine. Some medical researchers are working to identify human genes associated with alcohol impairment, while others are evaluating the safety implications of granting licenses to pilots with heart conditions to validate current health certification procedures.

The FAA Aviation Weather Research Program is investing in new sensor development and radar technology. Researchers finished developing a product that detects freezing drizzle to upgrade the Weather Support to Decision Making System used at Denver International Airport. Our research into convective weather included a demonstration near Chicago that led to new ways to detect surface effects and to predict thunderstorms earlier.

FAA researchers are developing a Real-Time Verification System to assess the quality of weather forecasts (http://www-ad.fsl.noaa.gov/fvb/rtvs/). The National Weather Service installed the prototype last summer. Researchers have now added higher resolution graphics and additional weather information to update the Rapid Update Cycle model.

Along with NASA, we are creating analytical tool modules to help educate the public about the affects of aviation noise and emissions. Universities in the Partnership for Air Transportation Noise and Emissions Reduction (PARTNER) are developing the Environmental Design Space and the Aviation Environmental Portfolio Management Tool. Researchers at the Volpe National Transportation Systems Center lead industry partners in completing a prototype of a third module, the Aviation Environmental Design Tool.

In FY 2005, the FAA Office of Commercial Space Transportation incorporated its work on non-traditional flight safety systems to an autonomous one NASA is developing and testing. They hope to formulate future regulations for use aboard spacecraft and space stations. Researchers expect to improve planning for expendable vehicle launches by studying weather data on more than 300 rocket launches. In other projects, scientists are analyzing the risk of debris-related casualties in nearby buildings if an accident should occur during blastoff.

This summary provides only a brief snapshot of the R&D activities we have undertaken in the past year. I hope you will visit our website, http://research.faa.gov, where you can see our 2005 R&D Annual Review. I invite you to keep up with current R&D developments on our frequently updated website and to download the FAA *R&D Review*, our quarterly news source, which further describes our programs.

Joan Bauerlein
FAA, Director of Operations Planning
Research & Development R&D Review

Preventing Runway Incursions

FAA Tests New Taxiway Screens

FAA airport safety researchers have created a prototype taxiway screen that can help prevent runway incursions at airports with taxiways that extend beyond the ends of runways. These screens can be placed at the end of a runway to block the view between that runway and an end-around taxiway.

End-around taxiways are built beyond the 1,000-foot runway safety area. Atlanta's Hartsfield-Jackson and Detroit's Metro airports have such taxiways, and one will be installed at Dallas-Fort Worth International Airport to allow aircraft to move between the runways and terminal gates without crossing active runways. In addition to safer operations, the taxiways have the potential to increase capacity.

The front portions of the screens only show aircraft that are taxiing on active runways. Aircraft that are located on end-around taxiways appear in the rear portion of the screens. Pilots in line for take off can safely focus their attention on the aircraft that are most critical to their departure.

"This project helps address two of the FAA's key challenges: increasing airport capacity and reducing runway incursions," said Joan Bauerlein, FAA Director of Aviation Research and Development. "Our researchers are working on engineered solutions to improve safety at airports, especially those that are limited in their ability to expand."

"The first prototype system that FAA researchers built and tested is a 112-foot long, 13-foot high plastic cardboard screen set up on two mobile trailers, allowing for easy movement on and off the runway," explains Jim Patterson, R&D project manager. "The screens are being tested in different configurations."

In the first test of the prototype, researchers set up the screens at Atlantic City International Airport, at the end of the 10,000-foot runway 13-31. They used an airport vehicle to simulate an airplane taking off, and videotaped its movement along the runway to see how well the screens blocked a pilot's view of the taxiway areas, beyond the end of the runway.

At the end of Runway 13, trucks had formed a prototype screen by lining up two trailers parallel with each other, the trailer in front hiding the truck towing the second one. To the test "pilot," the pair of 55-foot mobile platforms looked like one continuous structure. Engineers created the double-sided trailers to make them easier to tow on and off the runway, and especially to make them easier to remove quickly in the event of an aircraft emergency. They framed each trailer with wooden two-by-fours, and covered the sides with engineering grade reflective panels made from corrugated plastic used for signs and containers.

Researchers arranged the reflective sheets on one side of the screen in alternating red and white chevrons eight feet wide. They later turned around the trailers to show a checkerboard pattern of four-by-ten foot rectangles that covered the side opposite the diagonal stripes. The screen's 13-foot height reached the bottom of aircraft engines, high enough for pilots on the runway to still see plane fuselages behind the screen.

In more recent tests, researchers increased the width of the red and white stripes to 12 feet to possibly increase the viewable distance of the pattern. They also evaluated another reflective material, which possesses higher reflective characteristics, to determine if it would make the screens more visible at night. In addition, they conducted evaluations to determine if lighting the screens with external lights would enhance the screen's nighttime appearance.

"Our research thus far has indicated that the red and white diagonal stripes, each 12 feet in width, using the engineering grade reflective material, are the most effective visual presentation for the screen design" explains Mr. Patterson.

FAA visual guidance researchers held the final evaluation on this project the week of April 17 at the Atlantic City International Airport. During these tests, pilots who had no prior knowledge of the project watched the screens, in real time, as a Boeing 737 moved about on the airport surface. "The pilots were driven to two locations on the airport. At each location, they were afforded the opportunity to see the aircraft pass both in front of and behind the screen several times. They were asked to correctly identify the position of the aircraft as soon as they could, and then answer simple questions about what they thought of the screen," describes Patterson. The researchers conducted a debriefing session immediately after each test in which the pilots asked questions and discussed what they thought of the presentation. Preliminary data analysis shows an overwhelmingly positive response to the screen design. "We are excited that the results of our research worked well in the final evaluation. It makes it all worth it."

In May, FAA airport safety researchers will complete one final phase of the research in which data will be collected on the relationship of landing light configurations on commercial aircraft to the reflective characteristics of the engineering grade material. The final report for this project will be completed in June 2006.

Patterson explains that a project of this magnitude takes an extensive amount of coordination. "The FAA Technical Center Operations, Wackenhut Security, FAA Air Traffic Control, South Jersey Transportation Authority, and the FAA Aircraft Safety R&D Branch all made this research effort run as smoothly at it could. Many thanks go out to each organization."

This research supports a national agency standard for end-around taxiway screens. The first screens that will go up at Dallas-Fort Worth will be 700 feet long. Each will be 13 feet high. R&D Review

Fire Safety

International Cooperation Ensures Fire Safety

The public and private sectors are working together to keep fires from breaking out or spreading aboard aircraft. Recently, 136 representatives from U.S. and foreign government agencies and laboratories, airlines, aircraft manufacturers, materials suppliers and fabricators, and private testing labs met to discuss new research and test methods.

FAA fire safety researchers hosted the International Aircraft Materials Fire Test Working Group Meeting, March 20-21, 2006, in Atlantic City, NJ. It attracted experts from throughout the U.S., as well as 45 specialists from eight other nations. The Working Group meets three times per year. One meeting is held near Atlantic City, New Jersey, one meeting is held at a host organization at another location in North America, and one meeting is hosted by an organization outside of North America. Issues and concerns in the area of aircraft materials fire safety testing are discussed, with an emphasis on both current and improved test methods.

"Frequent working group meetings help professionals develop formal relationships, share their research, and create a spirit of cooperation," said Constantine (Gus) Sarkos, manager of the Fire Safety R&D program. "Our long-term working relationship means we can ask one another the hard questions, refocus efforts, and have an open and honest dialogue about needs, concerns, and successes."

In this recurring forum, FAA researchers discuss current programs with regulatory officials and solicit timely input on prospective research. For example, composite materials make up an increasing percentage of new aircraft such as the Boeing 777 and Airbus A380, and the Boeing 787 will be the first large transport aircraft with composite fuselage and wings. The greater use of composites raises a number of fire safety concerns, including the burnthrough resistance of a composite fuselage during a postcrash fire. The scientists believe the key factor for this scenario will be toxicity and how it relates to survivability. Testing was recently initiated to analyze the combustion gases and smoke generated when composite materials are subjected to a simulated postcrash fire.

At a recent meeting, the FAA's Louise Speitel helped attendees appreciate the complex instrumentation and methodologies used to analyze the gasses and assess the toxicity produced when composite aircraft materials burn. The FAA Chemistry and Material Science Laboratory is equipped with thermogravimetric analyzers, a gas chromatograph/mass spectometer with pyroprobe, process and research Fourier Transform Infrared spectrometers, an ion chromatograph with conductivity and electrochemical detectors, and various process analyzers. "Great care must be taken in selecting and/or developing an appropriate sampling and analysis methods for each gas. Accurate identification and accurate gas history data are needed" explained Speitel. "And, we must employ a valid toxicity model to determine the impact of the measured gas concentration histories on survivability."

Testing Insulation Blankets

Tim Marker, FAA fire safety specialist, briefed the Working Group members on methods developed to test insulation blankets. "In 2003, the FAA passed a new rule pertaining to the flammability of thermal acoustic insulation used in transport category aircraft. The rule established two new tests - the first measures a material's capability to resist flame spread from a small ignition source, and the second determines the ability of a material to resist penetration or burn through from an external fuel fire. A radiant panel is required to conduct the flame spread test, while an oil-fired burner is used to simulate the external fire in the burnthrough test. Both of these tests are significantly better than the previous test method used to qualify insulation materials," explains Marker.

Although researchers have developed and refined these new tests over the past two years, many details still exist with regard to the conduct of these tests and the actual installation of insulation blankets in an aircraft. In terms of flame propagation, for example, many components of the blanket system, such as tape and hook and loop fasteners must also be tested since they are considered part of the blanket system and affect whether or not the material will propagate a fire. To ensure that all blanket components are properly tested, the FAA recently developed Advisory Circulars (ACs) for new test methods based on results from the latest research. The radiant panel advisory circular (AC 25.856-1) describes the test methodology and pass/fail criteria for evaluating the flammability of insulation blankets containing sub-components, such as thread, tape, and hook and loop. Tapes, for example, are used during initial production and also in making repairs to in-service aircraft. Since it is not practical to test each possible configuration of tape and film/batting material, researchers have developed a simplified process using strips of tape. The advisory circular also requires testing for structural damping materials. For example, although small aluminum sheets bonded directly to the airplane skin are not considered insulation, materials that include a layer of foam or other material sandwiched between the skin and thin aluminum sheets should be tested. An electronic version of the radiant panel advisory circular can be found at http://www.airweb.faa.gov/rgl.

The burnthrough advisory circular (AC 25.856-2) describes the appropriate methods of installing the insulation in an aircraft. Insulation materials can be classified into three basic categories: batting systems; barrier systems; and encapsulating systems. The advisory circular describes each system type and provides schematic examples of each in an appendix. In addition, it highlights critical installation areas, such as blanket overlap at frame members, horizontal blanket overlap, penetrations, and types of installation hardware. It includes a detailed test methodology for evaluating the burnthrough resistance of two horizontally overlapped blankets and describes the appropriate test methodology for evaluating system performance in the event that an alternative approach is desired.

This methodology includes a description of the test apparatus modifications necessary to evaluate any unconventional approach. The proper installation of insulation blankets is a critical aspect of burn-through protection. It is complex and has many facets. Therefore, the FAA has issued a notice of proposed rulemaking to extend, by twelve months, the date for operators to comply with the fire penetration resistance requirements of thermal/acoustic insulation used in transport category airplanes manufactured after September 2, 2007. (See http://dms.dot.gov/search/document.cfm?documented=393768&docketid=24277.)

Standardizing Tests

Maintaining and improving the standardization of FAA-required fire tests is a continual process. At the symposium, FAA personnel informed the Working Group of plans to hold worldwide evaluations of the oil-fired burner test used to improve seat cushions. FAA's Pat Cahill commented on the results of previous round robin tests, in which the FAA discovered "that everyone is not conducting their tests the same way." To ensure standardized configuration, the FAA will remind operators of the proper test set-up, calibration, and conduct of tests.

The FAA also asked Working Group members for help to ensure fire test labs are set up properly for conducting the heat release test required for large surface area cabin materials such as side walls and ceiling. FAA researchers are preparing a package of photographs, videos, and questionnaires to help others with lab set up and test procedures, and is coordinating with labs throughout the world. The Working Group members also will test the smoke chamber, which is used to determine smoke-generating characteristics of materials in passenger cabins. Already, researchers have begun collecting sample materials for both tests.

Testing Hidden Materials

The FAA is committed to increasing safety by preventing fires from spreading in inaccessible areas of an aircraft. "Since the current test for aircraft ducts does not predict fire behavior in actual conditions," explained John Reinhardt, "FAA fire safety researchers are working with our international partners to develop a new fire test procedure to evaluate the fire worthiness of aircraft ducting." At the meeting, Reinhardt discussed realistic intermediate-scale fire test results on ducting materials with a comparison between the current and proposed duct test methods (see http://fire.tc.faa.gov/pdf/materials/Reinhardt_Duct_Presetnation.pdf).

Richard Hill, FAA fire safety program manager, appealed to laboratories, airplane manufacturers, and parts suppliers for feedback to improve ducting tests as well as tests on electrical wiring. Both wiring and ducting have been identified by FAA as materials whose fire performance need to be upgraded to the level now required for thermal acoustic insulation in order to prevent uncontrollable hidden in-flight fires. Hill declared, "We need input to make the tests the best they can be to ensure a higher level of fire resistance." He encouraged members to participate so the improved test methods submitted to the FAA regulatory side would reflect their input.

Additional topics will be discussed at the next Working Group meeting, scheduled for July 11-12, in Costa Mesa, California. For more information on the working group, please see http://www..fire.tc.faa.gov/materials.stm. R&D Review

Mark your Calendar for

Upcoming Events

FAA Seeks Aviation Research Award Nominees

The FAA is seeking nominees for its annual **Excellence in Aviation Research Award**. Applicants must be from outside the FAA and conducting aviation-related research at another government department, an educational institution, or a private company. The FAA presents the award annually to individuals and/or organizations whose R&D activities have significantly improved the safety or efficiency of the national airspace system.

In its ninth year, the prestigious nonmonetary award allows the FAA to recognize other researchers and thank them for significant contributions to the aviation community. The 2005 honorees were Richard Dolbeer and Colin Drury. Dr. Dolbeer, Coordinator of the Aviation Safety and Assistance Program at the U.S. Department of Agriculture, received the honor for his work in airport wildlife hazard mitigation. Dr. Drury has researched aviation maintenance human factors as Distinguished Professor and Chair of the Department of Industrial Engineering at the University of Buffalo.

Senior FAA managers will review nominations using three primary criteria:

Relevance
Quality
Performance

The FAA is accepting nominations and supporting documentation through July 31, 2006. Please download an application form and instructions by visiting http://research.faa.gov, or email your request to Dr. Terry Kraus at terry.kraus@faa.gov.

FAA Center of Excellence for General Aviation Research (CGAR) Annual Meeting
June 27-29, 2006
Embry Riddle Aeronautical University
Prescott, Arizona

This symposium will include two and a half days of meetings, tours, and research presentations. Members of industry, government and academia will be there to share ideas, discuss current and future research, and network with colleagues in the general aviation research community. For additional information, see http://www.erau.edu/omni/pr/academicorgs/prcoa/cgar/index.html.

2006 Conference on Risk Analysis and Safety Performance in Aviation
September 19-21, 2006
Taj Mahal Hotel, Atlantic City, New Jersey

The conference will provide a forum for participants to exchange success stories and lessons learned in the development and implementation of safety management systems, integrated safety systems, and analytical techniques to support systematic management of aviation safety. Experts from various national and international aviation organizations will address safety management issues related to aircraft operations, air traffic, and airport safety. Topics will include:

- Integrated Safety Systems: What comprises a successfully "Integrated" Safety System? How does a "safety culture" contribute to an Integrated Safety System?
- Safety Risk Analysis: What are some practical techniques for assessing risk in an operational environ ment?
- Safety Risk Management: How can new risk management practices be implemented within ongoing processes?
- Information Sharing: How can shared information improve the development of Safety Systems? Do the benefits of information sharing justify their costs?
- Oversight Role: How can better management ensure safer operations? How can regulators and the service providers "partner" appropriately in 21st century safety management?

For additional information, please see http://aar400.tc.faa.gov/FlightSafety/Conference2006.htm or contact Rosanne Weiss at rosanne.weiss@faa.gov.

2007 FAA Worldwide Airport Technology Transfer Conference - Call for Papers

The FAA and the American Association of Airport Executives (AAAE) are sponsoring the 2007 Worldwide Airport Technology Transfer Conference - New Directions in Airport Technology, April 16-18, 2007, in Atlantic City, New Jersey. This international conference will focus on the development of technology and its application to airports. It will cover a broad range of technology areas for airports. The conference will "showcase" the FAA National Airport Pavement Test Facility, which was built in a partnership between the FAA and the Boeing Company, and is now in its eighth year of operation. The conference will include plenary sessions with internationally recognized keynote speakers, technical presentations, exhibitions, tours of the FAA William J. Hughes Technical Center, and a site visit to the National Airport Pavement Test Facility. Papers and presentations are sought for all technical areas in airport pavement and airport safety technology. In addition to technical papers on airport technology-related research, authors are encouraged to submit papers pertaining to case studies, practical engineering applications in the field, operational requirements, and engineering research. For updates and additional information, please visit the FAA ATT07 web site: http://www.airport-tech.tc.faa.gov/naptf/att07/ or e-mail: att07@faa.gov.

Fifth Triennial International Aircraft Fire and Cabin Safety Research Conference
October 29 - November 1, 2007
Atlantic City, New Jersey

The conference is jointly sponsored by the:

U.S. Federal Aviation Administration (FAA)
Transport Canada Civil Aviation (TCCA)
European Aviation Safety Agency (EASA)
Centro Technico Aeroespecial of Brazil (CTA)
Civil Aviation Safety Authority of Australia (CASA)
Civil Aviation Bureau of Japan (JCAB)
Aviation Register of Russia (IAC)

This conference is the fifth in a series of triennial conferences established to inform the international aviation community about recent, ongoing, and planned research activities in transport category aircraft fire and cabin safety. The conference is designed to address both engineering and cabin crew concerns and requirements. Conference registration details, hotel reservation information, and preliminary conference information will be available at http://www.fire.tc.faa.gov as the agenda evolves.

Continuing the Legacy

The Metallic Materials Handbook

For over 70 years, aviation researchers and safety experts from the FAA, DoD, and industry have compiled and published a series of guidelines that standardize the engineering properties and related characteristics of the metallic materials and structural elements used in aircraft, missile, and aerospace vehicle structures.

These guidelines were first published in 1937 as the Army-Navy-Commerce Handbook 5 (ANC5). The United States Air Force became the lead service for this guidance role in 1956. Three years later, the publication became Military Handbook 5 (MIL-HDBK 5). In 1971, the Air Force incorporated detailed guidelines for statistical analysis of data into the handbook, establishing procedures for data requirements and data reduction. An industry steering group (ISG) was formed in 1997 to complement the government-supported activities. Budget constraints and policy changes later affected DoD's ability to lead the effort, and the FAA began to assume primary responsibility of the handbook in 2001. Two years later, the FAA renamed the publication Metallic Materials Properties Development and Standardization (MMPDS). Also in 2003, the agency published MMPDS-1.

"The handbook remains the only publicly available U.S. source that the FAA generally accepts specifying material allowables, in compliance with Federal Aviation Regulations (FAR), for the material strength properties and design values associated with aircraft certification and continued airworthiness," explains FAA project manager Dr. John Bakuckas, Jr. "Moreover, it is the only publicly available source for fastener joint allowables that comply with the FARs."

The handbook contains standardized design values and related design information for structural aerospace metals in various forms and thicknesses, as well as temperature dependence of mechanical properties, fatigue curves, and corrosion rankings and the complete fastener database. Structural engineers around the world recognize the handbook as the standard for design, maintenance, and repair of aircraft, missiles, and space vehicles.

Under FAA leadership, government and industry continue to maintain the standardized process for establishing statistically based allowables required for aircraft certification and continued airworthiness. Active government-industry coordination remains essential to maintaining the integrity of the guideline development process affecting design allowables.

An independent and thorough statistical analysis, followed by consensus approval by both the government and industry, must be completed before material property data can be included in the handbook. The material producers start this rigorous, lengthy process by developing and maturing an alloy. Then they generate an initial material properties database. Once these steps are completed, the manufacturer drafts a material specification and delivers it to the handbook secretariat. Next, the secretariat screens the draft. If the supporting data meet all of the handbook requirements, a statistical analysis is conducted to generate the allowables, and a data proposal is prepared for review at the semi-annual General Coordination Committee meeting. (The most recent coordination meeting was held on April 24-27, 2006.) If approved, the information is published in the meeting minutes. Only then may it be included in the next revision of the handbook.

"Maintaining the handbook process and publishing and distributing the over 1,900 page handbook is time consuming and costly," explains Dr. Bakuckas. "The handbook remains the worldwide industry standard. To maintain its impressive legacy, however, it is necessary to obtain broader government and industry support."

Last year, the FAA granted the nonprofit Battelle Memorial Institute an exclusive annual license to reproduce and distribute the handbook, thus ensuring the future of the MMPDS process. Under FAA's auspices, Battelle made version MMPDS-02 available for commercial sale in August 2005.

The new release includes more than 300 edited or added pages since MMPDS-01. These changes and additions incorporate substantial upgrades that identify twelve new alloys. Companies interested in the MMPDS-02 handbook may choose from a CD-ROM computer disk or a hardcover five-volume set. The volumes are broken down like this:

Volume 1 - Introduction and Guidelines (Chapters 1 and 9)
Volume 2 - Steel and Magnesium Alloys (Chapters 2 and 4)
Volume 3a - 2000-6000 Series Aluminum Alloys (First part of Chapter 3)
Volume 3b - 7000 Series and Cast Aluminum Alloys (Second part of Chapter 3)
Volume 4 - Titanium and Heat-Resistant Alloys (Chapters 5 and 6)
Volume 5 - Miscellaneous Alloys & Structural Joints (Chapters 7 and 8)

Additional information in the MMPDS process can be found online at http://www.mmpds.org/. R&D Review

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In His Own Words

A Conversation with FAA Elder Statesman, Bill Cavage

Bill Cavage is a propulsion and fuels researcher. He is also the elder statesman of the FAA's research program. He has been with the Agency for almost 40 years, beginning his career in August 1967. In a recent interview, Bill shared his insights, accomplishments, and advice.

Q: What is your current position and title?

A: I'm the Senior Technical Specialist in propulsion and fuels. I hope the "senior" isn't just because I'm the oldest . . . I've been here the longest.

Q: What was your first job with the Agency?

A: I was an aircraft mechanic. I joined the Air Force in 1959, serving as a crew chief on F-100 Ds and Fs (Super Sabre fighter-bomber) for about three years. After the Air Force, I went to work at Boeing. I worked full-time at night and went to school during the day to get my airframe and power plant technician license. Before starting at the FAA I worked at several other places maintaining big radial engines. When I began my FAA career as an aircraft mechanic, I worked on the flight line, maintaining our fleet of DC-3 aircraft, which carried mobile ILSs, or instrument landing systems. The planes had to be ready 24 hours a day to back up airports. For example, if there was a problem at Kennedy, we had to get a plane there quickly with the necessary navaids, because you couldn't have a big airport like that down.

Because I wanted a degree, I started going to Camden County College part-time at night, earning an associate of science degree in mechanical engineering. When the FAA announced a job opening in the emissions area, working with small engines, I applied and got the aircraft technician job in February 1974. As my first assignment, I did emissions testing on ten engines, five from Continental and five from Lycoming. I set up the engines for testing to verify the tests run by the manufacturers. Later, I worked in the Mobile Emissions Research Facility trailers. We would tow these big trailers out on the runway to test aircraft engines. We tested the engines to determine emissions change over a period of time and looked for engine degradation.

We'd start testing engines in the morning and continue through the day. Every ten minutes we'd take engine readings. In those days, it was a manual process. We'd record the readings from the manometers and pressure gauges. When we completed the tests, we would then have to reduce all of the data.

Q: Over your tenure, how has the Tech Center changed?

A: When I began my FAA career, the Tech Center ran like a military organization. We would go into the hangars in the morning, open up our toolboxes, and stand at attention by our toolboxes as they called roll. A Navy captain originally ran the hangar. As management became civilian, the operation changed. Right now, I'm working for one of the best supervisors I've ever worked for. Tom Flournoy's actually a Navy man too, he's in the Navy Reserve.

Q: What have been some of your most satisfying accomplishments at the FAA? Which ones do think had the biggest effect on the industry?

A: In terms of biggest effect on industry, I would say the work we did in fire and cabin safety, because of its potential for saving lives. We also worked on a safety program that used a catapult, called a "rhino," to test fuel tanks on school buses. At that time, school bus fuel tanks were located by the front door. I actually did a lot of safety-related work – so many different projects. We worked on a project to determine if a bomb could be safely exploded aboard an aircraft. We fired rockets into engines to see how fast we could stop them. We did things you wouldn't believe. ►

> “I think we’ll soon see some kind of cruise aircraft, a supersonic plane. I don’t think speeds will go hypersonic yet, but new aircraft will be able to transition from very high mach numbers into supersonic, and transition back. I think aircraft will be faster and travel longer distances, quieter and more efficiently.”

Q: Tell me about aviation – how far we've come, where do we need to go in the future?

A: We’ve come so far in a hundred years. It’s amazing – we’ve been to the moon! Technology is advancing at such a rapid rate. Just compare the technology my grandfather had in his car, his 1938 Dodge, to the technology we have in cars today. While aviation has witnessed a similar leap, in some ways, aviation technology is becoming even more sophisticated than that in other industries. For example, if you’re driving a new car and something goes wrong, you pull off to the side of the road and you call a tow truck. You can’t do that in aviation. The technology must be perfected before it goes on the plane. Now, I’m mostly an engine person. If you think about the first JT-3Cs we used – basically old military J57s – how much fuel they burned, how much pollution they put out – some of them looked like they were burning soft coal. If you look at today’s engines, and you listen to them, they are much quieter and burn less than one-half of what they did in the old days. New engine technology has really advanced the aviation industry.

Q: Where do we go from here? What’s next?

A: I think we’ll soon see some kind of cruise aircraft, a supersonic plane. I don’t think speeds will go hypersonic yet, but new aircraft will be able to transition from very high mach numbers into supersonic, and transition back. I think aircraft will be faster and travel longer distances, quieter and more efficiently.

Q: Do you have any advice for young people just starting their careers?

A: Follow your heart. Since you have to get up every single morning and go to work, you’d better find something that you really like to do. Aviation is my interest. It’s what I always wanted to do; I enjoy it; I really love it. I had opportunities to take my career in other directions – I probably could have made more money – but I don’t think I would have been as anxious to get up and go to work everyday. The years have gone by fast. I’ve been lucky to do what I love. I really am blessed. R&D Review

Awarding Success

Recipients of the Highest Honors

The Rutgers Alumni Association and Engineering Society awarded ATO-P R&D's **Constantine "Gus" Sarkos**, FAA fire R&D program manager, its *2006 Distinguished Engineer Award*. He received the award for his contributions to the improvement of fire safety in commercial and military transport airplanes. During his 36-year career with the FAA, Sarkos has authored more than 60 reports and papers related to aircraft fire safety, and lectured on this subject at 75 technical meetings. This outstanding work has earned him 31 awards, including the Distinguished Technical Center Employee of the Year, the Department of Transportation Secretary's Award for Meritorious Achievement, and induction into the U.S. Space Foundation/NASA Hall of Fame. R&D Review

Joan Bauerlein, Director of Aviation Research and Development, has received the *National Public Service Award* from the National Academy of Public Administration and the American Society for Public Administration. The award recognizes creative, highly skilled managers who have exhibited the highest standards of excellence, dedication, and accomplishments in their careers. Five leaders, representing all facets of public service, are selected for the honor each year.

"Joan Bauerlein exemplifies what civil service is all about," said FAA Administrator Marion C. Blakey. "She is a veteran executive, having served in a variety of senior positions over the years. She makes a difference in how our skies operate."

Bauerlein has directed the FAA's research and development organization since 2003. She leads many key programs that have resulted in major strides in improved aviation safety and capacity. These efforts focus on fire safety and firefighting technology, crashworthiness, airport and runway safety, and weather research. She has guided international collaboration in human factors research that led to the creation and testing of new techniques to analyze aviation incidents and runway incursions.

Her previous FAA managerial positions include: Deputy Director of aviation research; representative to the Inter-American Development Bank (on loan from FAA); Director, Office of International Aviation; Assistant Administrator for Government and Industry Affairs; and Deputy Director, Office of Budget. Prior to joining the FAA, Bauerlein held management posts with the Federal Highway Administration, the National Highway Traffic Safety Administration, and the Office of Budget and Program Review. She also served as a Congressional Fellow with Secretary of Transportation (then Congressman) Norman Mineta.

Complementing her many technical accomplishments, Bauerlein has been an active volunteer. She served two terms on the Washington, D.C. Aero Club Board, and she now serves on the Board's Education Foundation. She has led her employees to work in local soup kitchens, and worked with her staff to prepare and send care packages to U.S. soldiers in Iraq. She volunteers teaching English as a second language to recent immigrants, and has recently gone back to college to earn a certificate in teaching English as a second language.

This honoree also has received the President's Meritorious Award for the Senior Executive Service, multiple Equal Employment Opportunity awards and the Outstanding Woman in Aviation Award from the National Aeronautics Association. R&D Review

Lead by Example

Researcher Honored for FAA First

Dr. Richard Lyon recently became the first Department of Transportation/FAA employee to get an invention commercially licensed by the Department.

Dr. Lyon invented the microscale combustion calorimeter, a device that measures heat release rates of tiny specimens of materials faster, cheaper, and more accurately than the bench scale methods that now require 100-gram samples. The calorimeter needs one millionth of the amount to accomplish the same results. "The calorimeter," says its inventor, "achieves economies of scale by allowing an efficient test of a tiny portion of fiber, powder, or solid plastic. You can barely see a five-milligram sample with the naked eye." He credits the precision instrument for the creation of several new ultra fire resistant plastics.

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How the Calorimeter Works

Using a process known as pyrolysis-combustion flow calorimetry, the new tester quickly, easily, and without a flame measures the combustibility of plastics, wood, textiles, and composites. "This invention has revolutionized flammability research," explains Joan Bauerlein, FAA's Director of Research and Development. In minutes, instead of hours or even days, the new tool can determine the flammability of minuscule samples under conditions that accurately simulate, but do not require, burning. This greatly accelerated methodology allows researchers to develop new cabin materials that keep flames from spreading and giving off toxic fumes.

Lyon's technology heats a compound, burns the gases that come off of it in a known amount of oxygen, and calculates a related heat release rate. His device can reproduce and measure both the fire and the gas phases of combustion under controlled conditions that avoid the variability of actual fire testing. The precise results it provides depend on such factors as fire size, sample thickness, and amount of oxygen available for combustion. The calorimeter also predicts a substance's flame resistance, its ability to withstand brief exposure to a small flame without continuing to burn.

The Department of Transportation holds two patents for Dr. Lyon's invention and has filed for a third. U.S. patent 5,981,290 is for Lyon's initial microscale combustion calorimeter. U.S. patent number 6,464,391 is for a Heat Release Rate Calorimeter for Milligram Samples. This innovation will quantify a sample as tiny as one to ten milligrams, without the need to separately and simultaneously measure the sample's mass loss rate and the heat of combustion of the gases produced during heating. ▶

"This invention has revolutionized flammability research. . .In minutes, instead of hours or even days, the new tool can determine the flammability of minuscule samples under conditions that accurately simulate, but do not require, burning."

Commercial Licensing

Two companies signed commercial licensing agreements for the calorimeter in 2005: Govmark Organization, Inc., a testing laboratory and fire test equipment manufacturer in Farmingdale, New York; and Fire Testing Technology, Ltd., a fire test equipment manufacturer south of London, United Kingdom. Both of these firms are already producing and selling calorimeters. Two additional companies have purchased site licenses to use the calorimeter for internal testing of flame retardant materials.

Dr. Lyon continues working to develop materials that do not burn in cabin fires. His goal - a fireproof cabin in the near future.

Before joining the FAA in 1993, Lyon worked at Lawrence Livermore National Laboratory in California. He received a B.S. in Chemical Oceanography, and an M.S. and Ph.D. in Polymer Science & Engineering, all from the University of Massachusetts, Amherst.

For more information on Dr. Lyon's research, please visit http://www.fire.tc.faa.gov/materials.stm. For information on obtaining a commercial license for the calorimeter, please contact FAA technology transfer lead, Deborah Germak at Deborah.germak@faa.gov. R&D Review

Zeroing in on Debris

Using Radar to Detect Runway Debris

The presence of foreign objects in the airport environment presents a major hazard to aircraft safety. Foreign object debris (FOD) is any substance or article alien to the vehicle or system that would potentially cause damage. Providing continuous FOD management strains the capabilities of airport personnel, but modern technology offers a solution. Radar is a promising technology that continuously updates information to achieve a high level of FOD detection with a low false alarm rate.

"Every year foreign object debris at airports costs airlines, airports, and airport tenants almost $4 billion dollars," says Dr. Michel Hovan, FAA airport technology researcher. "FOD includes a wide range of material, including loose hardware, pavement fragments, catering supplies, building materials, rocks, sand, pieces of luggage, and even wildlife," Hovan adds. FOD is found at terminal gates, cargo aprons, taxiways, runways, and run-up pads. "To keep the risk of FOD damage to a minimum, airport operators need to ensure that any debris is detected and located as rapidly as possible, enabling rapid removal," explains Dr. Hovan. "That is why the FAA maintains an active R&D program to help prevent FOD incidents."

Sizable objects on a runway can cut airplane tires, be ingested into engines, or be thrown by a jet blast into equipment or people. Incidents can result in engine and airframe damage, runway closures, and harm to passengers and crew. In the Concorde tragedy in 2000, a 16-inch strip of metal lost by a plane that had taken off five minutes earlier punctured one of the Air France jet's tires, resulting in the loss of 113 lives.

Checking for debris is currently performed visually, a time consuming and expensive process that is open to human error. It can take as long as 45 minutes to check a runway between aircraft movements, and bad weather or darkness adds further complications. To ensure more accurate FOD detection, the FAA is evaluating an experimental technology, the Tarsier® debris monitoring radar, developed in the United Kingdom by QinetiQ. This device emits a frequency modulated continuous wave to a 2000 meter maximum range. Its 94 ghz frequency and very low transmitter power output were chosen to provide a detection system that poses minimal safety risk to workers and interferes as little as possible with existing communication or radar systems.

The first series of tests of the Tarsier® were conducted in 2005. Using the Global Positioning System and Geographic Information System maps, FAA researchers precisely recorded the locations of FOD items placed on runways. Then they assessed how well the radar detected debris, identified the nature of the objects, and determined whether the system could help airport personnel to retrieve and remove the objects quickly and efficiently.

The FOD items used in the tests varied in size from a metal sphere with a measured radar cross section of -27dBm2 to numerous uncharacterized items estimated to vary from -10dBm2 to -33dBm2. A total of 23 test series and three blind tests were completed. In some test series, FOD objects (including calibrated -27dBm2 spheres) were placed at three or four fixed distances from the radar. In other tests, single distances were tested. Testing occurred both before and after a winter storm. A first set of tests occurred under dry runway pavement conditions posing no interference to "clear field" analysis. A second set, conducted with variable snow accumulations and residual snow/ice present on the runways, posed some variation in clear field observations. Because testing also occurred over a multiple day schedule, there were slight daily changes to the quality of clear field conditions during the tests.

The capability of the Tarsier® radar to detect FOD items on airport surfaces at ranges of over 1 kilometer was effectively demonstrated. The radar performed well for distances up to approximately 500 meter with reduced performance at ▶

greater distances. Additionally, for some FOD items, the results showed differences in detection capabilities between dry pavement and winter conditions.

The analysis of the JFK tests and a preliminary evaluation of the radar are reported in a FAA report titled "Evaluation of the QinetiQ Tarsier® FOD Detection Radar at the John F. Kennedy International Airport."

While the tests involved cold weather and snow, the radar still needs to be evaluated during wet conditions.

Researchers plan to install a FOD system this summer at the T.F. Green International Airport in Providence, Rhode Island. The system will consist of two radar units that will monitor two runways and integrate information into one airport server. FOD data will be transmitted in real-time to airport personnel. The tests are scheduled to last for a period of six months, from September 2006 until February 2007. The longer test period will allow for a variety of weather conditions representing a working airport's true operational requirements. R&D Review

U.S. airlines carried 4.6 percent more passengers and flew more flights during 2005 than they did during 2004 on both domestic and international flights from the United States.

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Commercial Space

Space Flight

On December 23, 2004, President Bush signed into law the Commercial Space Launch Amendments Act of 2004. The legislation promotes the development of the emerging commercial space flight industry, and makes the Department of Transportation and the Federal Aviation Administration responsible for regulating commercial human space flight. The law requires a phased approach to regulating commercial human space flight. Regulatory standards governing human space flight must evolve as the industry matures.

Per the mandates of the law, the FAA is preparing for civilian space travel. In a notice of proposed rulemaking (http://dms.dot.gov/search/document.cfm?documented=378657&docketid=23449), the Agency proposes requirements for human space flight of crew and space flight participants as required by the 2004 law. If adopted, this rulemaking would establish requirements for crew qualifications, training, and notification. It would also establish training and informed consent requirements for space flight participants. The requirements are designed to provide an acceptable level of safety to the general public, and to notify individuals on board of the risk associated with a launch or reentry.

The FAA Office of Commercial Space Transportation predicts the development of an affordable commercial space tourism industry before the end of the decade. To meet the safety demands of this burgeoning industry, and while the proposed requirement progress through the Agency's rulemaking process, the FAA has issued medical guidelines for space travel. "We're making sure that passengers recognize their role in an ultrahazardous activity," FAA Administrator Marion Blakey said in a February 2006 speech at the ninth ▶

annual Commercial Space Transportation Conference. "They're engaging at their own risk, just the way they would climb a mountain or skydive."

"Space flight exposes individuals to an environment that is far more hazardous than what is experienced by passengers who fly onboard current airline transports," explains Dr. Melchor Antuñano, Director of the FAA Civil Aerospace Medical Institute. "With orbital and suborbital flights, pre-existing medical conditions can be aggravated or exacerbated by exposure to environmental and operational stressors such as acceleration, microgravity, and solar/cosmic radiation, among others."

The FAA's "Guidance for Medical Screening of Commercial Aerospace Passengers" (http://faa.gov/library/reports/medical/oamtechreports/2000s/media/200601.pdf), helps operators of space flights give health assessments of prospective passengers. The guidance covers orbital and suborbital flights. It identifies medical conditions that may result in an in-flight medical emergency, or may compromise the health and safety of any other passengers or crew aboard a commercial aerospace vehicle.

Suborbital or Orbital Passengers

To prepare the guidance, FAA aerospace medicine specialists determined a need to develop guidance for both suborbital and orbital flight. For suborbital flights, the guidance recommends that passengers should complete a simple medical history questionnaire prior to every flight, and have the responses reviewed by a physician experienced or trained in aerospace medicine. Doctors assessing potential suborbital passengers may deem physical exams necessary, especially if the possibility exists that the spacecraft's acceleration might incur a gravitational load (+Gz-load) above 3.

Since the Gz-load profile would likely exceed 3 for individuals planning orbital flights, medical researchers suggest they fill out more extensive medical histories and undergo physical examinations with laboratory testing. The medical tests would be valid for one year, but a passenger should update medical history and undergo an abbreviated physical one to two weeks prior to each flight.

Acceleration Risks

The main risks associated with acceleration exposure involve the neurological, cardiovascular, and musculoskeletal systems. To avoid potential problems, FAA aerospace medicine specialists suggest seating passengers facing upward, because human beings tolerate acceleration forces better when applied from the front to the back. Having the heart and brain located at approximately the same level reduces the chance someone will lose consciousness.

Stress from acceleration can change a person's cardiac rate and rhythm, as well as alter how a heart conducts electrical impulses. Even higher and longer exposures to acceleration increase the frequency of such dysrhythmias. Individuals with compromised cardiovascular anatomy or function may have reduced tolerances. Also, stabilizing the head, neck, and spine during acceleration can reduce the potential for musculoskeletal injury.

"Scrubbing" a Passenger

FAA aerospace medicine specialists recommend contraindicating space flight for a prospective passenger with any deformities (congenital or acquired), diseases, illnesses, injuries, infections, tumors, treatments (pharmacological, surgical, prosthetic, or other), or other physiological or pathological conditions that:

- May result in an in-flight medical emergency
- May compromise the health and safety of the passenger or other occupants and/or the safety of the flight
- May interfere with properly using and operating personal protective equipment
- May interfere with in-flight emergency procedures or emergency evacuation
- May have a negative effect on the passenger's health

FAA aerospace medicine specialists believe a space flight operator should consider medical conditions on a case-by-case basis, and determine whether they hamper a person's ability to function. Other considerations include:

- History of exposure to ionizing radiation (single dose or cumulative) that exceeds the maximum exposure limit of five millisieverts in five years recommended by the International Commission on Radiological Protection
- Any psychiatric, psychological, mental, or behavioral disorder that would cause an individual to become a potential hazard to him/herself or to others
- Current pregnancy, recent postpartum (less than six weeks), or recent spontaneous or voluntary termination of pregnancy

FAA aerospace medicine specialists admit no conclusive data exists concerning the possible adverse physiologic and pathologic effects of space flight on infants or young children. "We suggest operators establish a minimum age for passengers participating in aerospace ventures," says Dr. Antuñano. "And, people of all ages should be made aware of the health risks associated with going into space."

R&D Review

Panel Discussion

FAA Hosts International Civil Aviation Organization (ICAO) Panel

Some of the members of the Visual Aids Working Group

On April 4-6, Don Gallagher, a FAA visual guidance researchers hosted the first meeting of a sub working group of the International Civil Aviation Organization Aerodrome Panel, Visual Aids Working Group in Atlantic City, NJ. Twenty-five people from member states Canada, Italy, Germany, France, Belgium and the United States attended the meeting. They discussed the implementation of Light Emitting Diode technology at aerodromes and how their planned research would help resolve implementation issues. The group plans to develop a time line for completion. The minutes of this meeting will be presented to the full Visual Aids Working Group at their next meeting in Rome, Italy, in June 2006. R&D Review

For additional information, please contact donald.gallagher@faa.gov.

Preventing Onboard Fires

Aircraft Wiring Flammability

"Life-threatening, in-flight fires usually originate in hidden areas of the airplane, such as the attic above the cabin ceiling, beneath the floor, in or around the lavatories, or at similar locations that are not easily accessible by the crew," explain Patricia Cahill, FAA fire safety researcher. "Because of the incidence of in-flight fires in recent years, the FAA is examining the adequacy of its flammability test requirements for all hidden materials, which include thermal acoustic insulation, electrical wiring, and heating, ventilation, and air conditioning ducts."

FAA researchers are currently examining the standards for electric wiring, focusing their efforts on the wiring found in the attic area above the cabin, beneath the floor, around lavatories, and many other places that are difficult to access. "By requiring that hidden materials be capable of resisting this elevated fire threat, we can significantly reduce the incidence of in-flight fires," explains Cahill.

Over the years, a number of aircraft wire insulation materials have been used throughout the aircraft. The composition of the wire insulation is dependent upon the wire location and its purpose. Examples of common wire insulation materials include aromatic polyimide and fluoropolymer insulation, such as ethylene-tetrafluoroethylene, poly vinyl chloride/nylon, and cross linked polyalkene. "As technology has progressed, improvements in aircraft wiring have been made. Some of these improvements include arc propagation resistance, a decrease in smoke production, and better flammability properties," says Ms. Cahill. ▶

The 60-degree Bunsen burner test determines the resistance of electrical wire insulation to flame. The pass/fail criteria are based on the burn length, after flame time, and drip flame time.

Preventing Onboard Fires

The FAA issued its first flammability test requirement for electrical wiring in 1972, mandating, among other things, that insulation on electrical wire or cable installed in any area of the fuselage must be self-extinguishing when subjected to what is called the 60-degree test. The 60-degree Bunsen burner test determines the resistance of electrical wire insulation to flame. The pass/fail criteria are based on the burn length, after flame time, and drip flame time. It requires testers to clamp each wire at an angle of 60 degrees in a three-inch Bunsen burner flame for 30 seconds. Currently, a wire's mandatory average burn length may not exceed three inches, the average after-flame time may not exceed 30 seconds, and drippings must stop flaming within three seconds after falling.

In light of new wiring materials and manufacturing processes, the FAA is now examining the currency of this requirement to ensure the maximum safety for travelers. To test the adequacy of the flammability requirement, researchers subjected samples of electrical wiring and electrical wiring insulation to the standard flammability test. In these tests, researchers evaluated 12 different aviation and non-aviation wires and cables on three criteria:

- How much insulation burned;
- How long the insulation burned after removing the flame; and
- How much flaming insulation dripped from each sample.

Two materials failed both in burn length and in after-flame time. A polyvinyl chloride (PVC)/nylon wire burned and continued to burn for more than two minutes. The zero halogen telecommunication cable had an average burn length of 3.1 inches, just over the maximum, but burned for another 60 seconds after researchers took away the flame. None of the wires or cables dripped flaming insulation.

The 60-degree test did not discriminate very well between the performances of different materials. The difference in burn length for the best material and the worst materials proved minimal.

Next, scientists put the 12 samples through an intermediate-scale vertical flammability test. Instead of individual lengths, they tied the aviation wires together in bundles of 25 and the larger cables in bundles of 10, stood them in a vertical frame, and ignited a polyurethane block soaked in alcohol underneath the frame. The tests showed samples that passed the 60-degree flammability test might not perform as well under larger-scale test conditions.

In a later test phase, researchers evaluated five of the original 12 types of wire and cable, using a second type of flammability test. The selection criteria included data from the earlier test and widespread use in commercial and general aviation aircraft. Researchers found the polytetrafluoroethylene (PTFE)/polyimide/PTFE construction to be the overall best performer. Another round of tests confirmed these results.

In addition to testing wire flammability, the test results showed that the 60-degree single wire Bunsen burner flammability test might not be adequate to qualify wire when bundled and subjected to a severe ignition source. The FAA is currently expanding its research to upgrade the fire test criteria for electrical wiring and materials in other hidden areas, such as the attic above the cabin ceiling, areas beneath the floor, and areas in or around the lavatories. The test results are documented in Technical Note, DOT/FAA/AR-TN04/32, "An Evaluation of the Flammability of Aircraft Wiring," which can be found on-line at http://www.fire.tc.faa.gov/pdf/TN04-32.pdf.

R&D Review

Preventing Fuel Tank Fires

The FAA has issued a notice of proposed rulemaking that would require commercial aircraft operators and manufacturers to install inerting systems to reduce the chance of catastrophic fuel tank explosions. The proposed rule is the direct result of a FAA fire safety research project.

The focus of the FAA fuel tank inerting initiative is on center wing or body style tanks, which are frequently not used by the aircraft operators and are likely to be empty, except for a small amount of fuel, on most domestic flight operations. Extensive development and analysis has illustrated that fuel tank inerting during aircraft operation could, potentially, be practical if air separation modules could be integrated into a system and used in an efficient manner.

"Our design," explains William Cavage, FAA project manager, "was driven by the challenge of developing a practical and reliable system that could be installed in commercial aircraft within the next several years. We collaborated with several aerospace companies to develop the onboard system. We then designed models and experimental methods to predict oxygen levels and the progression of flammability in an aircraft fuel tank ullage throughout a typical flight cycle."

The relatively simple dual flow design uses hollow-fiber air separation modules to generate nitrogen-enriched air (NEA) in flight. These modules are made of thousands of tiny, hair-sized, hollow-fiber membranes fabricated into a tube-shaped vessel. When supplied with pressurized air, they ventilate a waste stream of gas from a permeate vent that is rich in oxygen, carbon dioxide, and water vapor. This allows the product gas passing through the module to be rich in nitrogen.

The NEA flow and purity the system generates, varies according to the stage of flight. During ascent and cruise an increased purity, but lower flow is required. This balance is reversed during descent. Analytical modeling in a range of flight regimes has shown that the fuel systems of aircraft with a system properly sized would remain inert upon landing, thus negating the need to operate the system on the ground.

"Our initial research helped us understand more completely fuel tank inerting requirements as well as the factors that affect the flammability exposure," explains Cavage. "While we thought we understood flammability pretty well on the ground, we wondered how it progressed in flight." So the engineers took the next step, and mounted the FAA inerting system in the pack bay of the Boeing 747 SCA that NASA uses to transport space shuttle orbiters.

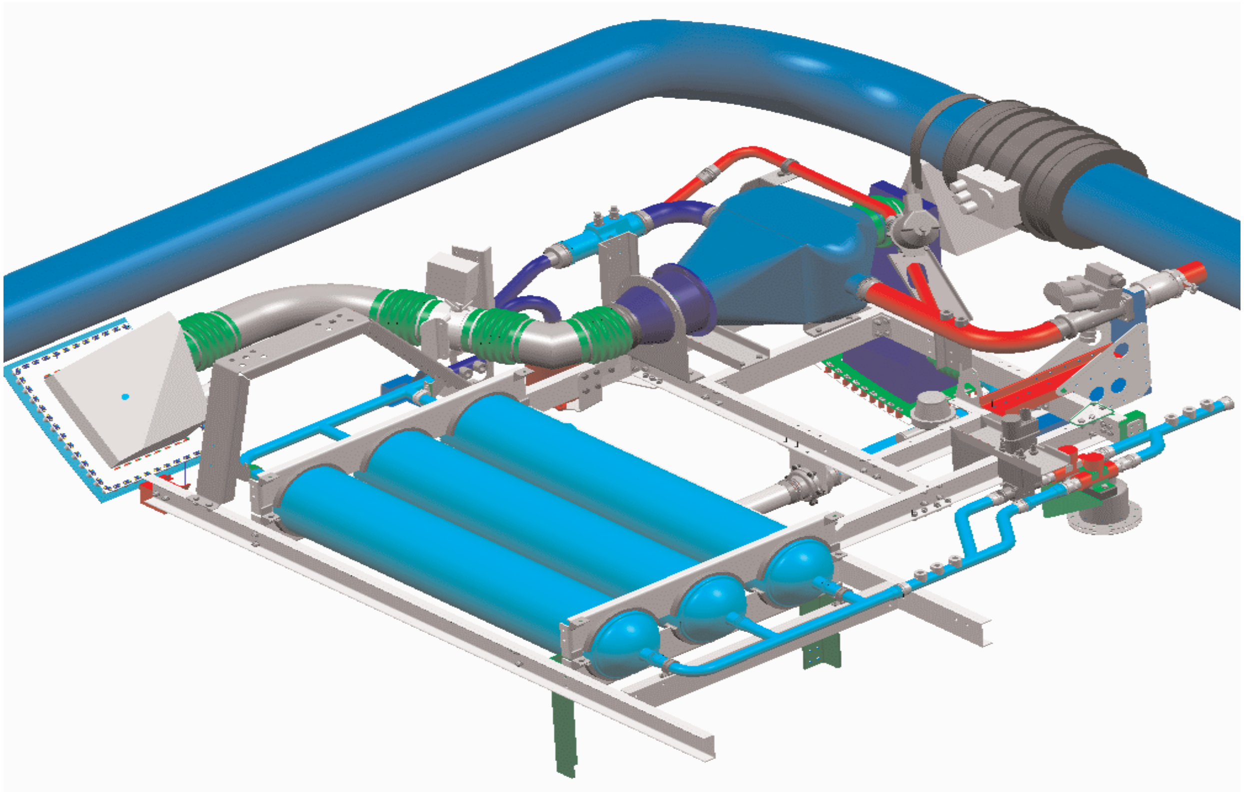
While testing the inerting system, technicians used special instruments to measure fuel tank oxygen concentration and flammability. These FAA-developed devices and techniques efficiently revealed the system's ability to reduce the flammability exposure of a commercial airplane center wing tank. "We designed the study to see how we could make our inerting system do its job better without taking more resources from the airplane," said Cavage. "Also, we wanted to measure the progression of flammability in flight, which had never been done before."

The results from the tests confirmed the FAA inerting system operated as expected. The prototype's required warm-up times had no measurable effect on the system's ability to keep the fuel tank inert during typical flight conditions. As intended, a variable flow methodology allowed engineers to generate a greater amount of NEA on descent at a higher oxygen concentration (lower purity). Flammability measurements from both the center wing tank and the wing tank showed trends consistent with experimental and computational analysis previously performed, and provided for potential improvement of flammability models.

"Now that we've seen this progression of flammability and how it relates to temperature changes, we're a lot smarter about flammability," said Cavage. "That knowledge will allow us to build future models of how flammability actually works in the complex dynamic of the fuel tank."[1]

[1] "Evaluation of Fuel Tank Flammability and the FAA Inerting System on the NASA 747 SCA," contains a description of the flight test program and findings. The report authored by Michael Burns, William M. Cavage, Robert Morrison, and Steven Summer is now available online at http://www.fire.tc.faa.gov/reports/searchresults.asp?searchType=author&searchPhrase=Cavage.

An inerting system replaces the oxygen in the fuel tank with an inert gas such as nitrogen, preventing the potential ignition of fuel vapor. Inerting systems have been used on military aircraft since World War II to minimize combat explosions and battle damage. Many different techniques have been used to generate inert gas on military aircraft. After World War II, some airplanes used engine exhaust to produce the inert gas. More recently, nitrogen has been generated onboard the aircraft to render the fuel tank inert. Various techniques exist for separating nitrogen from air for use in inerting, the simplest and most reliable being the hollow-fiber membrane technology that is used in the FAA-developed inerting system prototype. The FAA prototype weighs less than 200 pounds compared to a complex inerting system used by the military that can weigh thousands of pounds. It also takes up very little space on an airplane.



More recently completed research focuses on an inerted center wing tank when fully or mostly loaded with fuel. Previous FAA fuel tank inerting experiments focused on the amount of NEA gas needed to inert a commercial transport category airplane fuel tank during ground operations. The results of these experiments illustrated that an empty tank can be inerted to 8 percent oxygen (by volume) with 1.5 volume exchanges of 5 percent NEA (5 percent oxygen).

"Now we want to know what effect a fuel load has on the inert tank," explains Cavage. "Fuel tends to trap air and when an aircraft ascends to altitude the pressure in the fuel tank decreases causing a pressure discrepancy between the tank and the dissolved fuel gases. This allows for additional oxygen evolution to increase the oxygen concentration of an adjacent fuel tank ullage, potentially making it more flammable."

Researchers recently conducted controlled experiments to determine if the oxygen concentration in a full fuel tank increases as a result of the equalization of the partial pressures of dissolved oxygen in the fuel. They found that at sea level the increase in oxygen concentration can be as great as 7 percent for a tank inerted to 6 percent with an 80 percent fuel load if the fuel is stimulated. Increasing altitude allows for an additional increase in the oxygen concentration.

Inerting the tank through the fuel has the effect of scrubbing (displacing) the fuel of oxygen to some rudimentary level of protection that reduces or eliminates the increase in oxygen concentration due to fuel and ullage gas equalization. However, this fuel scrubbing method illustrates some significant increases in ullage oxygen concentration with higher fuel loads.[2]

In the next study phase, researchers plan to illustrate other potential uses for NEA to enhance fire safety in the commercial transport fleet. NEA could be used as a fire suppression agent in inaccessible or hidden areas of the aircraft as well as potentially enhancing cargo bay fire suppression. "Generating NEA onboard the aircraft allows for numerous areas of fire safety improvement without adding additional equipment to the aircraft," states Cavage. "This can only be a good thing." R&D Review

[2] William M. Cavage, "The Effect of Fuel on an Inert Ullage in a Commercial Transport Airplane Fuel Tank" (http://www.fire.tc.faa.gov/pdf/05-25.pdf).

Moving Forward

Advisory Subcommittee Supports Controller Workforce and Technology Transition

Over the next ten years, the FAA projects that a significant portion of the controller workforce will retire. Anticipating the need to fill many vacated positions, FAA Administrator Marion Blakey asked the Research, Development and Engineering Advisory Committee (REDAC) Human Factors Subcommittee to assess and provide recommendations related to the skills, training, and needs of the next generation of controllers.

May FAA employees supported the Subcommittee activity by providing briefings and materials regarding recruitment, selection, screening, training at the FAA Mike Monroney Aeronautical Center Academy, and on the job training in the field. Additionally, some Subcommittee members had the opportunity to visit the Academy's training facility as well as several field facilities. The discussions with the subject matter experts, managers, and controllers, as well as the visit to the Academy to see the training laboratories and simulators proved instrumental in providing the Subcommittee critical information on which to base their recommendations.

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

At a recent REDAC meeting, the Subcommittee praised the new Action Plan for establishing a single point of responsibility and authority to oversee its implementation, for clearly delineating the issues it addressed, and for matching metrics to the action tasks they would measure. The Subcommittee encouraged the Agency to be alert to ways it might turn near-term solutions in workforce development into longer-term successes in workforce transition. The Subcommittee continues to support controller transition activities. For example, members are now studying the best training practices that air transport operators have developed, and the lessons they have learned, for possible application to improving controller performance.

The FAA also recently embraced many of the recommendations by the REDAC Air Traffic Services Subcommittee Transition Working Group. In its twelve month study, this Working Group identified and analyzed barriers to transitioning technology from research to operations. Group members gathered information from relevant literature and over thirty briefings from industry, academia, government, national research centers, and aviation organizations.

The Working Group subsequently developed a set of findings and recommendations that it presented to FAA Administrator Blakey. In her response to the REDAC, the Administrator agreed to a number of recommendations that would facilitate technology transition.

Realizing that transition is one of the biggest challenges facing the introduction of new technologies, the Administrator has created a Development Liaison Team to provide recommendations to the Vice President of Operations Planning on research technologies that should be pursued. The FAA is also working closely with industry to evolve toward a performance-based national airspace system concept that will allow operators to leverage existing aircraft equipage capabilities, while showing increased performance value as aircraft equipage capabilities are increased.

In addition, the FAA is already working to establish guidelines for transitioning knowledge and data to industry. The Agency continually uses best practices from government and industry to improve its policies and guidance. New guidance is incorporated in the FAA's Acquisition Management System.

The Working Group reports can be found online at http://research.faa.gov/redac/reports/reports.aspx. R&D Review

Arlene Beisswenger and Jean Perron INDOOR SNOW TESTING OF AIRCRAFT GROUND ANTI-ICING FLUIDS (DOT/FAA/AR-06/14)

Currently, holdover time performance for aircraft deicing and anti-icing fluids under snow conditions are determined from outdoor tests on flat plates in natural snow. The FAA Airport and Aircraft Safety Research and Development Division has sponsored research to do similar tests under indoor laboratory conditions. Such indoor tests would lead to a more timely and improved assessment of a new fluid's performance without relying on outdoor snow conditions. During past investigations, when similar tests were conducted in laboratory cold rooms, the resulting holdover times were significantly different (typically shorter) from those produced outdoors in natural snow conditions. This difference was attributed to the effects of wind. Recent research at the National Center for Atmospheric Research has produced indoor procedures using temperature-controlled test plates that accounted for the effects of wind and produced holdover time results that more closely matched those obtained from outdoor snow tests.

Yann Hang Lee and Jim Krodel FLIGHT-CRITICAL DATA INTEGRITY ASSURANCE FOR GROUND-BASED COTS COMPONENTS (DOT/FAA/AR 06/2)

Ground processing systems are likely to use commercial-off-the-shelf (COTS) software and hardware for maintaining flight critical data. Hence, the COTS ground processing systems must be trustworthy and secure to maintain the integrity of the data. This requires various approaches, including information protection, data integrity and access security.

This report describes the results of our studies on the existing guidance governing the use of COTS components for safety-critical applications of ground-based systems, and the objectives of current guidance from the point of view of applicability and shortcomings. The use of hazard analysis and vulnerability analysis as a means for developing an effective risk mitigation strategy is provided and the relevance of the Rotorcraft Advisory Circular to a COTS components scenario is summarized. In order to address security and vulnerability concerns, several technologies such as encryption/decryption, authentication, access control, intrusion detection, etc., particularly in relation to application within a health and usage monitoring system (HUMS) context, are discussed. The report also includes two case studies involving COTS products to determine if they can be qualified by following existing software guidance, such as DO-178B and DO-278.

Keith Bagot and Nicholas Subbotin HIGH-REACH EXTENDABLE TURRETS WITH SKIN-PENETRATING NOZZLE (DOT/FAA/AR-05/53)

New equipment for aircraft rescue firefighting vehicles can help improve firefighting after an aircraft crash. New equipment, such as a high-reach extendable turret (HRET) with skin-penetrating nozzle mounted on an airport firefighting vehicle, could extinguish fires faster, apply firefighting agent more accurately on fires, and possibly save passengers lives as a result. The evaluation in this report will determine the extinguishment abilities of an HRET with a skin-penetrating nozzle on simulated real fire aircraft crashes and during a full-scale fire field test.

One objective of this research was to compare the abilities of an airport firefighting vehicle using an HRET to that of another vehicle using traditional airport firefighting methods of extinguishment on several real fire aircraft crash simulations. Another objective was to evaluate and determine if an airport firefighting vehicle using an HRET with a skin-penetrating nozzle can control and extinguish an aircraft interior fire and reduce interior temperatures. Two different research efforts were undertaken for the described objectives. One was completed by the Air Force Research Laboratory using its fire test facility, and the second was completed at the San Antonio Airport using a training aircraft.

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The HRET with the skin-penetrating nozzle outperformed the traditional firefighting methods during many simulated real fire aircraft crashes at the fire test facility with its ability to extinguish several fires faster, increased accuracy of firefighting agent application by positioning the HRET close to the source of the fires, and use of less firefighting agent on several fires. The skin-penetrating nozzle used on the full-scale fire field test showed the ability to control and contain the fire from spreading beyond the tail section, reduce high cabin temperatures from over 1500° to approximately 250°, provide rapid smoke ventilation, and still extinguish the fire.

Gordon F. Hayhoe ALPHA FACTOR DETERMINATION USING DATA COLLECTED AT THE NATIONAL AIRPORT PAVEMENT TEST FACILITY (DOT/FAA/AR-06/7)

Full-scale test data for multiple-wheel, heavy gear load (MWHGL) loading of flexible airport pavements are summarized from three separate test series: one test series, the MWHGL tests, was conducted by the U.S. Army Corps of Engineers (USACE), and the other two series of tests were conducted by the FAA at the National Airport Pavement Test Facility (NAPTF). The MWHGL pavement structural configuration was used as the reference, and all NAPTF structures were converted to equivalent reference structures by the use of thickness equivalency factors relating the NAPTF and the MWHGL structural materials. Load repetition factors (alpha factors), required for the computation of pavement thickness by the California Bearing Ratio (CBR) design procedure for flexible airport pavements, were calculated for the NAPTF test data and plotted with the MWHGL alpha factors. Least squares quadratic curve fits were computed for the four- and six-wheel alpha factors, and the alpha factors at 10,000 coverages were computed for comparison with the International Civil Aviation Organization (ICAO) standard for computing Aircraft Classification Number (ACN). The results of the analyses are consistent with the existing alpha factor of 0.825 for four-wheel gears, but the results of the analyses are not consistent with the existing alpha factor of 0.788 for six-wheel gears. The six-wheel alpha factor at 10,000 coverages should be changed to a value approximately equal to the interim value of 0.72 adopted by the ICAO for calculating ACN for six-wheel gears.

Roy M. Rasmussen, Matt Tryhane, Scott Landolt, and Alan Hills ENDURANCE TIME TESTS USING THE NCAR SNOW MACHINE: RESULTS OF ROUND-ROBIN TESTS USING A CONSTANT TEST PLATE TEMPERATURE (DOT/FAA/AR-05/58)

This report summarizes the results of round-robin tests with the National Center for Atmospheric Research (NCAR), Aviation Planning Services (APS), and Anti-icing Materials International Laboratory (AMIL) snow machines using a constant plate temperature. Previous results from snow indoor tests showed shorter fluid endurance times of anti-icing fluids for the NCAR snow machine compared to outdoor natural tests. A consistent result of the previous study was higher plate temperatures for outdoor tests exposed to wind compared to indoor tests not exposed to wind. A lower plate temperature will change fluid properties, such as viscosity and surface tension, and therefore, also affect fluid flow behavior and consequently endurance time. Previous tests have shown that most fluids show longer endurance times for warmer plate temperatures, and thus the shorter endurance times observed for the NCAR snow machine may possibly be explained by the lower plate temperatures. The previous report suggested that a method to reduce the bias would be to conduct the indoor snow machine tests at a selected plate temperature that better simulates the effects of the wind. Preliminary results from APS, AMIL, and NCAR all showed improved agreement with the outdoor tests when this procedure was used.

The suggested method was tested during the winter of 2003/2004 by conducting indoor round-robin tests with the NCAR, APS, and AMIL snow machines employing selected outdoor snow conditions. The indoor test conditions used commonly agreed to constant plate temperatures for each test and were based upon outdoor tests conducted by APS in previous years. APS provided the outdoor conditions and constant plate temperature to each laboratory, and each laboratory conducted as many of the tests as practicable. NCAR conducted 82 indoor tests at conditions previously tested outdoors and provided the resulting snow machine results to all the other laboratories. The results of these 82 tests and an intercomparison to the other laboratory results are provided in this report. R&D Review

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