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Multi-layer solutions

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Shedding the frosting

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Invisible weather phenomena

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Middle management crucial

ROLLBACK ON FINAL

BA 777 SUFFERS ICE BLOCKAGE

THE JOURNAL OF FLIGHT SAFETY FOUNDATION

FEBRUARY 2010

STRUCTURAL Issues

Last year's crash of a Colgan Air Bombardier Q400 at Buffalo, New York, U.S., is having quite an effect. It is already driving changes in the way the industry looks at fatigue and eventually it will have a big effect on the way we train and qualify pilots. As important as those are, I hope the accident brings at least one more big issue up for public debate: the relationship of safety, liability and code shares.

Nowhere in the world is the scope of this relationship bigger than in the U.S. regional airline industry. The U.S. National Transportation Safety Board and the U.S. Congress are onto this now, and they are not going to let this issue go unaddressed. I hope they are ready to ask the difficult questions and not look for political quick fixes.

Everyone talks about the "one level of safety" goal for all air carriers. But the truth is that regional operators' safety varies significantly. Several of these operators have world-class safety systems; others struggle with the most basic compliance issues. The normal response to this imbalance is to blame the regulator, but I suggest that sort of response is disingenuous and avoids the real issue of how this industry is structured.

Major airlines' transfer of traffic to regional airlines has always been about reducing costs. Regionals operate under contracts that obligate them to fly a given set of flights for the main-line carrier. It doesn't matter to the regionals if the flights fly full or empty; they have no control over revenue. All they can control are costs, and if they don't do that there is a 100 percent chance they will go out of business.

A regional that cuts corners on safety has about a one in 2 million chance of having an accident. Such an accident may or may not take the airline out of business. There is a powerful economic incentive to meet minimum FAA requirements at the lowest possible cost. In this economic environment, safety cannot be a priority unless leaders push for it. I worry about a system where safety is carried on heroes' backs.

The main-line carriers have the power to incentivize safety, but that doesn't always happen. Some carriers work diligently to raise the safety level of their code share partners. I can only explain this as more heroism because they don't have a business reason to do this. The smart business move for a major carrier — and the way some choose to do it — is to take a hands-off policy regarding the safety of their code share partner and declare that if the FAA hasn't shut them down, they must be safe. I'd say that position appears irresponsible to the flying public, but it might be the right answer for the stockholders, limiting operational costs every day and stockholder liability in the event of a crash.

If Congress wants to have an effect, it should focus on these fundamental issues. Small changes in the incentive schemes will have more effect than another 100 rules or 10,000 inspectors. If you really want one level of safety, then look for ways to make safety an economic priority and not just a moral imperative.

William R. Voss
President and CEO
Flight Safety Foundation

AeroSafety WORLD

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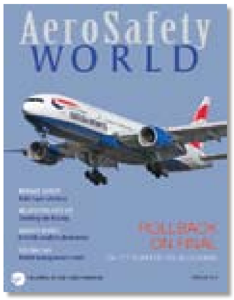

About the Cover
The British Airways 777 destroyed in the fuel blockage accident.
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POSITIVE Reflections

We spend most of our time thinking, talking and writing about strategies that will decrease the risk of an aviation accident; introspection generally is confined to the adequacy of our efforts. In the past several weeks, however, I've twice been reminded what an extraordinary achievement the aviation community has accomplished.

First was a report on the effort to introduce checklists into hospital operating rooms. Despite 100,000 post-surgical deaths in the United States alone each year, the medical community has been reticent to alter traditional ways.

The checklist approach, championed by Dr. Atul Gawande in his book, *The Checklist Manifesto: How to Get Things Right,* is being used in fewer than one-quarter of U.S. hospitals.

The checklists detail mostly simple things, such as making sure all necessary staff is present, reviewing the procedure before the cutting begins — a lot like briefing for an approach — and even ensuring the presence of supplies that might be needed, such as extra blood. The process seems very similar to crew resource management.

A test in eight hospitals around the world showed the same results in developing nations and the first world, a one-third reduction in post-surgical complications and a decline in patient mortality. However, 20 percent of surgeons still think the two-minute checklists are "a waste of time," Gawande says. Using cockpit checklists as his model, Gawande seems to believe that if captains can be convinced they might be fallible, perhaps doctors' thinking can be likewise swayed.

While the medical community at least is moving towards what we consider sound safety practices, my hometown rapid transit agency, Washington Metro, has suffered a succession of fatal accidents and seems unable to understand why this is happening. A National Transportation Safety Board (NTSB) hearing into a fatal subway train crash in June 2009, killing an operator and eight passengers, made it clear that Metro lacks nearly all of the tools the aviation community now considers essential. NTSB has investigated eight Metro accidents since 2004, and four employees have died in track accidents since the June accident.

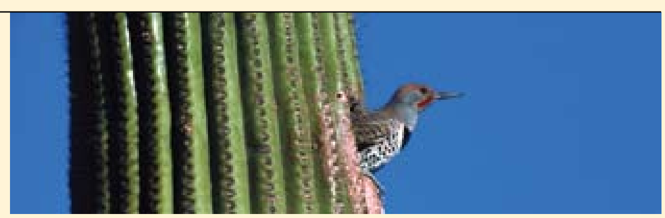
Metro's safety manager testified that there is no process for collecting or analyzing safety data; the overall manager of the operation, now on his way out, did not see safety reports until after the big accident last year and, despite operators being repeatedly found in voluntary noncompliance with operating rules, many report that a punitive safety reporting culture discourages participation.

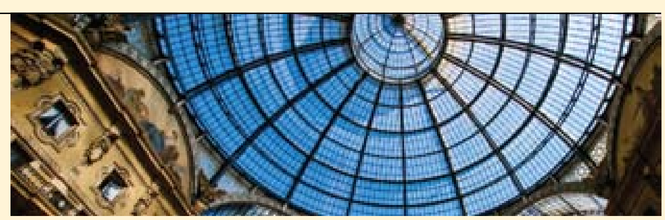
Metro Chairman Peter Benjamin minimized management's role in establishing a good safety culture, saying, "The best way to change a culture is to work from the bottom up."

This is not happening in some small, remote location; this agency runs trains and buses in the capital of the United States, including a station in the building that houses NTSB.

The aviation safety community, dedicated to getting better and better, rarely pauses to reflect on achievements, looking, instead, at all that remains to be done. I think it is important occasionally to reflect on the amazing progress that has been made, positive reinforcement motivating future progress. However, I shake my head in wonder about why these lessons cannot more easily be passed along for the benefit of the rest of civilization.

J.A. Donoghue
Editor-in-Chief
AeroSafety World





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CALL FOR PAPERS ➤ 41st Annual Seminar of the International Society of Air Safety Investigators. Sapporo, Japan, Sept. 6–9. Bob Matthews, <bob.matthews@faa.gov>.

CALL FOR PRESENTATIONS AND PANELISTS ➤ Shared Vision of Aviation Safety Conference. U.S. Federal Aviation Administration. June 1–3. San Diego. Lucy Erdelac, <lerdelac@utrs.com>, <www.aqp-foqa.com/Conferences/2010/index.html>, +1 215.870.2331.

MARCH 4–6 ➤ Annual Repair Symposium. Aeronautical Repair Station Association. Arlington, Virginia, U.S. <arsa@arsa.org>, <www.arsa.org/node/227>, +1 703.739.9543.

MARCH 8–11 ➤ Safety Management Course. ScandiAvia. Stockholm. Morten Kjellesvig, <morten@scandiavia.net>, <www.scandiavia.net>, +47 91 18 41 82.

MARCH 9–11 ➤ Managing Human Error in Complex Systems Workshop. Wiegmann, Shappell & Associates. Alexandria, Virginia, U.S. <www.hfacs.com>, 800 320.0833.

MARCH 9–11 ➤ ATC Global Exhibition and Conference. United Business Media. Amsterdam. <www.atcevents.com/ATC10/Website/HomePage.aspx?refer=1&id=mainLnk1>, +44 (0)20 7921 8545.

MARCH 10–11 Global ATM Operations Conference. Civil Air Navigation Services Organisation. Amsterdam. Anouk Achterhuis, <events@canso.org>, <www.canso.org/operationsconference>, + 31 (0)23 568 5390.

MARCH 15–16 ➤ First Middle East and GCC LOSA and TEM Conference. World Food Programme Aviation Safety Office. Abu Dhabi, United Arab Emirates. Samir Sajet, <samir.sajet@wfp.org>, +971 6 5574799.

MARCH 15–17 ➤ 22nd annual European Aviation Safety Seminar. Flight Safety Foundation, European Regions Airline Association and Eurocontrol. Lisbon, Portugal. Ahlam Wahdan, <wahdan@flightsafety.org>, <flightsafety.org/aviation-safety-seminars/european-aviation-safety-seminar>, +1 703.739.6700, ext. 102.

MARCH 15–17 ➤ Human Factors — General Principles. Baines Simmons. London. Kevin Baines or Bob Simmons, <officemanager@bainessimmons.com>, <www.bainessimmons.com/directory-course.php?product_id=99>, +44 (0)1276 855412.

MARCH 15–19 ➤ Accident and Incident Investigation Course. ScandiAvia. Stockholm. Morten Kjellesvig, <morten@scandiavia.net>, <www.scandiavia.net>, +47 91 18 41 82.

MARCH 16–17 ➤ Safety Management Systems Overview Course and Workshop. ATC Vantage. Tampa, Florida, U.S. <registrations@atcvantage.com>, <www.atcvantage.com/sms-workshop-March.html>, +1 727.410.4759.

MARCH 16–18 Dangerous Goods Inspector Initial Training. U.K. Civil Aviation Authority International. London Gatwick. Sandra Rigby, <training@caainternational.com>, <www.caainternational.com/site/cms/coursefinder.asp?chapter=134>, +44 (0)1293 573389.

MARCH 17–19 ➤ Spring Conference: Leadership and Advocacy. Association of Air Medical Services. Washington, D.C. Natasha Ross, <nross@aams.org>, <www.aams.org/Content/NavigationMenu/EducationMeetings/SpringConference/default.htm>, +1 703.836.8732, ext. 107.

MARCH 22–24 ➤ CHC Safety and Quality Summit. CHC Helicopter. Vancouver, British Columbia, Canada. <summit@chc.ca>, <www.chcsafetyqualitysummit.com/default.aspx>, +1 604.232.7424.

MARCH 24–25 ➤ AQD Customer Conference. Superstructure Group AQD Safety and Risk Management. Hong Kong. Liz Swanston, <liz.swanston@superstructuregroup.com>, <www.superstructuregroup.com>, +64 4385 0001.

MARCH 28 ➤ IS-BAO Workshop. National Business Aviation Association. New Orleans. Jay Evans, <jevans@nbaa.org>, <www.nbaa.org/events/pdp/is-bao/20100328.php>, +1 202.783.9353.

MARCH 29–APRIL 1 ➤ AMC — Improving Maintenance and Reducing Costs. ARINC. Phoenix. Sam Buckwalter, <sbuckwal@arinc.com>, <www.aviation-ia.com/amc>, +1 410.266.2008.

MARCH 22–24 ➤ Aircraft Accidents Crisis Preparedness and Management Conference. Singapore Aviation Academy. Singapore. Jasmin Neshah Ismail, <Jasmin_Ismail@caas.gov.sg>, <www.saa.com.sg/saa/en/index.html>, +65 6540 6209.

MARCH 29–APRIL 1 ➤ High Level Safety Conference. Civil Air Navigation Services Organisation. Montreal, Quebec, Canada. Anouk Achterhuis, <events@canso.org>, <www.canso.org/cms/showpage.aspx?id=1286>, +31 (0)23 568 5390.

APRIL 13–14 ➤ Business Aviation Safety Seminar-Asia (BASS-Asia) 2010. Flight Safety Foundation, International Business Aviation Council, National Business Aviation Association and Asian Business Aviation Association. Singapore. Namratha Apparao, <apparao@flightsafety.org>, <flightsafety.org/aviation-safety-seminars/business-aviation-safety-seminar-asia-2010>, +1 703.739.6700, ext. 101.

APRIL 13–14 ➤ Fatigue Risk Management 2010. Circadian Australia. Melbourne, Victoria, Australia. Janet Reardon, <seminars@circadian.com>, <www.circadianaustraliaseminar.webls.info>, +1 781.439.6388.

APRIL 13–15 ➤ Cabin Safety Workshop. U.S. Federal Aviation Administration Civil Aerospace Medical Institute. Oklahoma City, Oklahoma, U.S. Lawrence Paskoff, <lawrence.paskoff@faa.gov>, <www.faa.gov/data_research/research/med_humanfacs/aeromedical/cabinsafety/workshops>, +1 405.954.5523.

APRIL 19–21 ➤ Human Factors Train-the-Trainer. The Aviation Consulting Group. San Juan, Puerto Rico. Bob Baron. <tacg@sccoast.net>, <www.tacgworldwide.com/humanfactorstraining.htm>, 800.294.0872 (U.S. and Canada), +1 954.803.5807.

APRIL 19–23 ➤ 1st Pan American Aviation Safety Summit. International Civil Aviation Organization Regional Aviation Safety Group–Pan America and the Latin American and Caribbean Air Transport Association. São Paulo, Brazil. <panamericansafety@alta.aero>, <www.alta.aero/safety/2010/home.php>.

APRIL 20–21 ➤ Risk Management Course. ScandiAvia. Stockholm. Morten Kjellesvig, <morten@scandiavia.net>, <www.scandiavia.net>, +47 91 18 41 82.

Aviation safety event coming up? Tell industry leaders about it.

If you have a safety-related conference, seminar or meeting, we'll list it. Get the information to us early — we'll keep it on the calendar until the issue dated the month of the event. Send listings to Rick Darby at Flight Safety Foundation, 601 Madison St., Suite 300, Alexandria, VA 22314-1756 USA, or <darby@flightsafety.org>.

Be sure to include a phone number and/or an e-mail address for readers to contact you about the event.

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Flight Safety Foundation is an international membership organization dedicated to the continuous improvement of aviation safety. Nonprofit and independent, the Foundation was launched officially in 1947 in response to the aviation industry's need for a neutral clearinghouse to disseminate objective safety information, and for a credible and knowledgeable body that would identify threats to safety, analyze the problems and recommend practical solutions to them. Since its beginning, the Foundation has acted in the public interest to produce positive influence on aviation safety. Today, the Foundation provides leadership to more than 1,040 individuals and member organizations in 128 countries.

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Safety News

Most Wanted

The U.S. National Transportation Safety Board (NTSB) has added a new aviation issue to its updated "Most Wanted List of Transportation Safety Improvements."

The new entry calls for improved oversight of pilot proficiency and criticizes the U.S. Federal Aviation Administration (FAA) for what the NTSB characterizes as an unacceptable response to two 2005 safety recommendations, which said that the FAA should "require airlines to obtain histories of flight check failures by pilot applicants and to require special training programs for pilots who have demonstrated performance deficiencies."

The 2010 update of the Most Wanted list retained five aviation issues that have appeared on previous versions of the list, including an entry calling for mandatory image recorders on large transport category aircraft, as well as on smaller aircraft that have no other recording devices. The NTSB rated FAA progress on this issue as unacceptable.

"Although cockpit voice recorders and flight data recorders record sounds and relatively comprehensive airplane data during an emergency, they do not show the critical cockpit environment leading up to the emergency," the NTSB said.

The NTSB also described FAA progress as unacceptable on two other issues — improving runway safety and reducing dangers to aircraft flying in icing conditions. Past runway safety recommendations from the NTSB have included requiring "moving map displays in the cockpit, giving immediate warnings to the cockpit of impending incursions and requiring landing distance assessments with an adequate safety margin for every landing." The NTSB's examination of airframe structural icing led to the conclusion that certification standards have been inadequate, the board said.

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FAA progress was characterized as "acceptable response, progressing slowly" in the two remaining aviation issues on the list — improved safety of emergency medical services flights, an area in which the FAA plans to issue a proposed rule, and crew resource management (CRM) for U.S. Federal Aviation Regulations Part 135 on-demand operators.

"The NTSB has investigated a number of Part 135 on-demand operators where such training was not provided, and errors by the crew led to accidents," the board said, noting that the FAA has proposed requiring CRM training for these carriers.

Decrease Seen in ATM Link to Accidents

The number of aviation accidents in Europe involving air traffic management (ATM) is decreasing, according to a report by the Eurocontrol Safety Regulation Commission.

The commission's annual safety report said that in 2009, no fatal accidents were "directly induced" by ATM; an "indirect ATM contribution was reported in two nonfatal accidents.

"This continues a trend seen over recent years where the number of ATM-related accidents has decreased year-on-year," Eurocontrol said. The agency added, however, that progress toward full accident reporting by states is too slow and that more detailed risk analysis is necessary.

The report also criticized the lack of funding and resources at national supervisory authorities that oversee aviation safety processes in individual European countries, noting that the emphasis on safety must continue despite budgetary pressures.

© Mark Brouwer/Wikimedia

"It is clear that in the future, safety will be tested even more rigorously," said Jos Wilbrink, chairman of the commission. "While the overall situation is improving on a long-term basis, in order to meet the tenfold safety improvement aim of the Single European Sky, further efforts will be needed."

Cabin Crew Additions

The Australian Civil Aviation Safety Authority (CASA) is proposing a change in the required ratio of cabin crewmembers to passenger seats in aircraft used in regular public transport and charter operations.

The agency is seeking public comments on a notice of proposed rulemaking that would require one cabin crewmember for every 50 passenger seats in aircraft with more than 36 seats and fewer than 216; the current requirement — in place since 1960 — has called for one cabin crewmember for 36 passenger seats.

"The change would bring Australia into line with leading aviation nations and standardize current cabin crew ratio approvals," CASA said, adding that the current ratio "does not take into account significant improvements in aircraft design, crashworthiness, crew training, evacuation performance and survivability" that have been achieved in the past 50 years.

Request for Safety Data

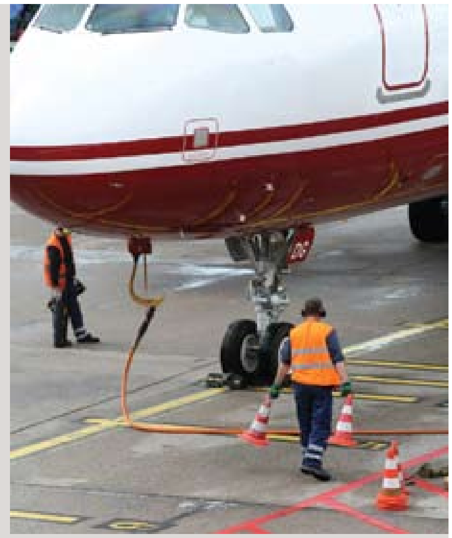
Aircraft Engineers International (AEI), which represents aviation maintenance personnel, has called on the European Commission to make public safety data involving the aviation operations under its jurisdiction.

AEI acted in response to a published report that indicated that 65,000 commercial passenger flights in the United States between 2003 and 2009 involved airplanes that were not airworthy. The report, in the *USA Today* newspaper, was based on an analysis of data from the U.S. Federal Aviation Administration (FAA). The report also said that the FAA imposed $28.2 million in fines against 25 U.S. airlines.

In Europe, AEI said, the European Commission "continues to protect the airlines which are under its control by consistently refusing to release the relevant safety data."

AEI cited one incident discussed in the *USA Today* article in which an airplane's flight controls jammed shortly after takeoff. The FAA had criticized American Eagle, the operator of the airplane, for allowing it to continue operating despite earlier reports of vibration. In Europe, AEI said, it was "aware of one airline having flown an aircraft a further 505 times before the aircraft vibration was finally eliminated"; the airline was not fined, AEI said.

"This situation must change before the next preventable accident occurs, and one method of achieving this is transparency," AEI said. "European citizens have a right to know how European airlines are really performing."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Industry Standards

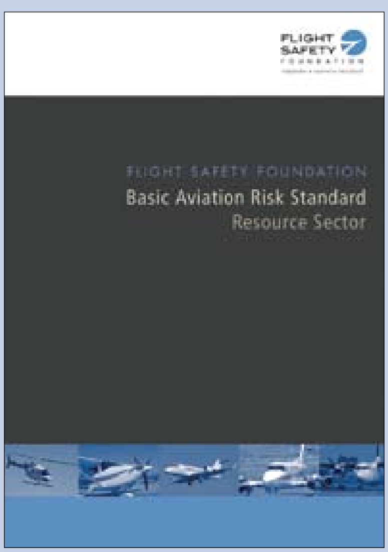
In an effort to improve safety for flights in the mining and resource industry, Flight Safety Foundation is initiating the Basic Aviation Risk (BAR) Standard Program.

"Aviation risk management has always been one of the single greatest challenges to the safety of personnel in the resource sector," said Trevor Jensen, Flight Safety Foundation international program director, who heads the BAR program. "Combined with the challenging and often remote areas of operation, additional variables increase the difficulty, including the variety of aircraft types, adverse weather and terrain, wide number of aircraft operators and differing levels of regulatory oversight."

The program is designed to provide a common safety approach for aircraft operations in the industry, which currently uses multiple aviation safety standards, depending on the expectations of individual companies. "This has the potential to introduce inefficiencies, varying degrees of acceptability and overall lower levels of flight safety assurance," the Foundation said.

The program, developed in consultation with some of the world's leading resource companies, will be managed by the FSF regional office in Melbourne, Victoria, Australia.

A full briefing on the program is available on the Foundation Web site at <flightsafety.org/files/bars_v2.pdf>.



Continuous Monitoring

The International Civil Aviation Organization (ICAO) plans to expand its safety oversight system with the introduction of an online reporting and data management system to monitor the oversight capabilities of ICAO member states.

Roberto Kobeh González, president of the ICAO Council, said in a speech in Madrid in January that the monitoring system also would enable ICAO to assess the safety level of aviation activities and evaluate safety management capabilities "in a harmonized and consistent manner."

He said the introduction of the continuous monitoring approach is the next phase in a safety oversight system that began with the introduction of the ICAO Universal Safety Oversight Audit Programme (USOAP) in 1999. USOAP was expanded in 2004, and in 2006, ICAO member states agreed to post the summary results of USOAP audits on the ICAO Web site. He called that agreement "tacit recognition that transparency is fundamental to a safe air transport system."

Proposed Penalties

The U.S. Federal Aviation Administration (FAA) has proposed two separate civil penalties totaling more than $5 million against American Eagle Airlines for failing to ensure that the weight of baggage was calculated properly and for using airplanes with landing gear doors that had been improperly repaired.

The FAA said that, between January and October 2008, the airline conducted at least 154 passenger-carrying flights in which "baggage weight listed on airplane cargo load sheets disagreed with data entered into the company's electronic weight and balance system." After American Eagle was informed of the problem, the company operated at least 39 flights without correcting the situation, the FAA said. The proposed fine was $2.5 million.

© Manuel Rocha/Wikimedia

American Eagle has since revised its *Station Operating Manual* to ensure the confirmation of proper weight and balance information, the FAA said.

In a separate action, the FAA proposed a $2.9 million civil penalty against the airline for operating more than 1,000 flights with airplanes on which improper repairs had been performed on landing gear doors. The flights occurred between February and May 2008 on four Bombardier jets; the airplanes' landing gear doors had not been repaired in accordance with a 2006 airworthiness directive, which required inspections of landing gear doors on some Bombardier airplanes for cracks or other damage, removal of the affected doors, and installation of new or repaired doors, the FAA said.

American Eagle found damaged doors on four airplanes, but "rather than removing the doors, the airline repaired them while they remained on the planes," the FAA said.

In each instance, the airline was given 30 days to appeal the FAA action.

In Other News …

An audible alert system has been developed to help prevent the unintentional deployment of airplane **evacuation slides**. Curtiss-Wright Controls says its SmartHandle, which can be designed to fit any aircraft door, can be programmed to issue alerts in either a male or female voice and in any language. … The Civil Air Navigation Services Organisation (CANSO) and aviation stakeholders throughout the Middle East have signed a **Middle East Declaration** pledging to work for improved air traffic management in the region. Signers said the declaration will pave the way for harmonization of air navigation services. … The Civil Aviation Safety Authority of Australia is working to standardize procedures for the **aerial firefighting** industry, which has grown significantly in recent years.

Mandatory Simulator Training

The Civil Aviation Safety Authority of Australia (CASA) is considering action that could eventually require pilots of a range of aircraft to undergo mandatory simulator training.

© Jordan Tan/Dreamstime

The agency solicited comments from aircraft operators, pilots and flight simulator training organizations on 12 options outlined in a discussion paper issued in December 2009. The options differ in three areas: the type of training activities that should be conducted in a flight simulator, the types of aircraft and operations that would be affected, and the availability and location of certificated training devices. Comments were due by Feb. 19.

Current CASA regulations do not require simulator training.

The discussion paper said, however, that "the quality and scope of training available in a flight simulator is superior to the training available in an actual aircraft. The accessibility of sophisticated simulators has opened up new avenues of pilot training, permitting the demonstration of nearly every possible emergency scenario during the course of a training and checking program."

The discussion paper said that any new simulator requirement would not impose additional training time; instead, simulator training would replace existing components of training programs that currently are conducted in aircraft "and place them in the safer, more versatile environment of a flight simulator."

Compiled and edited by Linda Werfelman.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Multi-Layer **Defenses**

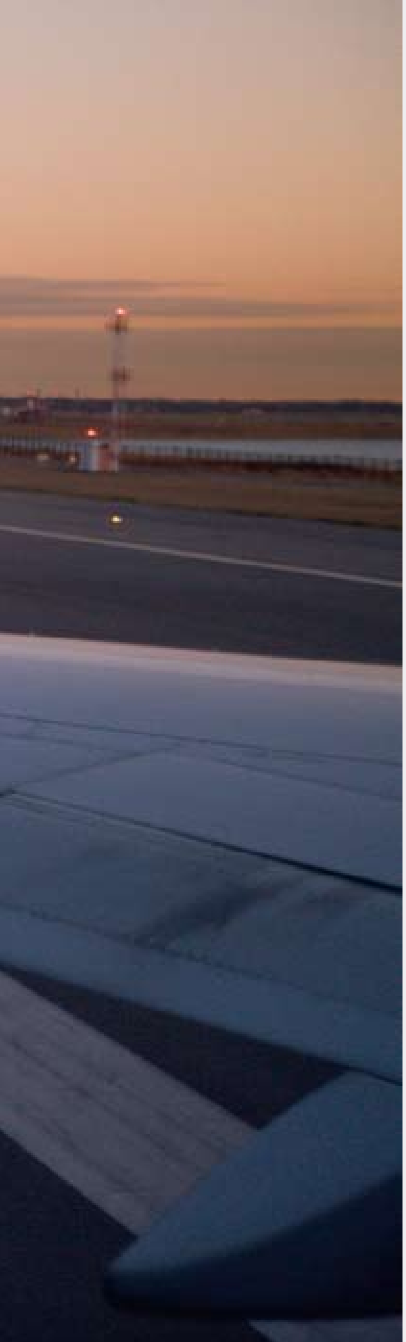
BY WAYNE ROSENKRANS

Specialists at FAA summit look beyond technology to latent and cognitive frontiers of runway risk reduction.

Technology-driven answers to human errors dominated a December runway safety conference during which presenters discussed various delays, gaps, lost opportunities and missteps of concern in the advance of safety. Many speakers called for broader, faster and less costly solutions than technology alone offers.

Efforts during the past three years to reduce European and U.S. risks of runway incursions, excursions and confusion events have been intense, they agreed. Still, some expect the next frontier of risk reduction to require overcoming ingrained misconceptions about human performance and errors. If standard operating procedures underestimate actual risks when flight crews taxi from the gate to the runway or vice versa, the apparent safety margin may be an illusion, several presenters suggested at the U.S. Federal Aviation Administration (FAA) International Runway Safety Summit held in Washington, D.C.

The U.S. National Transportation Safety Board (NTSB) was among organizations that have tackled broader runway issues that Chairman Deborah Hersman called as hazardous as runway incursions. "The [U.S.] runway incursion rate over the last four years stands at about six per 100,000 tower



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operations," Hersman said. "While these incursions represent close calls and are measured in feet rather than in miles, it is not due to luck that we avert disaster on a daily basis. It's because of robust procedures, safe designs and well trained and alert controllers and pilots. … We firmly believe that the implementation of our recommendations, some of which are over 10 years old, will reduce the chances of runway collisions, the likelihood of a pilot mistakenly selecting an incorrect runway or taxiway … or the likelihood of an excursion."

She cited an unfinished NTSB investigation into a serious incident that calls into question the multiple layers of defense. "On Oct. 19, 2009, at about 0600, a Delta Air Lines Boeing 767 completing a flight from Rio de Janeiro to Atlanta was cleared to land on Runway 27R, but instead landed [without injuries or damage] on a parallel taxiway just north of the runway," she said. "It was dark, and visibility was reported at 10 mi [16 km]. … Preliminary information indicates that neither the flight crew nor the air traffic controllers realized that anything was wrong until the aircraft was rolling out on the taxiway."

This incident should be "entirely sufficient" to accelerate adoption of direct warning systems on aircraft and in air traffic control (ATC) facilities, Hersman said, adding, "The FAA is taking commendable action, but it is just too slow."

Chris Glaeser, director, global safety, International Air Transport Association (IATA), joined others in calling for careful examination of latent and contextual factors before closing any investigation of a runway incident or accident. He cited one airline's investigation. "The flight crew had been given taxi [instructions] to a runway on five occasions — five different clearances to go to a particular runway — then the last clearance was to take off immediately on a different runway," Glaeser said. "They got it wrong and took off on the wrong runway."

IATA's worldwide incident data for 2009 showed one attempted and three completed landings on taxiways by large commercial jets, including the Atlanta landing cited by Hersman. IATA members' latest runway safety concerns have revolved around pressure on flight crews not to use reverse thrust at night, even on a short runway with a tail wind, because of noise abatement rules; lack of accurate measurement of runway contamination in a timely manner for flight crews; late runway changes by ATC for takeoff or landing; inaccurate airport diagrams in electronic flight bags (EFBs) for airports outside the United States that fail to depict unserviceable taxiways and taxiway construction; and lack of depiction of engineered material arresting systems (EMAS) on airport charts, which might cause pilots anticipating an overrun to steer away from an EMAS bed in a mistaken effort to avert striking the approach lights.

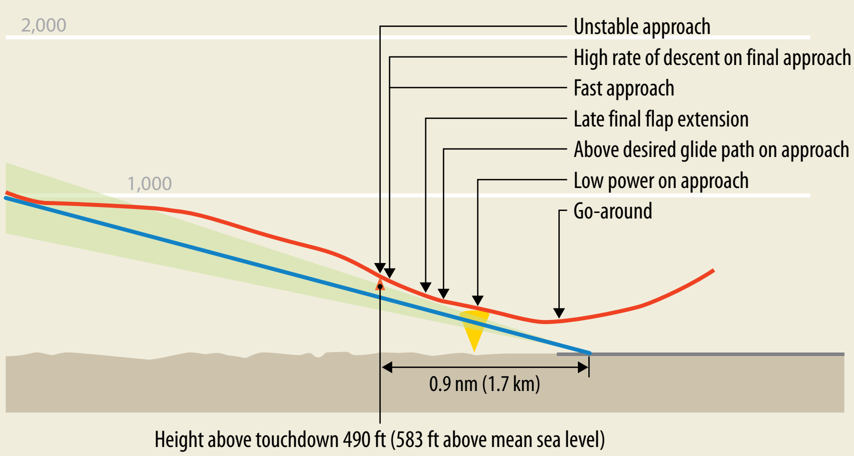
Aggregated voluntary pilot reports already can identify for the FAA and airlines airport hot spots of pilot/driver confusion, and recorded flight data can identify concentrations of the unstable approaches that figure into excursions (Figure 1, p. 16), said Michael Basehore, manager of the FAA's Aviation Safety Information Analysis and Sharing program (*ASW,* 8/09, pp. 12 and 32).

"We noticed a preponderance of aviation safety action program reports at one particular airport where confusion resulted from three closely spaced runway ends and numerous [runway position holding markings, Figure 2, p. 17]," Basehore said. "The triangle formed by the 'hold short' lines all in one location plus the parallel 'hold short' lines [led to] a high percentage of reports … saying, 'We are confused, there are so many hold short lines that we are not really sure where they are.' By having an aggregate of data, not just data from one airline, [we could see] a spike in the reporting so that we knew to go in and focus on this particular area."

Pilot Perspectives

"Technology is a word frequently associated with runway safety, but I want to emphasize that human factors, the human performance, is all-important whether we are talking about the snowplow driver or the air traffic controller

Identifying Trends in Unstable Approaches



Note: Deidentifed flight data collected by participating U.S. airline flight data quality assurance programs have been used by the Aviation Safety Information Analysis and Sharing program to interpret seven parameters for identifying unstable approaches and the runway end where they occurred. Trends in aggregate data from many flights and airlines will offer clues to reducing the risk of this significant cause of runway excursions.

Source: U.S. Federal Aviation Administration

Figure 1

in the control tower or, indeed, the pilot in the cockpit," said Rory Kay, an airline captain and executive air safety chairman of the Air Line Pilots Association, International (ALPA). "We have to be paying attention to the limitations of human performance, and we have to find how to deliver better training."

Another ALPA representative added that new captains tell him that the biggest challenge they face today in airline passenger operations is "How do I taxi that airplane around [the airport] and not find myself on a runway?" Charles Hogeman, an airline captain and chairman of the union's Human Factors and Training Group, said, "Sixty years ago, taxiing was not a big deal — but it is now. … We have to have company operating procedures that consider the high workload during ground operations."

Among taxi demands are head-down loading and verification of a runway and a departure procedure in the flight management computer; weight-and-balance verification that cannot necessarily be performed at the gate; last-minute taxi amendments; runway changes requiring performance analysis; and current company responsibilities of pilots, such as engine start during taxi and other fuel-conservation practices.

Disrupted radio calls on congested frequencies during taxi also affect runway safety, and blocked calls and multiple related transmissions concern airline pilots when this prevents read-back of taxi instructions, Hogeman said. "When pilots miss [hearing] that airline name, we lose that powerful cueing for our own awareness of what we're supposed to be doing," he said.

During the landing rollout, a rapid transition in thinking and communication must occur while the aircraft is moving, he added. Based on expectation bias at a familiar airport, a flight crew verifying the latest company gate assignment, parking position and ATC taxi clearance and routing can be caught off guard, for example, by unusual turns apparently away from the gate.

Taxi after landing involves repositioning flight controls, selecting lights and performing other checklist items while moving. Company responsibilities of pilots here include fuel-conservation measures such as an engine shutdown. "We have a lot of things going on that have made this a very high-risk area," he said.

Simple, low-tech solutions sometimes should receive high priority, said Heriberto Salazar Eguiluz, an Aeroméxico captain and vice chairman of the Aerodrome and Ground Environment Committee of the International Federation of Air Line Pilots' Associations (IFALPA). "Everywhere there is a runway that can be crossed, someone will make a mistake," he said. "So we should avoid crossing a runway whenever possible … just by constructing a perimeter taxiway."

Some IFALPA member pilots consider foreign object debris, wildlife on runways, bird strikes and inadequate infrastructure as their most pressing concerns. One runway excursion cited by Salazar involved a flight crew that rejected a takeoff because of bird ingestion and overran a runway that did not meet the international standard for a runway end safety area.

Overdue for corrective action are ATC reliance on issuing late changes of approach or assigned runway to cope with inadequate runway capacity and dense traffic; ATC reliance on visual approaches when the runway lacks the visual approach slope indicator or precision approach path indicator system that some airline standard operating procedures require for acceptance of such a clearance; ATC policies of waiting for at least a 7 kt tail wind before changing arriving aircraft to a more favorable runway; and what IFALPA considers excessive crosswinds for line operations, Salazar said.

Training of airfield drivers must be designed in light of the turnover of the workforce and frequently reinforce awareness of threats and errors, some presenters said. Every technology helps if it enhances situational awareness, enables airfield drivers to experience hazardous scenarios and escape from danger, or identifies surface hot spots in simulators, said James Crites, executive vice president of operations at Dallas/Fort Worth International Airport (DFW). Clear communication and consistent compliance with safe practices — not new systems — remain the highest priority, he added.

Practical Theories

Multitasking and prospective-memory limitations have major implications for runway safety, said R. Key Dismukes, chief scientist, aerospace human factors, Human Systems Integration Division of the U.S. National Aeronautics and Space Administration (NASA) Ames Research Center. Multitasking in most situations actually means rapidly switching attention among discrete tasks, he said (*ASW,* 8/09, p. 18). Prospective memory refers to a person's capability to remember something he or she intends to do later, and explains why the person can forget to perform the task despite the intention.

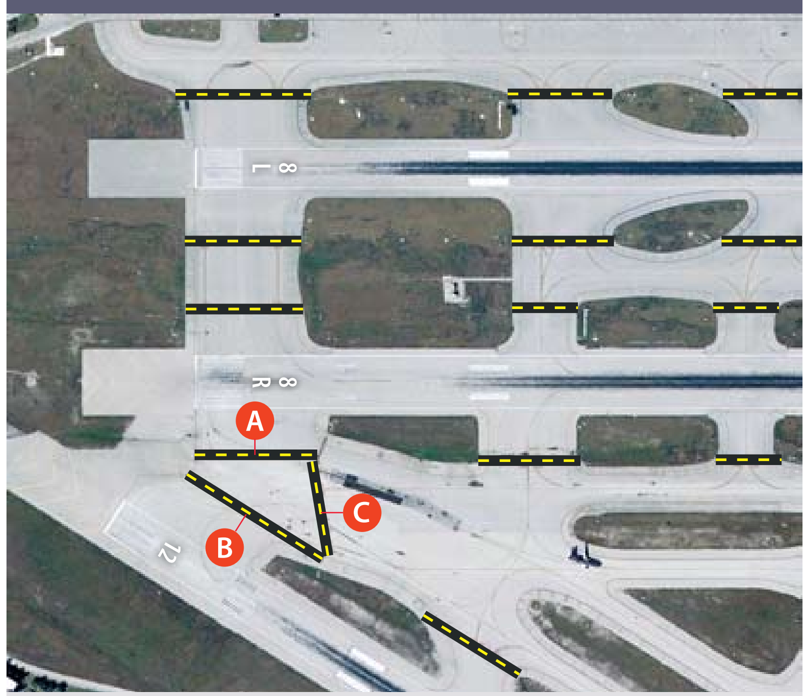
"It takes a moment while we disengage from one task and reengage in the other task," Dismukes said. "During that moment, people reconstruct their mental model [so] the flight crew is vulnerable to error — especially if they do not have good visual cues to remind them of the state of the other task."

Among unsafe behaviors noted by NASA flight deck observers have been first officers who received an amended ATC clearance during taxi, then became fixated in head-down mode trying to solve a problem instead of monitoring the captain's actions and overall situation. In some cases, the first officer missed the only opportunity to prevent a captain from taxiing without clearance onto an active runway.

International Concerns

Data show that 950 runway incursions — about three a day — occurred in Europe in 2008, and in 2009, preliminary numbers were regarded by Eurocontrol as "a serious problem," said Paul Wilson, head of air traffic management unit, Eurocontrol Centre of Expertise. "There are around 10 to 20 reported category A and category B incursions[1] every year in Europe, and it's proving almost impossible to deal with those … each one is different," he said. So the industry needs to think about the next evolution of safety nets, a single global concept of operations, he added. The publication of the *European Action Plan for the Prevention of Runway Incursions* has

Confusing Runway Position Holding Markings



A = Hold short here for aircraft arrivals on Runway 30

B = Hold short here for aircraft arrivals on Runway 26L

C = Hold short here for aircraft departures on Runways 8R/12

Note: A trend in aggregated pilot reports to the aviation safety action programs at some U.S. airlines revealed difficulty in correctly complying with air traffic control instructions to "hold short" of these runways at this U.S. airport location, according to the Aviation Safety Information Analysis and Sharing program.

Source: U.S. Federal Aviation Administration and Google Earth

Figure 2

facilitated adoption of many recommended practices within and outside Europe, and more than 100 runway safety teams in Europe now routinely identify local issues.

Eurocontrol has provided technical advice to several airports — including Charles de Gaulle Airport in Paris and London Heathrow Airport — on enhancing stop bars and other airfield systems with a common user interface to develop — within a five- to 10-year time frame — capabilities similar to runway status lights (RWSL) in the United States, said Eric Miart, manager, airport program and environment activity for the agency. "RWSL is [compatible] with the way we currently use stop bars at European airports … to protect the runways in low-visibility conditions," he said.

"In Europe, we strongly believe that communication is at the heart of the runway incursion problem," Miart said. "One way to improve is to provide the controllers and the flight crews specific tools and safety nets, trying as much as possible [to avoid situations] where the human … will be the weak link." This year, Eurocontrol expects to add 20 recommendations to the *European Action Plan* on the use of technology and on civil-military joint use airports.

The existence of more than 70 air traffic service providers in the region complicates sharing common elements of runway safety programs, said Jem Dunn, group customer account manager for NATS UK. "The only thing that will make the next step change [occur] in runway safety is the right piece of technology, but a flight deck solution is too far away, and we still have this problem today," he said.

In a recent incursion at night, a U.K. controller left the tower position — while a vehicle was on the active runway — without placing memory-aid blocking strips, contrary to the usual practice, then handed off duties without mentioning the vehicle to a controller who had no surface surveillance display. "The first transmission of the oncoming controller was 'cleared for takeoff' to the airplane [pilot who] had just called him," Dunn said. The driver vacated the runway in time solely because of training and adherence to operational and radio-monitoring procedures, he said.

The incident captured the attention of the NATS UK chief operating officer (COO), and the COO's follow-up letter had a "profound effect" in encouraging personal responsibility for safety, he said. "We should take that as a warning … as our accident, and behave as if we had an accident; it was only a couple of fortuitous things that stopped it being an accident," the COO's letter advised controllers and airport operations directors.

Stop Bar Caveats

ICAO favors expanded use of stop bars, and entities such as NAV Canada recently have installed more of them. Any inadequate procedures or inconsistent responses to illuminated stop bars by flight crews and airfield drivers, however, can increase risk, said Bert Ruitenberg, an air traffic controller and human factors specialist for the International Federation of Air Traffic Controllers' Associations (IFATCA). A survey of ATC and airport practices[2] has kept attention focused on discrepancies, especially practices in which a pilot or driver is expected to cross an illuminated stop bar, he said (*ASW,* 8/08, p. 27).

"ICAO says that if the stop bar is switched off, the aircraft or [vehicle] can proceed," Ruitenberg said. "IFATCA does not agree — we say that a clearance is needed in addition to the switching off of the stop bar. … Having aircraft and vehicles cross lit stop bars routinely on a daily basis means that the integrity of the protection that stop bars are intended to provide is, in fact, breeched on a daily basis."

Visible NextGen Steps

FAA Administrator Randy Babbitt said that leading the agency's runway safety efforts are the 23 airport surface detection equipment, model X (ASDE-X) systems in place as of December, with a total of 35 airports slated to receive ASDE-X by April 2011 (*ASW,* 9/08, p. 46). "Data from the last fiscal year [showed] 12 category A and B incursions[3] out of more than 50 million operations," he said. "That's 12 too many, but it's a staggering achievement that we have made that reduction." Joint government-industry efforts on many fronts — not any single technology such as ASDE-X or RWSL — will further reduce collision risk, he said. "Technology can help but it is not going to replace the need for training … and overall awareness," Babbitt said.

The FAA continues research, development and testing of prototypes; expanding ASDE-X and RWSL; and moving closer to adoption of new procedures and clearance phraseology, said Michael McCormick, director, FAA terminal safety and operations support.

Building blocks for the U.S. transformation into the Next Generation Air Transportation System (NextGen) became more visible to the aviation industry in 2009 with mutually reinforcing safety and efficiency benefits, added Mike Romanowski, FAA director of NextGen integration and implementation. In 2009, demonstration programs for widely sharing ASDE-X data at John F. Kennedy International Airport in New York and Memphis (Tennessee) International Airport enhanced situational awareness.

Integration of ASDE-X and automatic dependent surveillance–broadcast (ADS-B) also became apparent in new applications, and the first staffed NextGen ATC tower at DFW will demonstrate in early 2010 capability to manage airborne and surface traffic at remote airports, Romanowski said. "ADS-B is a remarkable success story … well on track for full nationwide deployment by 2013," he said. "We have gone operational with ATC critical services in Louisville, Kentucky, U.S., in November and [ADS-B in December] in the Gulf of Mexico. We are poised to go operational for broadcast services in Boston … Philadelphia in February and Alaska in April."

Vincent Capezzuto, FAA ADS-B program manager, considers ADS-B the key enabler for ground separation services and other runway-safety applications, noting near-term benefits as soon as airlines add the required avionics. "The next three [ADS-B development] blocks deal with the approach sequence, the final approach and runway occupancy and finally … airport surface situational awareness," he said. One such application to be tested aboard 20 US Airways Airbus A330s will be surface indications and alerting.

Other major 2010 activities include the transition of the FAA's final approach runway occupancy signal subsystem of RWSL to operational use; testing at Boston Logan International Airport of another RWSL subsystem — runway intersection lights — which soon will operate in conjunction with runway entrance lights and takeoff hold lights at some airports (*ASW,* 9/08, p. 46); and newly designed low-cost ground surveillance for smaller air carrier airports where ASDE-X could not be justified, said Paul Fontaine, program manager, FAA Advanced Technical Development and Prototyping Group. Other sites with RWSL among 22 scheduled are DFW, San Diego International Airport and Los Angeles International Airport.

Prototyping of the low-cost ground surveillance systems begins early this year at Manchester, New Hampshire. "We have done site preparation and taken delivery of some of the equipment, and plan evaluations starting in a third quarter of 2010 to 2011 time frame," Fontaine said. Other sites are San Jose and Long Beach, California, and Reno, Nevada.

The U.S. National Air Traffic Controllers Association advocates for the near-term the use of surface surveillance technology in every control tower at the 60 busiest U.S. airports, as well as tower simulators for the most effective training, said Dale Wright, director, safety and technology. "I have stood next to controllers when [their] runway incursions happened, and it's a life-changing experience some people don't come back from," Wright said. "Our ultimate goal is that every tower have surface surveillance."

EFB Mystery

The FAA has identified 21 cases in which pilots, despite using EFBs with airport moving map and "ownship" position display, were involved in a pilot deviation and runway incursion, said Pradip Som, research and development manager, FAA Office of Runway Safety. An unresolved question for the FAA is the degree to which safety benefits outweigh collision risks if pilots spend too much time head-down, he said.

To learn more, the FAA so far has paid for installation at each of five selected airlines up to 40 EFBs with airport moving map and ownship position, two per airplane, while targeting airports with a history of runway incursions, Som said. Analysis began in January, and after final aircraft installations by September, the FAA will survey and interview the pilots about effects on situational awareness, and develop recommendations by November 2011.

Before the FAA introduces any runway safety–related changes, time-consuming processes must be completed by a safety risk management decision panel and other officials, said the FAA's McCormick. Such processes currently operate within the Air Traffic Organization's safety management system. "Safety risk management needs to take place to ensure that we are not injecting unintended consequences or additional risk," he said.

Notes

1. In a category A runway incursion, separation decreases and participants take extreme action to narrowly avoid a collision, or the event results in a collision. In a category B runway incursion, separation decreases and there is a significant potential for collision.
2. IFATCA. "IFATCA Survey Report: Stopbars." <www.ifatca.org> December 2008.
3. The FAA said in an October 2009 news release that the 12 serious runway incursions in fiscal year (FY) 2009 were 50 percent fewer than in FY 2008. Two of the serious incursions involved commercial aircraft and were considered ATC operational errors.

A buildup of ice came loose during final approach.

SNOWBALLS

Flow restrictions caused by ice that dislodged from fuel pipes and smothered the fuel/oil heat exchangers resulted in rollbacks of both engines when a Boeing 777-200ER was on final approach to London Heathrow Airport the afternoon of Jan. 17, 2008. The flight crew was unable to increase thrust, and the aircraft was damaged beyond economic repair when it touched down hard short of the runway (*ASW*, 11/09, p. 26).

One of the 136 passengers was seriously injured, and 34 passengers and 12 of the 13 cabin crewmembers received minor injuries.

In its final report on the accident, the U.K. Air Accidents Investigation Branch (AAIB) said, "Ice had formed within the fuel system from water that occurred naturally in the fuel while the aircraft operated with low fuel flows over a long period. … Certification requirements with which the aircraft and engine fuel systems had to comply did not take account of this phenomenon, as the risk was unrecognized at that time."

Based on the findings of the accident investigation, the AAIB issued 18 safety recommendations, several of which called for actions to mitigate the risk of the buildup and sudden release of ice in aircraft fuel systems, a phenomenon the report called a "snowball."

Extreme Cold

The accident occurred at the conclusion of a British Airways flight from Beijing. The flight crew had received a 44-hour rest period before beginning the trip, and each pilot had taken about three hours of rest in the aircraft's crew rest area during the 10.5-hour flight.

The commander, 43, had 12,700 flight hours, including 8,450 hours in type. Two copilots were assigned to the flight. The senior copilot, 41, had 9,000 flight hours, including 7,000 hours in type. The other copilot, 35, had 5,000 flight hours, with 1,120 hours in type.

Before departing from China at 0209 coordinated universal time (UTC), the pilots discussed the need to monitor fuel temperature because of the unusually cold air temperatures forecast at altitude.

During the flight, the crew conducted a series of relatively gentle step climbs, using the autopilot's vertical speed mode to avoid large power increases that might disturb the passengers. The aircraft reached its final cruise altitude, Flight Level (FL) 400 (approximately 40,000 ft), over Sweden.

The lowest outside air temperature (OAT) en route was minus 74˚ C (minus 101˚ F), about 13˚ C (23˚ F) below average. The lowest OAT at which the aircraft's Rolls-Royce Trent 895-17 engines are certified to operate is minus 75˚ C (minus 103˚ F), the report said.

Despite the low OATs, however, the crew did not receive a low fuel temperature warning, which is generated when the fuel temperature nears the freezing point, or minus 47˚ C (minus 53˚ F) for the Jet A-1 in the 777's tanks. The lowest fuel temperature observed was minus 34˚ C (minus 29˚ F).

Transfer of Control

The commander flew the aircraft with the autopilot and autothrottles engaged during the descent from cruise altitude. The London weather was mild for the season, with visual meteorological conditions and a surface temperature of 10˚ C (50˚ F).

Air traffic control held the aircraft at FL 110 for five minutes before issuing radar vectors for the instrument landing system (ILS) approach to Runway 27L.

The approach was stabilized, and "at 1,000 ft AAL [above airfield level] and 83 seconds before touchdown, the

in the Fuel System

BY MARK LACAGNINA

aircraft was fully configured for the landing," the report said. "At approximately 800 ft AAL, the [senior] copilot took control of the aircraft in accordance with the briefed procedure."

The procedure called for transfer of control from the commander to the copilot if the copilot established visual contact with the runway before the aircraft reached decision height; otherwise, the commander would fly the missed approach. The copilot spotted the runway when the 777 was about 2.5 nm (4.6 km) from the threshold.

Shortly after the copilot took control, the autothrottle system commanded an increase in power from both engines. The engines initially responded, but engine pressure ratio (EPR) — the ratio of outlet pressure to intake pressure — for the right engine then decreased to 1.03, or just above flight idle, when the aircraft was at 720 ft AAL. Seven seconds later, left-engine EPR decreased to 1.02.

No Response

The aircraft was below 400 ft AAL when the crew noticed that airspeed was decreasing below the target of 135 kt and that the engines were producing only slightly more than flight idle thrust. These anomalies likely distracted the copilot from disengaging the autopilot at the intended altitude.

"The engines failed to respond to further demands for increased thrust from the autothrottle [system] and manual movement of the thrust levers to fully forward," the report said. "The airspeed reduced as the autopilot attempted to maintain the ILS glideslope."

Master caution and low-airspeed warnings were generated when airspeed dropped to 115 kt. "The airspeed stabilized for a short period; so, in an attempt to reduce drag, the commander retracted the flaps from flap 30 to flap 25," the report said.[1]

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Despite fuel and oxygen leaks, there was no fire.

After the brief stabilization, airspeed again began to decrease. As the 777 descended through 200 ft AAL, airspeed was about 108 kt. The stick shaker activated 10 seconds before touchdown, and the copilot pushed his control column forward.

"This caused the autopilot to disconnect as well as reducing the aircraft's nose-high pitch attitude," the report said. However, the aircraft was only 150 ft above the ground — too low to build sufficient airspeed. Just before impact, the copilot pulled back on his control column.

Descent rate was about 1,400 fpm and peak vertical acceleration was 2.9 g when the aircraft touched down in a grassy area about 330 m (1,083 ft) short of the runway threshold at 1242 UTC. The landing gear collapsed, and the 777 slid, turned right and came to a stop off the side of the runway threshold. Significant leakages of fuel and oxygen occurred, but there was no fire.

"The cabin crew supervised the emergency evacuation of the cabin, and all occupants left the aircraft via the slides, all of which operated correctly," the report said. "One passenger was seriously injured, having suffered a broken leg as a result of detached items from the right main landing gear penetrating the fuselage."

Unique Combination

The report said that an analysis of data from 35,000 flights by aircraft with Rolls-Royce engines showed that the 777's Beijing-to-London flight was unique in having combined the lowest overall cruise fuel flow, the highest overall approach fuel flow and the lowest fuel temperature during approach.

Average fuel flow to each engine during the 9.5-hour cruise portion of the flight was about 7,000 pounds per hour (pph). "From the top of descent to the time of being fully configured for landing, fuel flow had not exceeded 7,300 pph for either engine," the report said. Fuel temperature during the approach was minus 22° C (minus 8° F).

The autothrottle system commanded four thrust increases during the approach. "Of the four thrust commands, it was the second that resulted in the highest delivery of fuel flow, reaching a peak of 12,228 pph for the left engine and 12,032 pph for the right," the report said. "Peak fuel flows during the first and third thrust commands were lower, at about 9,500 pph and 9,000 pph, respectively."

The rollbacks occurred after the fourth thrust command. Fuel flows reached 8,300 pph for the right engine and 11,056 pph for the left engine before they gradually decreased below 6,000 pph, which was suitable to maintain near-flight-idle thrust. The fuel flows stabilized at these values despite attempts by the autothrottles and the pilots to apply full thrust.

Troublesome Ingredient

The aircraft had departed from Beijing with 79,000 kg (174,163 lb) of fuel. There was as much as 5 kg (11 lb) of water in the fuel — a normal amount, according to the report.

"Water is always present to some extent in aircraft fuel systems and may be introduced during refueling or by condensation from moist air which has entered the fuel tanks through the tank vent system," the report said. "The water in the fuel can take one of three forms: dissolved, entrained (suspended) or free."

As fuel cools, dissolved water is released from solution and takes the form of tiny entrained droplets. Further cooling causes the droplets to freeze as ice crystals that initially drift within the fuel and then adhere to each other and to cold surfaces — inside fuel pipes, for example. This type of ice is relatively soft and easily dislodged.

Free water is denser than fuel and settles as droplets or puddles to the bottoms of tanks, filters and stagnation points in the fuel-delivery system. The ice formed from free water is hard and clings to tank linings and other structures.

The fuel/oil heat exchangers in most large turbofan engines are designed to prevent ice from forming on sensitive downstream components such as fuel-metering units. Inside the 777's heat exchangers, fuel is pumped through more than 1,000 small tubes, around which hot engine oil flows (Figure 1). The fuel is warmed, and the oil is cooled.

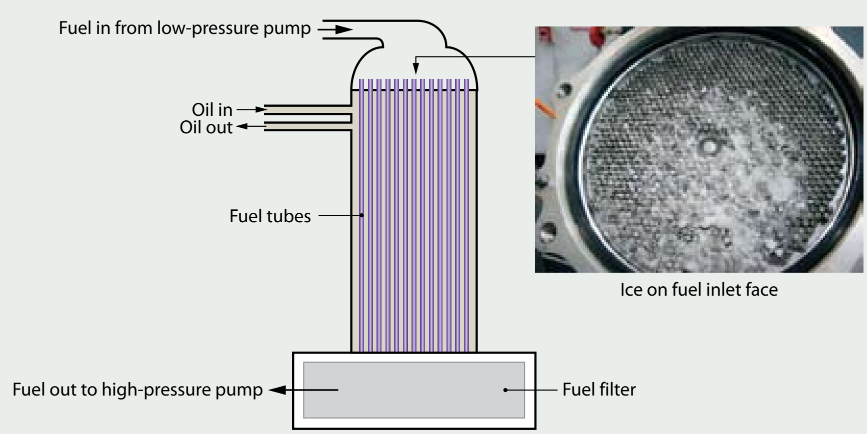
Heat exchangers in large jet transports are sufficiently effective that icing inhibitors commonly are not added to the fuel. Although icing inhibitors are approved for use in 777s, none had been used when the accident aircraft was refueled.

Recipe for Snowballs

Extensive testing during the investigation showed that the combination of low fuel flow during cruise and the high fuel flow and low fuel temperature during approach fostered an accretion of soft ice in fuel pipes located within the engine pylons. The ice was released by the fuel flow spikes — and possibly turbulence, pitch changes and other factors — during the approach. It then flowed downstream and coated the fuel inlet faces inside the fuel/oil heat exchangers, blocking most of the fuel tubes.

Eleven months after the Heathrow accident, another 777-200ER was 9.5 hours into a flight from China to the United States when the right engine rolled back after power was increased for a step climb to FL 390. "The power reduction persisted for 23 minutes despite several autothrottle commands for increased thrust," the report said. Power was restored after the throttles were retarded to idle for descent. The U.S. National Transportation Safety Board determined that the incident was caused by ice that restricted fuel flow in the fuel/oil heat exchanger.

Boeing 777 Fuel/Oil Heat Exchanger



Sources: U.K. Air Accidents Investigation Branch and U.S. Federal Aviation Administration

Figure 1

Fuel temperature when this incident occurred was minus 22° C, the same as when the accident occurred at Heathrow.

The photograph in Figure 1 shows fuel-inlet icing that occurred during post-accident tests. At the time, the heat exchangers on Rolls-Royce Trents differed from those on other engines in that the tubes protruded slightly from the inlet faces. This was found to have been a factor in the blockage. The engine manufacturer recently modified the fuel inlet faces so that they are smooth.

More Research Needed

Noting that most of what is known about fuel system icing is based on research conducted in the 1950s, the report said that the investigation of the Heathrow accident "has established that the risk from fuel system icing is complex and is dependent on a number of interactions that are not fully understood."

Accordingly, the AAIB called on the U.S. Federal Aviation Administration and the European Aviation Safety Agency to jointly conduct research on ice formation and release in aircraft fuel systems. The AAIB also recommended research on the feasibility of expanding the use of ice inhibitors in jet fuel.

This article is based on AAIB Aircraft Accident Report 1/2010, "Report on the Accident to Boeing 777-236ER, G-YMMM, at London Heathrow Airport on 17 January 2008." The report is available at <www.aaib.gov.uk/home/index.cfm>.

Note

1. The flap retraction moved the touchdown point about 50 m (164 ft) forward, just enough to clear the ILS antenna. "The effects of contact with the ILS antenna are unknown, but such contact would probably have led to more substantial structural damage to the aircraft," the report said.

A civilian-operated Mil Mi-8 utility helicopter lands at a Forward Operating Base in Afghanistan. As in arid and dusty conditions, flying operations in freezing conditions present their own occupational hazards in this rugged country.

Bad Vibrations

Researchers are studying a variety of ways to eliminate icing on helicopters.

BY THOMAS WITHINGTON

Ice is an enemy of all aviators, including helicopter pilots. The unique flight attributes of these aircraft place them in high demand for difficult civilian operations such as emergency medical services, remote and off-shore transportation and search and rescue. Due to the on-call nature of many of these operations, they cannot always wait for perfect visual meteorological conditions with mild temperatures. The danger that a helicopter crew may unwittingly encounter freezing temperatures and icing when performing such missions cannot be discounted. Hot air and heated blades are technologies available in some aircraft, while ultrasonic technology has the potential to provide protection in the future.

Canada's Department of National Defence encountered some nasty surprises in a 2007 experiment involving an AgustaWestland CH-149 Cormorant helicopter belonging to the Canadian Forces Air Command and a Sikorsky CH-53 heavy-lift military helicopter equipped with a spray rig designed to form a cloud of freezing water around the Cormorant. Ice accumulated on the Cormorant's main rotor blades until the centrifugal force of their movement eventually shook the ice free, sending it crashing into the aircraft's tail rotor. This caused the tail rotor to dislodge ice that had accumulated there, and the aircraft began to suffer severe vibrations. Such aircraft behavior would be alarming in the best of times, but would be particularly unwelcome for a crew dashing through clouds of snow on a dark night en route to a medical pickup on a remote oil rig.

Aircraft icing is caused by super-cooled water that remains a liquid at temperatures below 32 degrees F (0 degrees C) but is denied a surface upon which to freeze. An aircraft flying through a cloud of super-cooled water thus provides the surface, and ice builds up — accretion. This can be especially dangerous, as it can alter the aerodynamic characteristics of the rotor blade airfoils and aircraft fuselage, causing excessive vibration, increased weight and drag, and other hazards.

As ice begins to accumulate on the leading edges of the rotor blades, the deformation of the airfoils and the corresponding need for increased torque to maintain any given flight situation are accompanied by airframe vibration as the blades become more unbalanced. This vibration can have adverse effects on the helicopter's airframe, increasing structure stresses and, at the least, raising discomfort levels inside the aircraft, which can accelerate crew fatigue.

Ice also affects the aerodynamic performance of the rotor blades. The larger the ice buildup, the more pronounced the drag of the rotor blades. As a result, more power is required from the engine and transmission, a process that, if left unchecked, eventually

U.S. Department of Defense

Canadian Department of Defence

Canada's location and climate mean that helicopters are at real risk from icing. The Canadian Air Command's Sikorsky CH-149 Cormorant helicopters have been involved in icing trials to ascertain the dangers that ice can pose to helicopter operations.

requires full power to maintain altitude. If accretion continues unchecked, the aircraft begins to descend. If the pilot is lucky, warmer air will be present at lower altitudes and the ice will melt. However, an absence of warmer air beneath the helicopter will prevent the ice from melting and may cause an uncommanded altitude loss.

Moreover, helicopter pilots must contend with the many different forms icing can take, each having different effects. For example, water droplet size affects the position, texture and size of the ice buildup. Larger droplets, for example, hit a rotating blade and run back toward the trailing edge before becoming a solid, increasing the surface area covered by the super-cooled water and therefore increasing the size of the ice buildup.

The flight trials of the Cormorant illustrated how dangerous ice can be. This frozen water can become a deadly missile when it is shed by the rotor blades. Not only does it risk damaging the tail rotor and the airframe itself, but it may also hit exterior protrusions on the aircraft, such as antennas and night vision systems. Such damage can be expensive, and these systems may also be relied on by the crew to enhance flight safety and to assist in the completion of the mission.

While helicopter pilots and operators have several measures that can mitigate the dangers of icing, there is not yet a silver bullet that can eliminate all incidences of icing on a helicopter at no cost in weight or power consumption.

Invented by BF Goodrich in the 1920s, the pneumatic boot is still in use on rotary and fixed-wing aircraft today. The boot is an inflatable rubber structure that fits on the leading edges of helicopters' vertical and horizontal tail surfaces and is inflated to break off ice as it accumulates. However, such a system cannot remove ice from an aircraft's rotor blades, and there remains a threat of shedding ice moving around the airframe.

Another method to reduce ice buildup on a helicopter is fluid-based, preflight deicing, spraying aircraft with a heated glycol-water mix to remove any ice that has built up prior to flight. Using such a product is better and safer than doing nothing, but it is not designed to keep the aircraft ice-free once in flight. Furthermore, glycol-based products are not considered environmentally friendly. There are other issues beyond the cost of such procedures, including the risk that such a product may damage to the helicopter's lubricants and the composite components that are increasingly finding their way into helicopter construction to reduce weight and improve strength and resistance to corrosion.

These materials may not react well to the sudden change in temperature when ice is removed by heated glycol-based products, and delamination is possible. Published in 2004, a paper[1] written by three scientists engaged in helicopter icing research at the U.S. Army Cold Regions Research and Engineering Laboratory in New Hampshire and the U.S. Army Research Laboratory in Adelphia, Maryland, warns that "the thermally induced stress caused by rapid thermal gain, and differential heating of dry and ice-covered surfaces, have the potential for invisibly weakening multi-layered aircraft structures of composite materials."

They note that "non-visible damage such as delaminations, disbonds and structural integrity losses can occur due to low temperature exposure and freeze-thaw cycling effects." Preflight deicing has a secondary disadvantage in that it can be time-consuming and an aircraft may have to wait for deicing equipment to become available before the procedure can be performed. This can be a problem for helicopters that are called upon at short notice to perform emergency missions.

Another helicopter anti-icing option is to use warm air bled from the aircraft's engines through pipe work embedded in tail surfaces, for instance. The disadvantage here is that the air becomes colder as it moves away from the heat source, with a risk that deicing coverage is not uniform; areas near the heat source are ice-free while those farther away remain ice-covered.

Heating mats are another alternative. These mats use an embedded mesh of electrical wire through which a current can pass to heat the surface and prevent the formation of ice. These heating mats can be installed on rotor blades or around engine inlets to prevent ice formation and ingestion into the turboshaft powerplants. Yet, as with the other systems, heating mats add a weight penalty and drain system power.

Along with heating mats, helicopters can also use electro-thermal heating systems in their rotor blades. These raise the blades' temperature to remove ice, or to stop the ice from forming in the first place. However, as all ice protection systems bring costs as well as benefits, such equipment may add an additional burden to the helicopter's electrical system.

Goodrich Corp. provides the ice protection system, consisting of heating mats on the rotor blades and a deicing system on the windshield, on AgustaWestland's AW-139. Although this equipment brings a weight penalty, such systems are the only means by which a helicopter can be certified to fly in icing conditions. The company told *AeroSafety World,* "Ten years ago, these were considered niche systems, but now we are seeing a number of customers requesting this kit." In addition to customers in North America and Europe, operators in Central Asia, especially those involved in the oil and gas industries, are showing interest in the AW-139's ice protection system. Despite the arid terrain of this part of the world, it can suffer harsh winters: "At the moment, the requests for ice protection systems are mainly for aircraft servicing oil platforms and performing search and rescue, but we are also seeing a number of VIP customers requesting this equipment so that they can fly their helicopters to the ski slopes, for instance." In order to save fuel and weight costs, elements of the AW-139's ice protection system can be removed during warmer months when such protection is not needed.

Curtiss-Wright produces the electronics for the Rotorcraft Ice Protection System (RIPS). The rationale behind RIPS is to prevent the buildup of ice on the rotor blades, thus

A Eurocopter EC-145 engaged in search-and-rescue operations on a snow-covered mountain. The very nature of helicopter search-and-rescue operations means that these aircraft may often be at risk from encountering icing conditions.

preventing the problem of ice being thrown around the airframe as it detaches. John Kuperhand, president of Curtiss-Wright Controls Integrated Sensing, Avionics and Electronics, notes that the latest versions of RIPS, installed on the Sikorsky S-92 and soon appearing on the S-76D, are exceptional in that the equipment is “fully automatic,” and does not require the pilot to turn RIPS on and off during the flight. Kuperhand says that RIPS is “the first system that was certified for full flight operation into known icing conditions by the U.S. Federal Aviation Administration, the European Aviation Safety Agency and Transport Canada.” The automatic nature of the system is achieved via the use of “software to determine the proper application of where, when and how frequently heat has to be applied to rotor blades to prevent the buildup of ice.”

RIPS uses heating elements embedded inside the helicopters’ rotor blades. These elements are cycled through a pre-determined timing sequence to prevent ice accretion. The advantage of this approach is that it does not melt the ice through a sudden transmission of heat. Because of the dynamics of the movement of a rotor blade, “if you pump a lot of heat and suddenly melt the ice, you’ll melt the ice on the front end and it will re-ice and add to ice formed on the back end,” notes Kuperhand: “Our system acts by breaking the [adhesion] between the ice and the blade, and lets the ice peel off the front to the back.” When the ice is shed from the leading portion of the airfoil in a gentle, controlled manner, it reduces the danger of larger ice chunks impacting the fuselage, tail rotor and other components.

RIPS has been in production for five years and is offered as an option on Sikorsky’s S-92 and S-76D helicopters because some companies operate them in warmer climates, where ice protection is not a major concern. Curtiss-Wright concedes that RIPS adds weight, but Kuperhand says that the company is “looking at size and total weight reduction” to make the product less intrusive on the helicopter’s performance. The reliability and availability of the system have won operator approval.

Curtiss-Wright also provides electronic controllers for windscreen and engine inlet ice protection. Windshield ice protection is provided by heating elements embedded inside the transparencies. This approach is slightly less sophisticated than RIPS, given that “the pilot can see if ice is forming, and just turn on the windshield de-icer, or it can be set for automatic operation triggered by temperature,” says Kuperhand. The important consideration for rotor blade deicing is that, given the blades’ speed and location, a pilot cannot see whether ice is forming and must therefore rely on a system like RIPS which can sense the temperature changes and then take appropriate deicing action.

Other research is intended to develop the next generation of products to help safeguard rotary operations in freezing temperatures, and one promising option could be the use of sound. A 2006 research report[2] said, “Ultrasonic modes generated by horizontal shear waves produce sufficient interface stresses between a host structure and ice to remove the accreted ice layer.”

What this means is that ultrasound could dislodge ice by disrupting the adhesion between the ice and the blade. Ice is prevented from forming, and ice that formed before the activation of the system can be removed through the use of sound vibrations. An example of such technology can be found in many household bathrooms: Electric toothbrush technology uses ultrasound to shift plaque from teeth using a similar disruptive technique. The researchers discovered that within five minutes, a layer of ice 0.06 in (1.5 mm) thick could be melted using this technique and that “as the amplitude of the ultrasonic waves increased, the ice adhesion strength decreased.”

Ultrasound is still some years away from becoming a viable ice protection system for helicopters. Furthermore, given that such a system would use electrical power and require dedicated equipment to generate the ultrasonic waves, the power generation and weight penalties associated with the system remain undefined. However, as with many aspects of aviation safety equipment, trade-offs and balances have to be reached. Ice protection systems may be an additional drain on electrical and engine power, but the protection that they offer can mean the difference between safe flight and hazardous operations.

Thomas Withington is an aviation journalist residing in the United Kingdom.

Notes

1. Dutta, Piyush K.; Ryerson, Charles C; Pergantis, Charles.*Thermal* “Deicing of Polymer Composite Helicopter Blades.” 2004.

2. Palacios, Jose L.; Smith. Edward C., Pennsylvania State University, “Ultrasonic Shear Wave Anti-Icing System for Helicopter Rotor Blades.” 2006.

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BY LINDA WERFELMAN

Checking the List

A European review praises the EU's airline blacklist as an effective safety tool.

The European Union (EU) blacklist of airlines banned from operating in member nations has — in the three years of its existence — proved to be "an efficient dissuasive measure," according to a report adopted by the European Commission (EC).

The list has been so effective that it should be used as part of a system of expanded international cooperation to enforce safety standards, the report recommended.

The blacklist, first issued in March 2006, has been updated 12 times, most recently in November 2009. The next update is due early this year. According to the November list, all air carriers from 15 non-EU countries, as well as five individual carriers, were banned from operating within the EU. In addition, eight carriers were permitted to operate only under specific conditions (*ASW*, 11/09, p. 10).

The EC report praised the list as "a success story from every angle" and said that it is

Many countries outside Europe also have monitored the list and banned the carriers that it names from operations in their jurisdictions.

"regarded internationally as an effective tool in ensuring a high level of safety to the benefit of the traveling public."

The report added, "There have been a number of cases where air carriers subject to a ban have acknowledged that their safety performance fell below the internationally accepted standards and embarked upon, and demonstrated the successful completion of, remedial and corrective actions. As a result, these carriers have been removed from the list. … On a different but related note, a number of carriers are regularly removed from the EC list as a result of their cessation of operations and the revocation of their air operator certificate by their regulatory authorities, in many cases as a direct result of the EC ban."

Comprehensive Actions

In other cases, when a country has been given evidence of safety deficiencies in the operations conducted by one of their air carriers, that country has acted on its own either to suspend the operator certificate held by the affected company or to impose restrictions on its flight operations. After these countries ordered "comprehensive remedial and corrective actions" and determined that adequate corrections had been made, they lifted the suspensions or ended the restrictions.

"This process, whereby cases are solved through a cooperative exchange between the [EC] and the parties concerned without the need to resort to a ban as a punitive measure of last resort, [has] been an increasing trend," the report said.

The report also noted that many countries outside Europe also have monitored the list and banned the carriers that it names from operations in their jurisdictions.

In recent updates of the list, the results of the International Civil Aviation Organization (ICAO) Universal Safety Oversight Audit Programme (USOAP) — which audits ICAO member states, not individual airlines — have been increasingly significant, the report said.

"The [European] Community[1] has been imposing operating bans on air carriers from states whose performance is characterized by a very high level of noncompliance with ICAO standards and recommended practices (SARPs)," the report said. "The Community has strived to enforce international safety standards by requiring air carriers and the authorities responsible for their safety oversight to satisfactorily resolve the safety deficiencies identified in USOAP audit reports before they can resume (or begin) operations into the European Community."

The report said that countries that have been found by USOAP audits to have what the EU views as "considerable problems" implementing ICAO SARPs — that is, to have failed to implement more than 75 percent of the SARPs — typically have also had their air carriers banned from operating in the European Community.

The report said that the existence of the list has encouraged cooperation between the European Union, non-European air carriers and international organizations in verifying carrier compliance with relevant safety standards.

Limitations

Despite the blacklist's contributions to aviation safety, the report said that it "cannot be seen as a blanket cover for the safety performance of airlines," largely because of two limitations: "Inclusion on the EC list depends on available and verifiable information [and] inclusion on the EC list constitutes an operating ban only to Europe, while banned airlines continue to fly to other regions of the world."

To address these limitations, the exchange of verifiable, reliable information must be strengthened at the international level, the report said.

"The application of the EC list over the last three years has shown that the objective of establishing and maintaining a high level of safety worldwide can only be reached if ICAO safety standards are actually complied with," the report said. "Therefore, appropriate actions need to be taken to ensure that these standards are effectively respected both at the level of the state and by individual air carriers."

The report recommended that the EC clarify what action will be taken by the member states that are affected by any attempt to circumvent the blacklist, such as an overflight by a banned carrier. It also called for clarification of what types of flights are not affected by the ban, such as ferry flights, inspection flights and private flights; and how to record decisions by non-EU countries to limit the air operator certificates held by their air carriers regarding operations within the EU.

Other recommendations call for modernizing the system of aviation accident investigation, in part by establishing a network of accident investigation agencies in EU countries, and for providing technical assistance to help the civil aviation authorities responsible for overseeing blacklisted air carriers.

The EC "intends to further support ICAO's efforts at addressing the needs of international civil aviation … by improving the coordination of the global efforts to help countries strengthen their safety, notably those for which ICAO publishes significant safety concerns and those where audit reports show a very high lack of implementation of international safety standards," the report said.

Worldwide Goals

The EC plans to strengthen its cooperation with other countries that share the same safety goals, including the exchange of safety data — especially data gathered through inspections of aircraft on airport ramps, "the objective being to align as much as possible the overall format of the reporting system of safety data to improve the capability of data used," the report said. "Beyond the cooperation in the field of information sharing, such ties should encourage further convergence between the assessment made and actions taken to remedy the deficiencies detected by third countries."

The report said that since the inception of the blacklist, "it has become evident how much member states [and other European states with close economic ties] are basing their safety decisions on the results of ICAO safety audits carried out in the framework of the USOAP."

ICAO Concerns

The report added that, in cases in which ICAO expresses significant safety concerns as a result of a USOAP audit, the EC will "ensure that airlines certified in such countries are not allowed to fly in the Community until their authorities can guarantee conformity with ICAO standards." Banning airlines will continue in cases in which cooperative efforts do not alleviate safety risks, the report said.

The document added that the EC would propose that ICAO make public significant safety concerns identified through USOAP audits, that ICAO identify the acceptable safety risk "beyond which it should recommend that states waive the acceptance" of air operator certificates from states that have not complied with ICAO SARPs, and that ICAO become more active in coordinating efforts to improve safety after its audits.

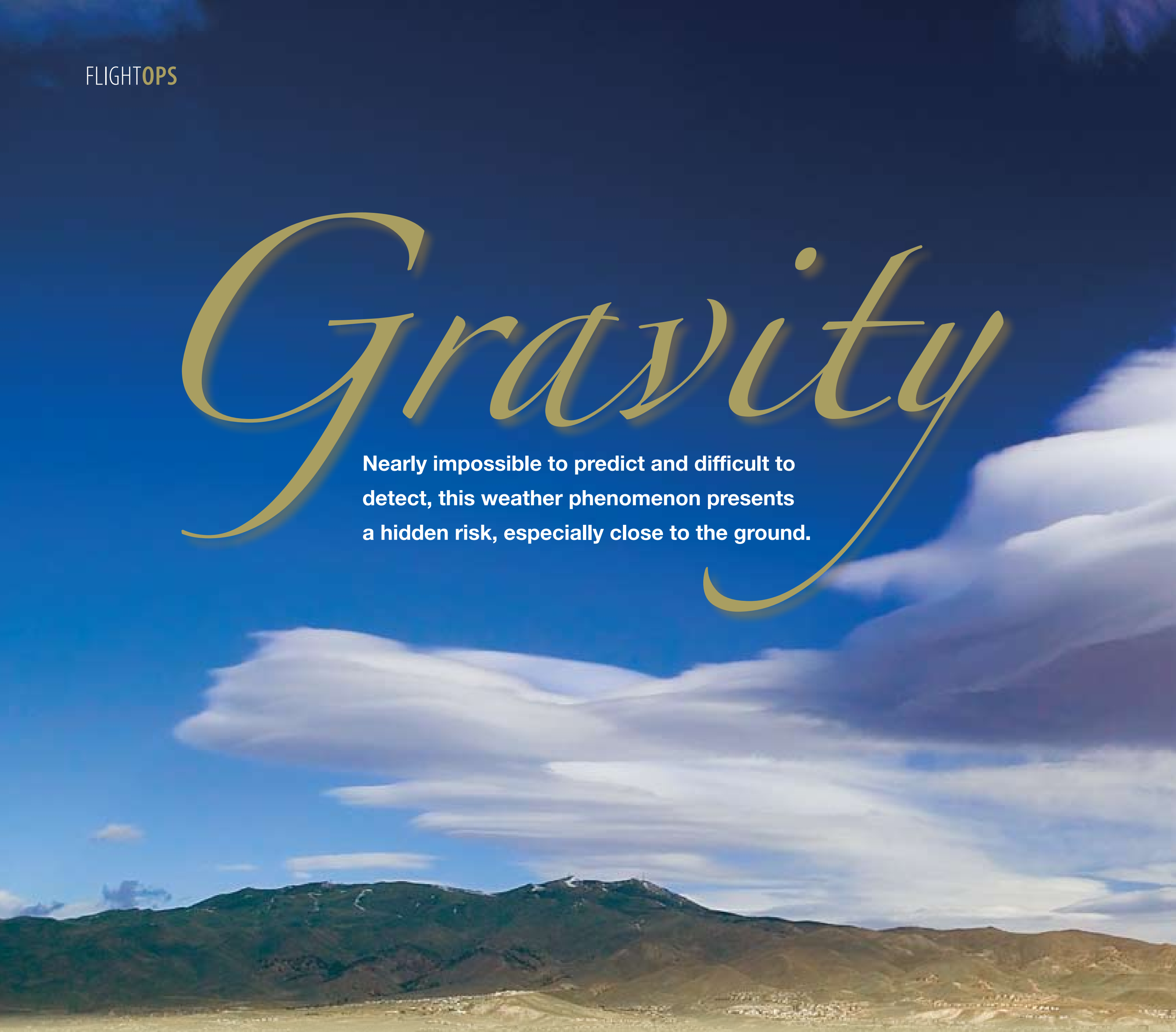
"Such a move should promote respect for international safety standards by all ICAO contracting states, thus ensuring a high level of safety throughout the world and not only where legal tools [such as the blacklist] apply," the report said. "It would *de facto* act as an international list of banned carriers."

Note

1. The European Community was the principal component of the European Union from 1993 until 2009. In 2009, under the Treaty of Lisbon, the European Community was officially replaced by the European Union. The European Commission report, made public in January 2010, was written in late 2009, while the European Community was still an official entity.

Further Reading from FSF Publications

Werfelman, Linda. "Making a List." *AeroSafety World* Volume 4 (April 2009): 42–45.



Gravity

Nearly impossible to predict and difficult to detect, this weather phenomenon presents a hidden risk, especially close to the ground.

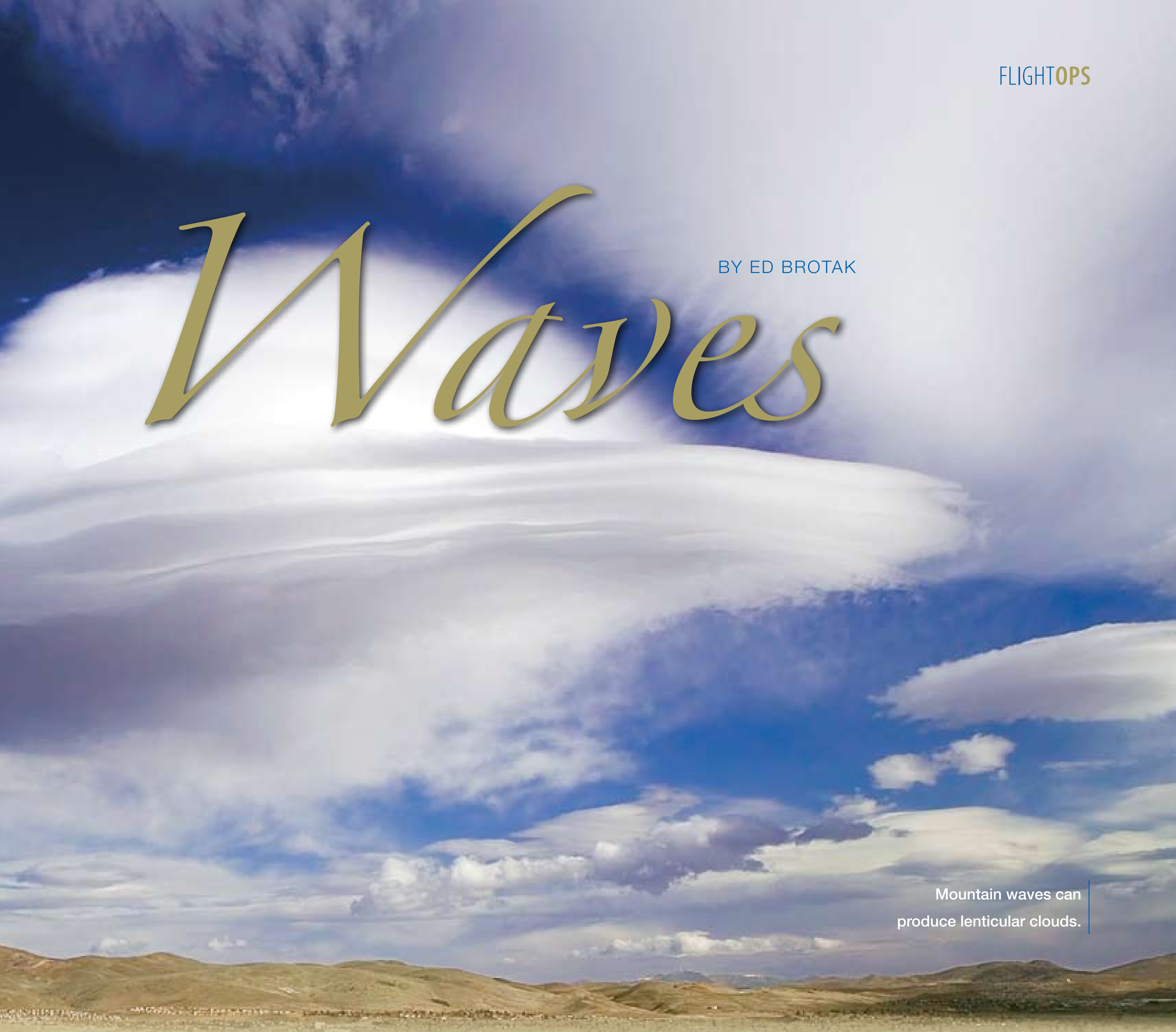
Gregory Bean, an experienced pilot and flight instructor, says he wasn't expecting any problems while preparing for his flight from Burlington, Vermont, to Plattsburgh, New York, U.S. His Piper Seneca checked out fine. The weather that April evening seemed benign. While waiting for clearance, he was taken aback by a report of winds gusting to 35 kt from 140 degrees. The air traffic controller commented on rapid changes in pressure he was observing. He said the National Weather Service observer referred to this as a "gravity wave." Neither the controller nor Bean knew what the weather observer was talking about.

Deciding he could deal with the wind, Bean was cleared for takeoff. The takeoff and initial climb were normal but he soon encountered turbulence "as rough as I have ever encountered." He wanted to climb to 2,600 ft. With the vertical speed indicator (VSI) "pegged," he shot up to 3,600 ft. Finally controlling the airplane, Bean opted to turn around and land back at Burlington. The wind had now swung around to 270 degrees at 25 kt. At this point, he recalled, his rate of descent became "alarming." The VSI now pegged at the bottom of the scale. Despite the control difficulty, he landed the aircraft without further incident. Bean may not have known what a gravity wave was, but he now knew what it could do to an airplane.[1]

Gravity waves are just waves as most people normally think of them.

Waves

BY ED BROTAK



Mountain waves can produce lenticular clouds.

Waves in the ocean are technically gravity waves, for example. The "gravity" part of the term probably confuses the meaning outside the field of meteorology. Gravity is only one of the forces that affect waves. Getting a little into the science here, gravity waves are *physically* induced waves, as opposed to *thermally* induced waves. Thermally induced waves are the result of temperature and density contrasts. Most standard weather systems both at the surface and aloft are thermally induced waves. Some oceanic circulations would also fall into this category.

A gravity wave is the result of a physical disturbance in an otherwise flat fluid flow. You can see waves in water because the water itself is visible. You can't directly see waves in air because air is invisible. A simple way of visualizing gravity waves, however, is to think of what happens when you throw a rock in a pond. Waves move out in all directions from the disturbance. The same thing happens in the atmosphere. Various disturbances produce gravity waves in the atmosphere.

How do gravity waves form? To start, air must be physically forced up, forming the crest of a wave. If the environment is stable, this displaced air will tend to come back down to its starting or equilibrium point. A stable atmosphere is usually one in which a cooler layer of air sits under a warmer layer. The displaced air will start to sink and gain downward momentum. Due to the momentum, the air will sink below its starting elevation. This forms the trough of the wave. But thermodynamic forces — or buoyancy — will make the air rise again toward its original level. If it overshoots again, this time on the upside, another wave crest is formed. Usually numerous waves in a set, an undulating "wave train," will be formed.

For pilots, the best-known atmospheric gravity waves are the mountain and lee waves formed when winds blow across mountainous terrain. The horizontal vortex, or rotor, which can form immediately on the lee side is associated with extreme turbulence. These rotors are a threat to even large aircraft, and numerous accidents have been associated with them. Often these waves are indicated by specific cloud formations such as lenticular or rotor clouds. If the air is drier, the danger zone may not be clearly visible. However, these waves tend to be stationary or propagate downstream with the wind. Thus, they normally can be avoided.

What is usually referred to in meteorology as a "gravity wave" is a mobile wave in the atmosphere, which presents more of a threat. Gravity waves have a multitude of causes: wind shear associated with the jet stream, the formation of a front or low, thunderstorms and hurricanes. All of these events can produce gravity waves. These waves often are damped out in the atmosphere and pose no problem. Other times they can propagate for hundreds of miles. Stable parts of the atmosphere are best for propagating waves.

Gravity waves are relatively small-scale features, with wavelengths varying from roughly 5 to nearly 300 nm (approximately nine to 555 km). The period or time between waves in a set can vary from minutes to hours. They can at times move very quickly, up to about 80 mph (130 kph). The pressure amplitude — pressure change you would see on a barograph trace — can vary between a few tenths of a millibar to more than 10 millibars (0.3 in Hg) for the strongest waves.

A gravity wave's effect on sensible weather makes it important to meteorologists and aviators. The undulating waves and their interaction with the prevailing wind field instigate vertical motions in the atmosphere. Lifting motions are maximized just ahead of the wave crest (Figure 1). Sinking motions are strongest just ahead of the trough. What does this mean in terms of flying conditions? Obviously, the updrafts and downdrafts would directly affect the vertical motion of an aircraft. This is even more of a concern if convection is also initiated, which would exacerbate the lifting and sinking motions of the air.

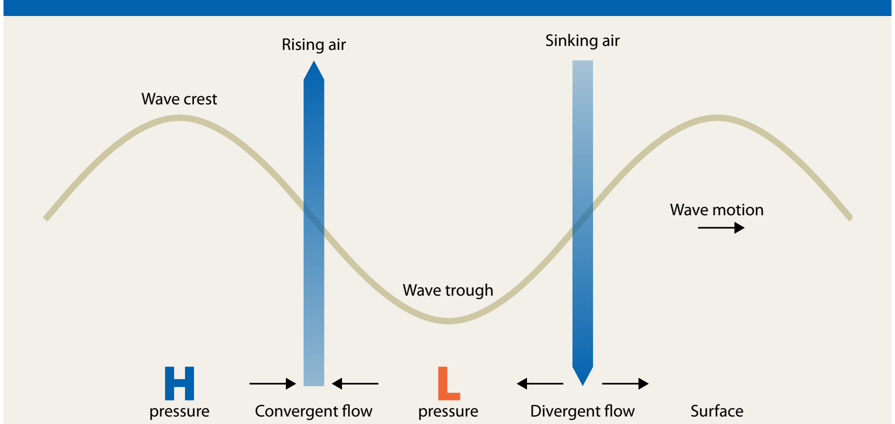
Moderate to extreme turbulence could be expected. In addition, horizontal air motions would increase, leading to strong and quickly shifting winds. The maximized lift area often could be associated with heavier precipitation rates and subsequent decreases in visibility. And, with gravity waves commonly occurring at low levels, these effects would be maximized close to the surface, such as during takeoffs and landings, with the greatest potential for the waves to affect aircraft flight path.

Forecasting gravity waves is extremely difficult. Computer models handle large-scale features very well but have trouble with factors as small as gravity waves. The grids used by the models usually are too big to identify gravity waves. Another problem is that false indications of gravity waves can be generated by the models themselves. Very often, mathematical filters are used to eliminate gravity wave indications so the models can run efficiently.

Meteorologists usually can determine situations where gravity waves are likely. Even then, it is impossible to know if the waves will produce significant weather. On the other hand, once a wave or set of waves gets started, meteorologists can track them and determine speed and direction of movement. This information then can be used to make short-term forecasts to warn those downstream of the coming weather.

What gravity wave situations should pilots look for? The classic winter situation involves gravity waves occurring

Cross-Section of a Gravity Wave



Source: Ed Brotak

Figure 1

north of a warm front and northeast of the surface low (Figure 2). Strong jet stream winds well aloft are to the southwest. The gravity waves propagate northward within the sloping frontal layer above the ground. In these situations, the effects on sensible weather are often profound.

For example, a major winter storm was affecting northern Illinois and Chicago O'Hare International Airport. Light to moderate snow was falling with visibility reduced to ½ mi (0.8 km). Winds were blowing steadily from the northeast at 20 kt (37 kph). Then a gravity wave began to affect the region. Within minutes, the visibility dropped to 1/16 mi (0.1 km) in heavy snow. Thunder was heard. Winds gusted to 56 kt (104 kph).

Gravity waves generated by thunderstorms or thunderstorm complexes develop in a similar manner. In these cases, cooler air from the thunderstorm downdrafts hits the ground and spreads out, the leading edge of this outflow forming the familiar gust front. Behind this feature, a sloping frontal surface separates cooler air near the ground from warmer air above. Gravity waves can develop and propagate within the cooler, stable air.

Often no clouds are associated with the gravity waves themselves, so they can approach unannounced to pilots. On Dec. 6, 1998, a Beech Baron crashed during approach to the airport at Norman, Oklahoma, U.S., killing the pilot. The National Transportation Safety Board concluded that severe turbulence and wind shear were the probable cause of the loss of control. Pilot weather reports from nearby aircraft were part of the support for this conclusion. The flight crew of a Boeing 737 approaching Oklahoma City's Will Rogers Field, about 30 mi from Norman, near the time of the crash reported encountering wind speed variation of 50 kt (93 kph). This variation was enough to convince the crew to conduct a missed approach. Researcher David W. Miller analyzed meteorological radar data relevant to the accident. At the time of the crash, thunderstorms were at least 10 nm (18 km) away from the crash site. Miller concluded that gravity waves generated by the storms were the likely cause of the loss of control.[2]

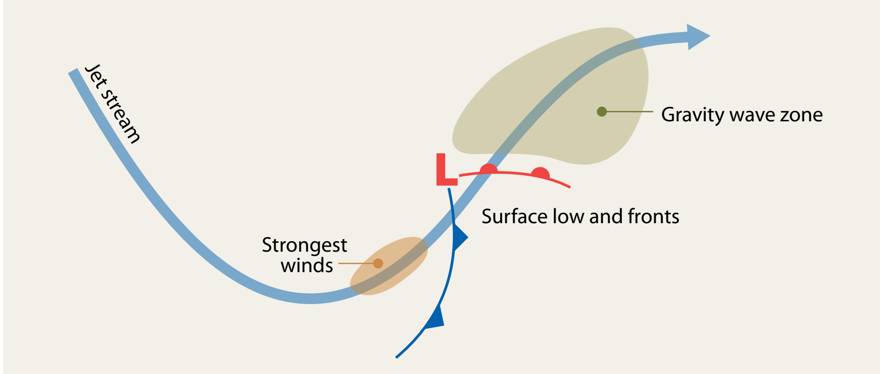
Gravity waves can interact with existing low-level boundaries and initiate new convection. Some theories even suggest that gravity waves interacting with already severe thunderstorms can help produce tornadoes. Offshore hurricanes can generate gravity waves that can move ashore and produce thunderstorms.

With such a variety of sources, gravity waves are common weather features around the world. From the cold climates to the tropics, gravity waves may be encountered. In fact, gravity waves in some form probably are omnipresent. Fortunately, most are fairly weak and don't present a threat to flight crews.

It is difficult to say how big a problem gravity waves are for the aviation industry. As noted, they can be quite difficult to detect. Thus, when incidents or accidents occur and detailed post-event analyses are conducted, gravity waves may have not left any clue about their presence. Many such encounters go unreported in this situation. Clear air turbulence may be acknowledged but not cited as a causal factor.

Until forecasting techniques improve, the best defense that meteorologists can offer against the adverse effects of gravity waves is better detection. The first step in this is simply educating the aviation industry about the problem. The next step is for the aviation community to be alert for the situations in which gravity-wave generation is most likely. The changes in pressure and wind due to gravity waves are measurable with the meteorological instruments we now have if we know what to look for.

Cold Season Gravity Waves



Source: Ed Brotak

Figure 2

Notes

1. Bean, Gregory. "Gravity Waves: A Pilot's Perspective." *AOPA Online: Never Again*, April 8, 2004.

2. Miller, David W. "Exploring the Possibility of a Low Altitude Gravity Wave Encounter as the Cause of a General Aviation Accident near Norman OK on Dec. 6, 1998." A presentation to the 9th Conference on Aviation, Range, and Aerospace Meteorology, September 2000, Orlando, Florida, U.S.

Idea Search

The FAA seeks comments on proposals to enhance training and certification requirements for airline pilots.

BY LINDA WERFELMAN

In the aftermath of the fatal February 2009 crash of a Colgan Air Bombardier DHC-8-400 and a subsequent call for enhanced airline safety, the U.S. Federal Aviation Administration (FAA) is seeking recommendations on how to improve requirements for pilot qualification and training.

The FAA published an advance notice of proposed rulemaking (ANPRM) on Feb. 8 to request public comment on possible regulatory changes.[1] The FAA said the notice was intended to "gather information on whether current eligibility, training and qualification requirements for commercial pilot certification are adequate."

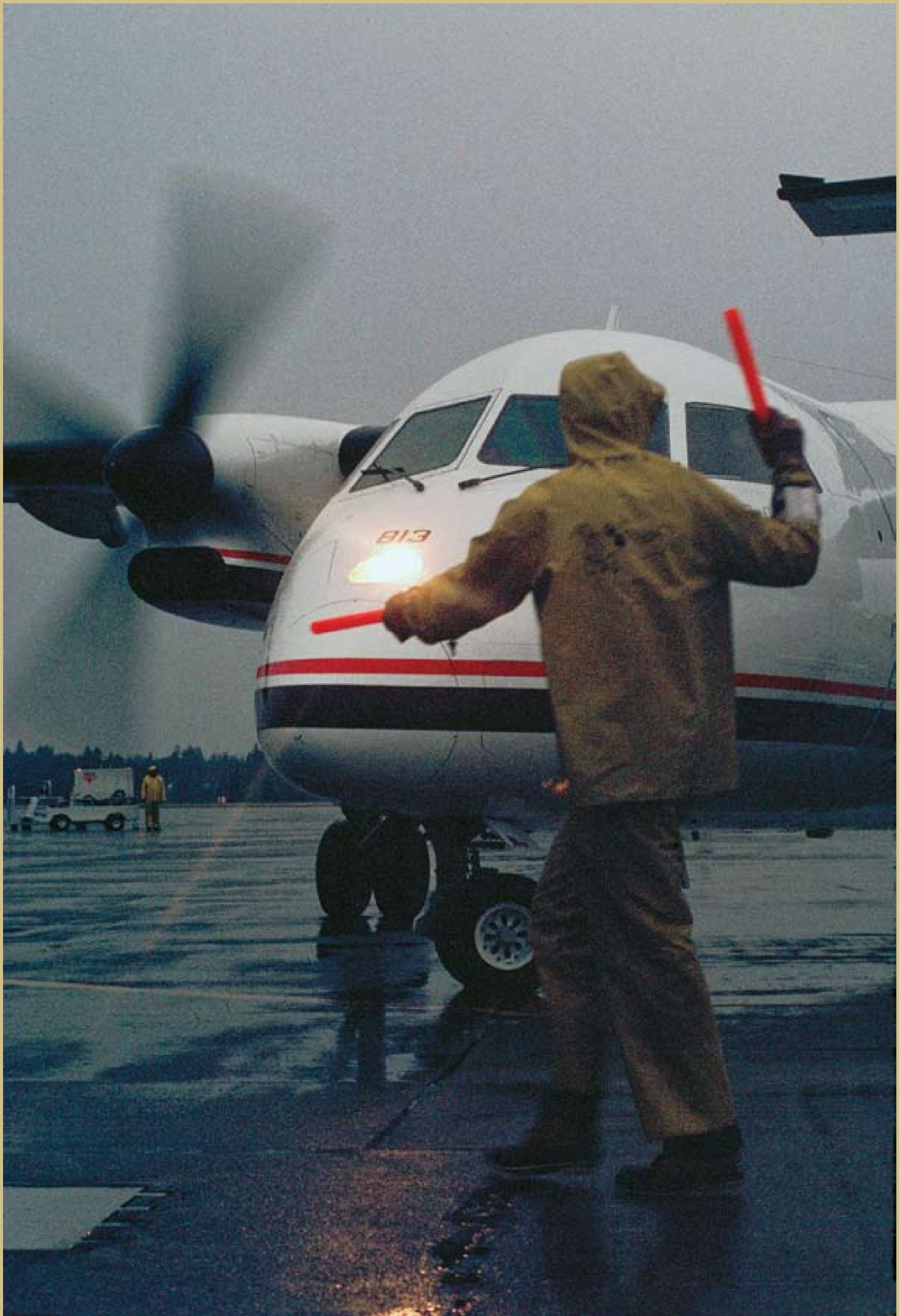
The comments filed in response to the ANPRM will be used "to determine the necessity of establishing additional pilot certification requirements and to determine what those new requirements might include," the FAA said. Comments must be submitted by April 9.

In the ANPRM, the FAA said that the Colgan crash "focused attention on whether a commercially rated copilot in [U.S. Federal Aviation Regulations] Part 121 [air carrier] operations receives adequate training. Specifically, does a copilot's training include enough hours of training in various weather conditions to be able to recognize a potentially dangerous situation and respond in a safe and timely manner?"

FAA Administrator Randy Babbitt, in testimony delivered before the aviation subcommittee of the U.S. House Committee on Transportation and Infrastructure, said that the agency is working to identify methods of enhancing the pilot certification process to "identify discrete areas where an individual pilot receives and successfully completes training, thus establishing operational experience in areas such as the multi-pilot environment, exposure to icing, high altitude operations and other areas common to commercial air carrier operations."[2]

Babbitt criticized proposals by some outside the FAA to increase the minimum hours required for a pilot to operate a commercial aircraft, reasoning that increasing the required flight time total is not, in itself, an adequate response to the problem.

"There is a difference between knowing a pilot has been exposed to all critical situations during training versus assuming that simply flying more hours automatically provides that exposure," he said.



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Specific Questions

In the ANPRM, the FAA noted that it already is reviewing public comments on a January 2009 NPRM that proposed to require use of flight simulation training devices to enhance existing training programs for air carrier crewmembers. However, the 2009 NPRM did not address basic pilot certification.

The ANPRM requested comments on specific questions, including whether the FAA should require all pilots in Part 121 operations to hold an airline transport pilot (ATP) certificate, which is issued only to pilots with at least 1,500 flight hours. Alternatively, the ANPRM asked whether, if a Part 121 pilot does not have an ATP, he or she should be required to have the same aeronautical knowledge and experience that is required for an ATP.

'Although the flight hours required to qualify for an ATP certificate can benefit pilots, experience is not measured in flight time alone.'

The ANPRM also asked if graduates of accredited aviation university degree programs are likely to have "a more solid academic knowledge base than other pilots hired for air carrier operations." Related questions were whether these graduates should receive credit from the FAA for their academic experience in place of flight time experience, and whether, if the FAA decides to give credit for academic study, the agency should maintain a minimum flight hour requirement for Part 121 operations.

"Some have suggested that, regardless of academic training, the FAA should require a minimum of 750 hours for a commercial pilot to serve as SIC [second in command] in Part 121 operations," the ANPRM said. "Is this number too high or too low, and why?"

Other questions focused on the advisability of creating a new commercial pilot certificate endorsement that would be required before a pilot could serve as SIC for a Part 121 air carrier, and what types of ground and flight training would be required before the endorsement would be issued.

"The FAA believes that an endorsement approach would target specific skill sets needed for Part 121 operations, and establish the associated standards for content and quality of training," the ANPRM said. "The endorsement option would also eliminate the time-based requirements that aviation universities argue is not a reasonable requirement for graduates of their four-year aviation degree programs."

The FAA said in the ANPRM that "although the flight hours required to qualify for an ATP certificate can benefit pilots, experience is not measured in flight time alone. Other factors, such as certain types of academic training, practical training/experience, and experience in a crew environment, are also important. A pilot's skills and abilities may also be enhanced by exposure to specific operational conditions."

Comments

At press time, many organizations had not yet filed comments on the FAA's ANPRM. Among the early responders was Stephen H. Bradford of the U.S. Airline Pilots Association, a captain with US Airways, who said that the FAA "should not be relaxing standards in any way."

Bradford said that he and many other U.S. air carrier pilots accumulated experience in jobs as flight instructors and as pilots in night freight operations, commuter airlines and/or corporate aviation.

"Successful candidates to the major airlines have all followed a long career path to gain the experience required to be in this profession," Bradford said. "This knowledge … cannot be gained in a classroom; it must be gained the hard way, by actually doing it. There may be some room for replacing some of the flight time requirement with the use of full, three-axis simulators, but only to a limited extent."

He said that the FAA should require Part 121 pilots to hold an ATP — "or at a minimum, [demonstrate] the necessary aeronautical skill level as required by an ATP" — to "maintain the confidence of the traveling public."

FlyRight, a North Carolina firm that provides training in full-motion simulators, endorsed the proposal to create a new commercial pilot certificate endorsement that would be required before a pilot could work as a required pilot in Part 121 air carrier operations.

"There are certain skill sets unique to [Part] 121 flight operations that are essential for pilots to possess in order to obtain the highest level of ongoing air safety," the company said. "Pilots must be taught how to manage a cockpit in both normal and abnormal situations using all available tools. … The specific training required to receive a type rating provides a good outline for this proposed … endorsement."

The Air Transport Association of America, which, at press time, had not submitted comments on the ANPRM, said it would comment "in due course" and added, "As a general matter, however, the airlines are always interested in exploring measures that will improve the safety performance by utilizing training resources more effectively and efficiently."

During congressional hearings in late 2009, other organizations discussed some of the proposals that ultimately were addressed in the ANPRM.

During a September hearing before the aviation subcommittee of the U.S. House of Representatives Committee on Transportation and Infrastructure, John Prater, president of the Air Line Pilots Association, International (ALPA), discussed his organization's support for legislation — subsequently approved by the House —to require all airline pilots to hold an ATP and a minimum of 1,500 flight hours.[3]

"The bill contains numerous provisions, which, if enacted, will make a profound difference in the selection, training, education and safety of future airline pilot professionals," Prater told the subcommittee.

Some of those provisions would require every Part 121 airline to establish a flight crewmember mentoring program and to provide stall avoidance and recognition training for its pilots.

In a subsequent letter to lawmakers, Prater said, "Many pilots in the current pool of applicants lack the level of experience that generations of pilots ahead of them had when they came into the airlines. Pilot qualification requirements and regulator oversight of airline pilot training have not kept pace with these industry changes."

Call to Action

The ANPRM developed from the FAA Call to Action initiative that followed the Feb. 12, 2009, crash of the Colgan DHC-8, operating as a Continental Connection flight from Newark, New Jersey, U.S., to Buffalo–Niagara International Airport in Buffalo, New York. The airplane crashed in night visual meteorological conditions about 5 nm (9 km) northeast of the airport during an instrument approach to Runway 23. All 50 people in the airplane and one person on the ground were killed, and the airplane was destroyed.

The U.S. National Transportation Safety Board (NTSB) attributed the crash to "flight crew failures," including the captain's inappropriate response to activation of the stick shaker, which resulted in an aerodynamic stall.[4]

The captain's response to the activation of the stick shaker "should have been automatic," the NTSB said, "but his improper flight control inputs were inconsistent with his training and were instead consistent with startle and confusion."

As a result of the accident investigation, the NTSB issued a number of safety recommendations to the

FAA, among them several that dealt with pilot training, including specific recommendations for stall training and remedial training.

"As pilots transition to larger transport category airplanes, they do not have an opportunity to experience stalls in flight or in a simulator, because air carrier training does not require pilots to practice recoveries from fully developed stalls," NTSB Chairman Deborah A.P. Hersman said later, in testimony to the aviation subcommittee of the U.S. Senate Committee on Commerce, Science and Transportation.[5]

In the Colgan accident, approach-to-stall training did not prepare the crew for the unexpected stall and "did not address the actions that are needed to recover from a fully developed stall," Hersman said.

The NTSB's stall training recommendations included calls for the FAA to require Part 121, Part 135 (commuter and on-demand) and Part 91K (fractional ownership) operators, and Part 141 flight schools to "develop and conduct training that incorporates stalls that are fully developed; are unexpected; involve autopilot disengagement; and include airplane-specific features, such as a reference speeds switch." Another recommendation said the FAA should require Part 121, Part 135 and Part 91K operators of airplanes with stick pushers to "provide their pilots with pusher familiarization simulator training."

The NTSB said that the captain's "continued weaknesses in basic aircraft control and attitude instrument flying," as demonstrated in several check rides, should have made him a candidate for remedial training. At the time, however, Colgan did not have a formal remedial training program.

The NTSB recommended that the FAA require all Part 121 air carrier operators to establish remedial programs for flight crewmembers with demonstrated performance deficiencies.

The Call to Action that followed the Colgan crash included goals in several areas, including pilot training, and the FAA said in a January report that progress has been made in completing a number of objectives.[6]

For example, the agency said it has inspected 85 air carriers; 14 other carriers were not subject to the same inspection because they had implemented FAA-approved advanced qualification programs (AQPs) — voluntary programs designed to increase safety by improving training and evaluation. Of these 99 carriers, 76 — including all 14 AQP carriers — had systems in place for remedial training requirements.

The FAA also said it had developed guidance for the industry and for FAA inspectors on "how to review training in the context of a safety management system." In addition, the agency plans to publish an NPRM this year on flight and duty time limitations and rest requirements for flight crewmembers.

The FAA has received written commitments from 82 percent of U.S. Part 121 air carriers — which represent 98 percent of all Part 121 aircraft — to implement specific safety practices outlined by the agency. Of the Part 121 aircraft, 98 percent are operated by carriers that either have implemented, or are planning to implement, an aviation safety action plan (ASAP), a voluntary, self-disclosure reporting program; and 94 percent are operated by carriers that have implemented or are planning to implement both an ASAP and a flight operational quality assurance (FOQA) program, sometimes known as a flight data monitoring program.

"Also," the FAA said, "the largest passenger airlines have taken steps to increase communication, data sharing and cooperation with their partner airlines on implementation of effective safety practices."

All seven labor organizations contacted by the FAA have provided written commitments to support professional standards committees in the development of peer audit and review procedures and formal codes of ethics, the agency said. The FAA plans to host a meeting of these organizations this year to develop guidelines on cockpit discipline and professionalism.

The FAA already has held 12 regional safety forums to discuss pilot fatigue, labor-management issues and other safety issues.

Notes

1. FAA. *New Pilot Certification Requirements for Air Carrier Operations*. Docket No. FAA-2010-0100. <www.regulations.gov/search/Regs/home.html#docketDetail?R=FAA-2010-0100>.

2. Babbitt, J. Randolph. Testimony before the U.S. House Committee on Transportation and Infrastructure, subcommittee on aviation. Feb. 4, 2010.

3. Prater, John. Testimony before the U.S. House Committee on Transportation and Infrastructure, subcommittee on aviation. Sept. 23, 2009. Also, an Oct. 13, 2009, letter to members of the House.

4. NTSB. *Loss of Control on Approach, Colgan Air Inc., Operating as Continental Connection Flight 3407, Bombardier DHC-8-400, N200WQ, Clarence Center, New York, February 12, 2009*, NTSB/AAR-10/01. Also, safety recommendation letter to FAA Administrator J. Randolph Babbitt, Feb. 23, 2010.

5. Hersman, Deborah A.P. Testimony before the U.S. Senate Committee on Commerce, Science and Transportation, aviation subcommittee. Feb. 25, 2010.

6. FAA. *Answering the Call to Action on Airline Safety and Pilot Training*. January 2010.

SMS for the MIDDLE Manager

The engine that drives SMS is line management.

BY MICHAEL BARR

A safety management system (SMS) is becoming the standard safety program throughout the world. It has become mandatory for International Civil Aviation Organization (ICAO) air carrier operations and is voluntarily being implemented by corporate and government aviation departments. Its potential value to the success of an organization's mission has been proven.

Accountable executives have shown their support by verbal and visible measures. They produce strong safety policies and are instrumental in the development of a proactive and predictive program. Safety personnel are

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One of the major stumbling blocks to the implementation of an effective and dynamic SMS program is middle management.

receiving formal safety training and education in the mechanics and implementation of SMS. The benefits of SMS are shown by increased productivity with less risk to the organization. Unit personnel are educated on how they can support the SMS program.

With all these people working so hard to implement a vibrant SMS, why hasn't it matured into a strong working program with positive benefits throughout the aviation industry? In many cases, organizations say they have an SMS program, but in reality they only change the cover page on their safety program document and call it SMS. The previous safety program management system contained many elements of an SMS, but it failed to hold all levels of management accountable for a safety system.

The safety department is responsible for establishing an SMS, but the success of such a program rests on the shoulders of management personnel. A personal review with more than 400 safety professionals reveals that one of the major stumbling blocks to the implementation of an effective and dynamic SMS program is middle management. The reasons are many, but two of the most important are a lack of understanding of their role and the belief that safety programs are solely the responsibility of the safety department.

I believe we need to stress the importance and methods of involvement of middle management in programs such as goals and objectives; education and training; just culture; risk management programs; change management process; operational safety reviews; audits; safety action group (SAG); and accountabilities.

Remember that Safety is a corporate staff function that advises but has little if any authority to direct actions. The engine that drives SMS is line management; they are accountable for implementing SMS. Plus, they ensure that company personnel comply with SMS policies and procedures. Without the active support of middle management, SMS is doomed to fail.

Safety advisers' constant theme is that their biggest hurdle is mid-level management. They wish that middle managers would receive the SMS training, even if the education covers only the basics of the program. Since this is not always possible or probable, line management must be educated about the benefits of SMS by safety personnel.

Given the importance of middle management support and involvement in a successful SMS program, suggestions to safety advisers on how to educate middle managers are needed. Middle management cannot be expected to support such a radical new concept if they do not know its principles and potential benefits to the organization's mission.

A quick review shows us that safety is defined as "acceptable risks that enable an organization to succeed in its mission." It used to be said that safety always came first, but this idea has been modified to recognize that a company's mission, its ultimate business goal, must be the primary focus. The company would not exist if it failed in that mission.

Where does that leave safety? Safety is, or should be, inherent in every aspect of the operation. Without it, the mission surely would fail to reach the performance level needed for success. A good statement concerning safety is, "Safety is critical for … ," to be completed in any way that meets your needs.

Prior to SMS, the safety manager or Safety function was totally responsible for safety programs. They were trained in all aspects of the safety program. When an organization had a safety problem, the expectation was that Safety would correct the situation, but Safety had little authority to direct change or implement corrective actions. This was the situation until SMS became the required methodology of safety management.

An organization's safety culture is an integral part of an SMS. Although SMS is triggered from the top of an organization, it is measured at the bottom, where the productivity is measured, as well. For that cultural concept to reach the employees, it must first travel through middle management. The success or failure of a culture depends on the support from middle management.

A strong SMS will establish goals and objectives. These goals and objectives set a course that an organization wants to follow to achieve mission success. These goals usually are established by top management and implemented by middle managers. If middle management does not actively support and is not continually aware of the status of these goals and objectives, the chance of success is reduced.

Middle managers need to be trained and educated the same as all other employees. They need to know exactly what SMS is and how they individually interface with the program. They must be aware that the success or failure of SMS rides largely on how they understand and support SMS concepts.

Middle managers are responsible for the job safety training of their personnel as well as a workplace hazard analysis. The first line manager is the most important influence on individual safety behavior. Middle managers have to understand the basis for a just culture. The implementation of a just culture may not be the same in all parts of the world, but its concept should

When an organization had a safety problem, the expectation was that Safety would correct the situation, but Safety had little authority.

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be universal. Personnel should be able to report hazards and events without fear of punishment. Of course, there are some defined exceptions, such as purposely committing illegal activities or violating company regulations. A blame culture and open reporting culture cannot coexist. It is up to middle management to openly support a strong reporting system and ensure that supervisors follow the just policy of reporting.

A cornerstone of an SMS is an active hazard identification program. Three important programs that support the hazard identification program are change process management (CPM), operational safety reviews (OSR) and a program that allows personnel to report hazards.

A CPM review should be activated when there is a new system design, a change to existing systems, a new operation procedure and/or a modified operation or procedure. The implementation of this process has to start with the middle manager in charge of the department where the change will occur. If that person does not inform Safety of this change, then the change management process cannot be implemented.

An OSR in an organization is the difference between believing that you are safe and knowing that you are safe. The review allows you to look at all of your operations to determine if latent risk conditions have become part of your operations. While this is done at the middle management level, it should be a formal risk assessment that blankets the whole operation. It is only through these reviews that middle managers can have an educated knowledge of the risk potential of their operation.

Middle management should be highly supportive of these operational reviews and welcome the findings as a way to improve their operations and not consider it to be a process that will negatively reflect on their leadership skills and management capabilities.

Finally, employees should have a method to report hazards that they observe in the operation. They should be free to report without fear of reprisal. The safety office should take all reports very seriously and evaluate cited hazards in a timely manner. Middle managers often discourage these reports. Then, after an incident, investigators find that the organization was aware of a hazard that led to the mishap but that institutional mechanisms failed to correct it or at least report it so that it could be fixed. These reports allow employees to participate directly in the SMS and be part of the prevention process. It is a positive motivator.

The SAG plays a vital role in an SMS. The group is made up of managers who will review the data that has been provided by the safety office. They will look at audits, mishap investigations, hazard reports, goals and objectives, future activities and other areas of concern. It is their duty to review the data and make recommendations to senior management. Another reason for the importance of the SAG is the possible reduction of direct communication between the safety manager and the accountable executive. Paragraph 8.6.5 of the ICAO *Safety Management Manual (SMM)*, Document 9859, second edition, says the following concerning those communications:

"Normal: Safety communicates through the [SAG] and/or the Safety Review Board (SRB).

"Exceptional/special circumstance: Safety must have direct emergency access to the accountable executive. This 'backdoor' communication should rarely be used and properly justified and documented.

"The safety manager will likely be more often than not the bearer of bad news, safety wise."

This new organizational concept about safety makes middle managers all the more important in the success of an SMS. Without middle management's active and genuine support, SMS will be unable to exist as a proactive and pre-emptive risk management program. More important, the overall process will become ineffective, since the role of safety has been reduced to a data collection agency with little or no direct access to the accountable executive, thereby eliminating an objective source of information to the accountable executive. The essential education of the role of middle management must rest with the safety managers.

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InSight is a forum for expressing personal opinions about issues of importance to aviation safety and for stimulating constructive discussion, pro and con, about the expressed opinions. Send your comments to J.A. Donoghue, director of publications, Flight Safety Foundation, 601 Madison St., Suite 300, Alexandria VA 22314-1756 USA or donoghue@flightsafety.org.

BY RICK DARBY

Slippery When Wet

Grooved runways help, but a variety of other safety measures also could reduce wet-runway overruns.

Worldwide, the likelihood of a jet or large turboprop overrunning the runway on landing was about seven times greater when the runway was wet rather than dry, based on accidents during the period 1990–2007. The risk of an overrun accident when landing on a grooved wet runway was significantly lower than that.

Those are among the findings of a study performed by a consulting firm for Transport Canada.[1] The study, designed to assess the costs and benefits of regulatory options to change procedures for landing on wet runways, resulted in a report that considered the problem of these landings from many aspects.[2]

"Degraded aircraft performance on wet runways has accounted for the majority of aircraft accident overruns on landing," the report says. "Recent catastrophic accidents in São Paulo, Brazil, and Toronto, Ontario, have highlighted the concerns of landing on wet runways."[3]

Based on a detailed examination of wet runway landing overrun occurrence reports and studies, aircraft test data and analysis of landing performance on wet runways, a computer model was created for estimating the distribution of required landing distances under specific conditions. "This model was used to estimate the risks and benefit-costs for a range of aircraft under various conditions to provide an understanding of the risks and the likely overall benefit-costs of the alternate regulatory options considered," the report says.

The accident and incident analysis and computer model showed that "the risks of overrun accidents are much lower in countries or regions where runways are grooved." Those with grooved runways at major airports include Australia, much of Europe, Hong Kong, Japan, Malaysia, the United Kingdom, the United States and other countries. Canada is an exception; almost none of its runways are grooved, the report says.

"The ratio of the risk of an overrun accident on a wet runway compared to the risks on a dry runway was estimated to be approximately 10 on un-grooved/non-PFC (porous friction course) runways and 2.5 on grooved/PFC runways," the report says. "Grooved or PFC runway reduced the risks of an accident on a wet runway by approximately 75 percent."

A review of landing overruns in Canada from 1989 through March 2007 identified 27 involving jets and 11 involving turboprops. Of the 27 jet overruns, the runway was wet for 10, or 37 percent, and contaminated for 14, or 52 percent.[4] Almost half of the jet overruns involved large passenger-carrying aircraft in scheduled or major charter carrier service. The remaining approximately 50 percent of overruns were disproportionately high for the operators' level of exposure. "Since approximately 90 percent of jet aircraft movements are conducted by large passenger aircraft, the risk of aircraft overruns is far greater for cargo and corporate jet aircraft," the report says.

Four of the 27 jet overruns resulted in serious injuries or substantial aircraft damage, and there were no fatalities. The 2005 Toronto overrun produced 12 serious injuries and destroyed the A340 (*ASW*, 2/08, p. 40). "Considering both the jet and turboprop overruns, in most cases where the aircraft was damaged or destroyed, the aircraft struck an object or went down a slope or ravine," the report says. "In only a few cases was the aircraft damaged where the overrun area was flat and free of objects, usually the nose wheel breaking off."

Overrun distances — the distance traveled past the end of the runway — varied from 10 to 1,500 ft (three to 457 m; Figure 1). "Surprisingly, overrun distances tended to be greater for occurrences on wet runways than on contaminated runways," the report says.

In the United States, between 1990 and 2006, 27 landing overruns involving large turboprops and jets were identified. Although runway conditions were not always specified in the occurrence reports, the runway was classified as wet for 10, or 37 percent, of the occurrences and contaminated for three occurrences, or 11 percent. The risk ratio of landing overruns for wet versus dry runways was in the range of 4 to 6, the report says, and considering accidents only, the risk ratio was between 3 and 5.

"Aircraft without reverse thrust or disking [flat pitch] capability are also over-represented in overrun occurrences for wet runways," the report says. It cites downhill runway grade as a factor in 40 percent of wet runway overruns, compared with 26 percent of all overruns. Tail wind was a factor in 30 percent of wet runway overruns, compared with 26 percent of all overruns. Other factors, such as excessive speed, landing long, improper braking and equipment failure or malfunction, were not correlated with wet runways.

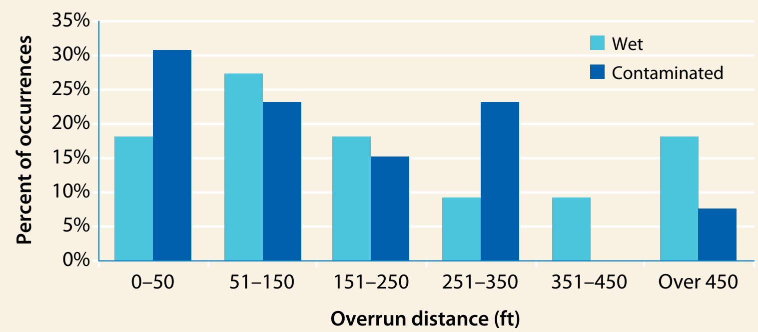
Of the five wet runway accidents examined, two were on un-grooved runways, and in one of those, hydroplaning occurred. Three were on grooved runways, and two of the three occurred during heavy rain.

In countries other than Canada and the United States, 40 landing overrun accidents were identified between 1990 and 2007 (Table 1). Fifty-five percent were on wet runways, and 5 percent on runways contaminated by ice and/or snow. More than half were fatal.

"Of the 40 accidents, in only three cases was the runway known to be grooved, and for all three, the runway was dry at the time of the accident," the report says. "None of the 22 wet runway accidents were on runways known to be grooved at the time of the accident."

Approximate landing overrun accident rates were calculated for the period 1990–2006 for Canada, the United States and the rest of the world (Table 2). "The rate for wet runway conditions increases by a factor of

Landing Overrun Distances, Canadian Jets, 1989–March 2007



Source: Jacobs Consultancy Canada

Figure 1

Landing Overrun Accidents, Large Jets and Turboprops, Excluding United States and Canada, 1990–2007

		All Accidents		Wet Runway Accidents	
Consequences	Accidents	40	100%	22	100%
	Number of fatal accidents	19	48%	13	59%
Runway condition	Dry	4	10%	0	0%
	Unknown	12	30%	0	0%
	Wet	22	55%	22	100%
	Snow/ice	2	5%	0	0%
Operator/ service	Passenger jet	25	63%	17	77%
	Passenger turboprop	8	22%	2	10%
	Cargo	7	19%	3	15%
Aircraft type	Jet	32	80%	20	91%
	Turboprop	8	20%	2	9%

Source: Jacobs Consultancy Canada

Table 1

Approximate Landing Overrun Accident Rates, 1990–2006

		All Runway Conditions		Wet Runway Conditions	
Countries	Annual Landings	Number of Accidents	Rate/Million Landings	Number of Accidents	Rate/Million Landings
U.S.	11,332,000	18	0.09	5	0.2
Canada	929,000	4	0.25	3	1.7
Rest of the world	13,683,000	37	0.16	20	0.6
Total	**25,944,000**	**59**	**0.13**	**28**	**0.4**

Note: Runways were assumed to be wet 11 percent of the time in Canada, 12 percent in the United States and 15 percent for the rest of the world.

Source: Jacobs Consultancy Canada

Table 2

Frequency of Runway Conditions at European Airports

Country	Aircraft Landings	Wet/ Contaminated	Estimated Contaminated	Estimated Wet	Dry
Austria	123,772	24.0%	4.0%	20.0%	76.0%
Belgium	143,351	22.0%	2.0%	20.0%	78.0%
Denmark	160,431	19.0%	3.0%	16.0%	81.0%
Finland	123,614	21.0%	5.0%	16.0%	79.0%
France	780,890	14.0%	2.0%	12.0%	86.0%
Germany	849,203	23.0%	5.0%	18.0%	77.0%
Greece	145,026	5.0%	0.0%	5.0%	95.0%
Ireland	94,143	29.0%	0.0%	29.0%	71.0%
Italy	562,159	11.0%	1.0%	10.0%	89.0%
Luxembourg	22,599	20.0%	4.0%	16.0%	80.0%
Netherlands	217,137	20.0%	3.0%	17.0%	80.0%
Norway	315,806	26.0%	5.0%	21.0%	74.0%
Poland	56,392	19.0%	5.0%	14.0%	81.0%
Portugal	100,052	9.0%	0.0%	9.0%	91.0%
Spain	571,605	6.0%	0.0%	6.0%	94.0%
Sweden	275,322	19.0%	5.0%	14.0%	81.0%
Switzerland	254,665	20.0%	5.0%	15.0%	80.0%
Turkey	250,000	12.0%	0.0%	12.0%	88.0%
United Kingdom	886,949	20.0%	1.0%	19.0%	80.0%
Overall	**5,933,116**	**17.1%**	**2.4%**	**14.7%**	**82.9%**

Note: Aircraft include commercial jets and large turboprops. "Contaminated" includes snow, ice and slush.

Source: Jacobs Consultancy Canada:

Table 3

three overall, but the variation between countries is more pronounced," the report says. "The rate for Canada increases six-fold, for the rest of the world it increases four-fold, while the U.S. rate only doubles. The Canadian rate is eight times the U.S. rate, and the rate for the rest of the world is three times that of the U.S. … The Canadian rate is based on a very small number of accidents, three, but is statistically significantly higher than the U.S. rate at the 0.01 significance level [a probability of one in 100 that the result is due to chance] and the high rate is consistent with the increased risks associated with un-grooved runways. The rate for the rest of the world is based on many more accidents and the high rate is also consistent with a significant proportion of the landings being on un-grooved runways."

An analysis of runway conditions at five major Canadian airports during November through March determined that the runways were wet 12.1 percent of the time. Another analysis found that the percentage of movements on wet runways in Europe varied from 5 percent in Greece to 29 percent in Ireland (Table 3). For the 19 countries, taking into account the numbers of landings in each country, it was estimated that typically 15 percent of landings are conducted on wet runways.

Aviation regulations in Canada, the United States and Europe require that the runway conditions at the destination airport be taken into account before an airplane is dispatched. The landing weight of the airplane must allow a full-stop landing within 60 percent of the landing distance available for jets and 70 percent for turboprops.[5]

The report says that while Canadian, U.S. and European civil aviation authorities require the airplane flight manual (AFM) to include information about an adjustment factor for landing on *contaminated* runways, "there is no such requirement for landing performance on a wet runway. The only specific operational requirement for landing when the runway is wet is that an additional factor of 15 percent be applied to the landing field length required."

The extra 15 percent, or more, may compensate for poor braking. The report says, "The effectiveness of braking on a wet runway is reduced due to hydroplaning; i.e., when the rolling or sliding tire is lifted away from the pavement surface as a result of water pressures built up under the tire. Braking efficiency on a wet runway depends on the surface texture of the runway and whether the runway is grooved; the tread depth and type of the tire; tire pressure; rubber contamination on the runway; and the depth of water.

"Braking friction is far more dependent on these factors on a wet runway than a dry runway. Also, braking friction on a dry runway is fairly constant with aircraft speed, but on wet runways the friction is much less at high speeds, especially on smooth runways and/or with low tread-depth tires. Thus, situations where the aircraft has higher landing ground speeds such as tail winds and/or high loads result in a greater loss of friction and longer stopping distances."

Airplane operating manuals (AOMs) of five Canadian carriers and AFMs of two manufacturers showed wet/dry landing distance ratios for eight aircraft types, all based on using reverse thrust or an equivalent (Figure 2).[6] Six of the aircraft types have a wet/dry ratio of 1.15 to 1.22. Two have a higher ratio of 1.36 and 1.38, respectively.

The wet/dry landing distance ratios were reviewed for six of the aircraft types when the runway is covered with 6 mm (0.24 in) of water. They range from 1.35 to 1.55.

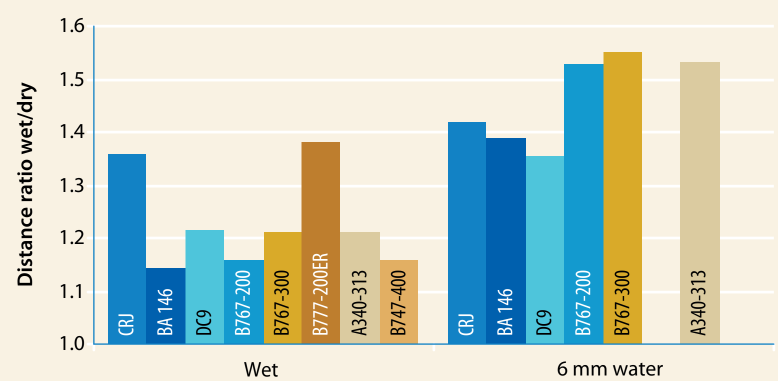
The wet/dry landing distance ratio also varies with the weight (Figure 3). For the McDonnell Douglas DC-9, British Aerospace (now BAE Systems) 146 and Canadair Regional Jet (CRJ), the wet/dry ratios are 2 to 5 percent higher for high weight compared with low weight.

Reverse thrust significantly affects the landing distance calculation for wet runways. The wet/dry landing distance ratios obtained from its AOM for a Boeing 747-400 for no, partial and full use of reverse thrust when landing on a wet runway are 1.16, 1.26 and 1.41 respectively. The report says, "With full reverse [thrust], the landing distance ratio is close to the 15 percent wet runway dispatch adjustment factor, but the landing distance increases by 21.6 percent … when reverse thrust is not used."

A Transport Canada landing performance study modeled the effect of reverse thrust for several aircraft and runway types. The average effect of not using reverse thrust on wet runway landing distance was as follows:

- Category B/C (un-grooved) runway, 10.5 percent increase;
- Category D/E (grooved) runway, 80 percent anti-skid efficiency, 6.6 percent increase; and,
- Category D/E, 90 percent anti-skid efficiency, 4.9 percent increase.

Wet vs. Dry Landing Distance With Reverse Thrust for Selected Aircraft Types

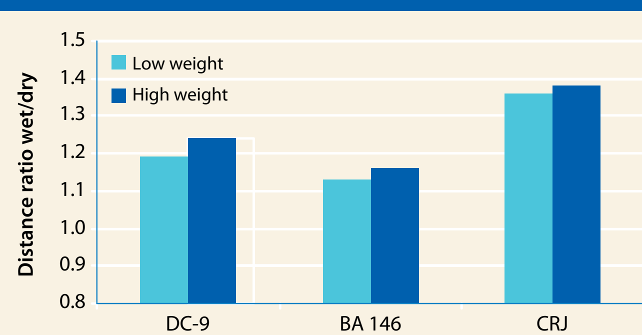


Note: Data were obtained from aircraft operations manuals and aircraft flight manuals.

Source: Jacobs Consultancy Canada

Figure 2

Effect of Aircraft Weight on Wet/Dry Landing Distance for Selected Aircraft Types



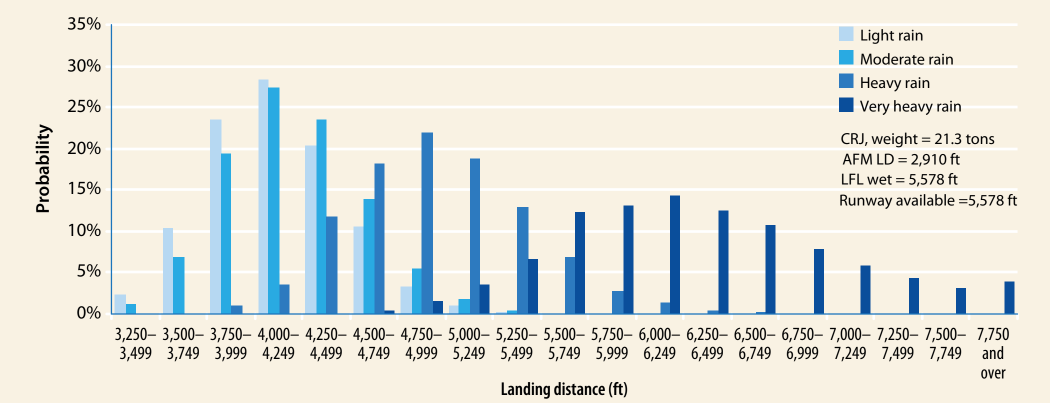
Source: Jacobs Consultancy Canada

Figure 3

The current adjustment factor for wet runways does not take into account whether jets have reverse thrust capability or turboprops have disking capability, the report says.

The consultants conducted a risk analysis for common aircraft types landing on wet runways under various conditions of runway lengths available, grades and altitudes, as well as factors such as wind speeds and aircraft weights. One example was a probability distribution of landing distances for a CRJ at maximum landing weight on a 5,578 ft (1,700 m) wet, un-grooved runway (Figure 4). With no or light rainfall, the chance of an overrun was found to be "very low." In moderate rainfall, the landing distance increased, but the odds of an overrun were still "low."

Probable Landing Distances for a CRJ on a Wet 5,578 ft Runway



CRJ = Canadair Regional Jet; AFM LD = aircraft flight manual landing distance; LFL = landing field length.

Note: Aircraft is a Canadair Regional Jet, weight restricted.

Source: Jacobs Consultancy Canada

Figure 4

Using the risk model, the report considers three proposed regulatory alternatives for an increased dispatch factor for landing on wet runways. "Currently, the only additional requirement related to landing on wet runways is that at the time of dispatch, the landing field length required must be increased by 15 percent," the report says. "This results in a factor which must be applied to the AFM landing distance of 1.92 for turbojet aircraft and 1.64 for turboprop aircraft."

The proposed alternatives are:

Option 1. Increased Dispatch Factors and No En Route Requirement

The wet runway landing dispatch factor would be set as follows:

- Jet without reverse thrust: 2.00 (grooved or PFC runways), otherwise 2.45.
- Jet with reverse thrust: 1.92 (grooved or PFC runways), otherwise 2.10.
- Turboprop: 1.64 (grooved or PFC runways), otherwise 1.90.

Option 2. Increased Dispatch Factors Plus En Route Requirement

In addition to the dispatch factors in Option 1, there would be a requirement that at the beginning of the final approach:

- If the runway is un-grooved and the depth of water on the runway is greater than 3 mm (0.12 in) or if rainfall at the airport is reported as "heavy," the required landing distance must be recalculated assuming the runway is flooded (i.e., water depth greater than 3 mm) and the braking action is "poor" using manufacturer's guidance material; or
- If the runway is grooved or PFC and the depth of water on the runway is greater than 3 mm or if rainfall at the airport is reported as "very heavy," the required landing distance must be recalculated assuming the runway is flooded, using manufacturer's guidance material.

If the calculated distance is less than the runway length available, the pilot must not attempt to land, except in an emergency.

Option 3. Current Dispatch Factors With En Route Requirement

Wet runway dispatch factors the same as under current regulations (1.92 for jets and 1.64 for turboprops) and the en route requirement at the beginning of final approach the same as under Option 2.

Based on the risk model, the report says:

- "Increasing the wet runway dispatch factors as under Option 1 reduces the risks of landing on wet un-grooved runways to a little above those for landing on dry runways, and slightly less than those for landing on wet grooved runways, for aircraft with reverse thrust;

- "The dispatch factor of 2.45 under Option 1 for aircraft without reverse thrust reduces the risks to below those for a dry runway. A factor of 2.25 gives risks comparable with those on a dry runway;
- "The en route landing distance calculation as described under Option 2 greatly reduces the risks when landing on an un-grooved runway under heavy rainfall conditions and, overall, results in a significant reduction in the risks;
- "Use of the current dispatch factors and the en route requirement, Option 3, reduces the risk from the current regulations significantly, but risks are still much greater than for a dry runway and greater than for Options 1 and 2; [and,]
- "The en route calculation as described under Option 2 for landing on a grooved runway typically has no effect on the risks for many aircraft, as the adjustment factor based on manufacturer's material for landing on runways with 3 to 6 mm (0.23 in) of water is usually below the current wet runway adjustment factor."

In terms of the benefit-cost ratios of the options, the report concludes:

- "Increasing the dispatch factor on un-grooved runways and for aircraft without reverse thrust when the arrival runway is expected to be wet as outlined in Option 1 incurs a relatively small penalty on many flights, and does not target the flights most at risk;
- "Requiring pilots to recalculate the landing distance just prior to landing assuming braking will be 'poor' when rainfall is heavy and the runway is un-grooved targets landings at greatest risk. Benefit-cost ratios are close to, or greater than, 1.0 when the en route check requirement is made with the current dispatch factor requirements. This approach is cost-beneficial, but the requirement does not reduce the risk for landings in less wet conditions, and the overrun rate is still much higher than on dry or grooved runways;
- "When the en route check requirement is applied with the increased dispatch factors, Option 2, for all wet runway landings, costs far exceed the benefits for most aircraft; [and,]
- "The requirement to increase dispatch factors only when the weather forecast is for moderate to heavy rainfall at the time of arrival at the destination improves the benefit-cost ratio by a factor of eight, provided the forecasts are accurate. Benefit-cost ratios would be greater than one for the majority of aircraft landings. The requirement to make an en route landing distance calculation assuming braking is 'poor' if rainfall is heavy would reduce the risks in situations where the forecasts were inaccurate and rainfall is heavier than expected."

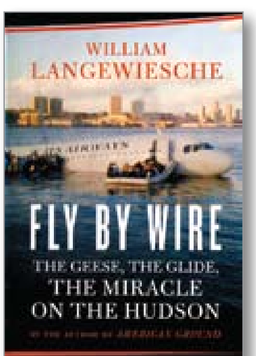
The report concludes that "few flights would be affected by the increased dispatch factor or en route landing distance calculation requirements considered. The costs of grooving would be much greater than savings to airlines and will vary depending on the runway length and surface type, types and weights of aircraft and the runway safety areas at the airport. The benefits may exceed the costs of runway grooving at some airports, particularly where the grooving has a long lifespan, the runway safety area is small and/or a high proportion of aircraft landings are at, or close to, being weight restricted."

Notes

1. Biggs, David C.; Hamilton, Gordon B.; Jacobs Consultancy Canada. *Risk and Benefit-Cost Analyses of Procedures for Accounting for Wet Runway on Landing.* July 2008. Available via the Internet at <www.tc.gc.ca/tdc/menu.htm>.
2. The study was limited to operations of jet and turboprop aircraft with a maximum takeoff weight greater than 5,670 kg (12,500 lb).
3. On July 17, 2007, an Airbus A320 landing in heavy rainfall at Congonhas Airport, São Paulo, Brazil, overran the runway and crashed into a building. All 189 passengers and crew were killed. An Air France A340 overran the runway at Toronto Pearson Airport on Aug. 2, 2005, and came to rest in a ravine. All occupants evacuated safely; the aircraft was destroyed by a post-crash fire.
4. Transport Canada defines a wet runway as a surface condition where there is a thin layer of water and the layer of water is 3 mm (0.11 in) or less in depth. A contaminated runway means a runway that has any portion of its surface covered by a contaminant, including standing water, slush, snow, compacted snow, ice or frost, or sand and ice control chemicals.
5. The formula for calculating the additional landing distance is 1/60 percent = 1.67 (1 + 0.67) or 1/70 percent = 1.43 (1 + 0.43).
6. The wet/dry *landing* distance ratio is much closer to 1 than the wet/dry *stopping* distance, because the former includes the period from when the airplane is 50 ft above the runway until touchdown, during which the runway condition has no effect on braking.

Miracle Ingredients

Flight 1549 was a triumph of decision making and piloting skill.



Extraordinary Concentration

Fly by Wire: The Geese, the Glide, the Miracle on the Hudson

Langewiesche, William. New York: Farrar, Straus and Giroux, 2009. 208 pp.

If there is such a thing as a feel-good accident, US Airways Flight 1549 was it. On Jan. 15, 2009, at 3,000 ft after takeoff from New York LaGuardia, the Airbus A320 and a flock of Canada geese tried to occupy the same space at the same time. Geese were ingested into the engines, which lost almost all thrust. Chesley "Sully" Sullenberger, the captain, and Jeffrey Skiles, the first officer, glided the airliner to a landing in the Hudson River. All passengers and crew evacuated the floating A320 and were rescued; the aircraft was destroyed.

It was a great story with a happy ending, and the news media ate it up. Sullenberger was proclaimed a hero — most of the non-pilot public does not think about first officers or crew resource management — and indeed, the maneuver was a tribute to pilot skill and training, along with built-in layers of protection in modern passenger aircraft.

Langewiesche is not a revisionist; he gives full credit to the flight crew and praises the LaGuardia controller who worked with them during the flight that lasted five minutes from takeoff to touchdown. Nevertheless, his book takes a somewhat skeptical view of the "miracle" angle in popular culture, and examines the accident's facts and background. Along the way, he writes of the problem of wildlife strikes, the aerodynamics of gliding, pilot abilities, psychology and mental states during stressful moments, accident investigation, the political clashes of pilot unions following airline mergers, the state of the airline industry, and the differing design philosophies of Boeing and Airbus.

While the accident is described in detail based on information in the public record, *Fly by Wire* presents the big picture subjectively. A 10,000-flight-hour private pilot, Langewiesche offers his own opinions about many aspects of the accident and the airline industry.

The writing style is geared to the general public, but aviation professionals will also find it interesting. Langewiesche's writing is deft and somewhat informal. It is at times ironic, humorous and colorful — this reviewer has never before encountered a book about an accident whose text includes four-letter words, apart from directly quoting speech.

Langewiesche writes that Sullenberger "was capable of intense mental focus and exceptional self-control. Normally these traits do not much matter for airline pilots, because teamwork and cockpit routines serve well enough. But they had emerged in full force during the glide to the Hudson, during which Sullenberger had ruthlessly shed distractions, including his own fear of death. He had pared down his task to making the right decision about where to land, and had followed through with a high-stakes flying job. His performance was a work of extraordinary concentration, which the public misread as coolness under fire. Some soldiers will recognize the distinction."

Sullenberger was willing, following the accident, to accept all kinds of awards, privileges and offers, including one for his autobiography, which has since been published. But it was not egotism that prompted him, Langewiesche believes.

"After decades of enduring the insults of an airline career — the bankruptcies, the cutbacks, the union strife, a 40 percent reduction in salary, the destruction of his retirement pension — he was determined to leverage this unexpected opportunity to maximum advantage," the book says. "He was due to retire in seven years, at age 65. Now he was suddenly on a ride as critical to his family as the glide to the river had been … ." Married, with two teenage daughters heading for college, Sullenberger focused on practical goals.

"The first was financial stability," Langewiesche says. "He was forthright about it from the start, when he announced through the press that he would consider all offers and possibilities. He was going to gain from this event, and why not? The second goal was slightly less obvious. It was to promote a union argument, couched as usual in the language of safety, that holds that if pilots are not better paid, airline travel may become increasingly unsafe. … His message was that successive generations of pilots willing to work for lower wages might perform less well in flight, and especially during emergencies."

Langewiesche doesn't buy the argument. He says, "It is a questionable assertion, since it links financial incentive to individual competence, and ignores the fact that, with exceptions, the 'best and brightest' have never chosen to become airline pilots, at whatever salary, because of the terrible … monotony of the job. Furthermore, although unusual stupidity is often fatal in flying, the correlation between superior intelligence and safety is unproven, given the other factors that intrude — especially arrogance, boredom and passive rebellions of all kinds. If you had to pick the most desirable trait for airline pilots, it would probably be placidity."

Langewiesche does not make light of the accident, but he is prone to irreverence about certain aspects of the flying experience. The chapter on bird strikes is one example. This may be the first-ever account of a bird strike accident that pauses for a moment to consider it from the birds' point of view.

"Much about these particular geese will never be known — for instance, where they had come from that day, and where they were headed, and why — but it is likely that they were well-fed and self-satisfied," he says. "Evidently they were also fairly dumb. Their stupidity cannot be held against them, since they were just birds, after all, but geese are said to be adaptive creatures, and it is hard not to think that they should have had better sense than to go blithely wandering through New York City's skies. New York is a busy place, and January 15 was a typical day there, propelled by all those schedules to keep. Was that so difficult to understand?"

In the case of New York's Canada geese, human intervention was to no one's benefit. The geese were once welcomed features of the natural environment. But "in the early 1960s, however, the situation began to change after state wildlife agencies came up with a bioengineering scheme whose purpose in part was to enhance state revenues by stimulating the purchase of bird-hunting licenses. The agencies captured breeding pairs of an endangered but supersize species known as the giant Canada goose and, by clipping their wings, forced them to settle permanently into authorized nesting grounds along the Eastern Seaboard and elsewhere in the United States. The offspring of the clipped-wing geese imprinted to the new locations and, having lost the collective memory of

This may be the first-ever account of a bird strike accident that pauses for a moment to consider it from the birds' point of view.

migration, became full-time resident populations — endowed, however, with the urge and ability to fly."

Presently, thanks to banning of pesticides harmful to birds, environmental protection laws and the conversion of former farmlands, "the newly non-migratory giant Canada geese settled comfortably into a paradise with few predators, where hunting was frowned upon, where food was abundant and where there were plenty of golf courses, corporate lawns and preserved wetlands to dominate." Langewiesche says their U.S. population grew from about 200,000 in 1970 to 4 million today.

The description of the accident — which is interrupted by chapters about its causal factors — offers few surprises but is thorough and detailed. We learn, for example, that Sullenberger was carrying in his flight bag a library book, *Just Culture: Balancing Safety and Accountability* (*ASW*, 4/08, p. 53).

Langewiesche's narrative of the accident captures the drama:

"In the cabin, the veteran flight attendant Doreen Welsh was sitting in the aft galley strapped into a forward-facing jump set with a view up the aisle toward the front. The other two flight attendants, Donna Dent and Sheila Dail, were sitting side by side just behind the cockpit, facing aft. They felt the thumps and heard the engines wind down. Dail whispered, 'What was that?' Dent answered, 'Probably a bird strike.' The cabin turned eerily silent. An engine slowly clanked. The cabin filled with a trace of smoke, accompanied by a burning smell. …

'The cabin turned eerily silent. An engine slowly clanked. The cabin filled with a trace of smoke, accompanied by a burning smell.'

"Passengers behind the wing saw large flames trailing from the left engine, and concluded that the engine was on fire. It was not. Unburned fuel was passing through the crippled combustion chamber and torching harmlessly in the slipstream. …

"Skiles still had the controls at that time [about 15 seconds after the strike]. Sullenberger urgently tried to restore thrust to the engines. They were still turning, but at very low speed. It was possible that they had simply flamed out, and that with the standard engine-start igniters he could relight the fires. He said, 'Ignition start,' and rotated a knob one click to that position. The igniters began to click, but the engines failed to respond. They simply were not meant to swallow geese and survive."

The full account of the glide and ditching is engagingly written, with enough carefully rendered detail to maintain interest, even suspense, but not so much as to bog down in minutia. From a literary standpoint, this will probably remain the best book about Flight 1549. That applies to the digressions as well — for example, an explanation of how engines are tested for bird strikes by a cannon firing bird carcasses of different weights into spinning engines: "The cannons are known variously as chicken guns, turkey guns or rooster boosters. The tests are filmed with high-speed cameras and can be viewed on the Internet in slow-motion videos, some set to music. In real time, the birds pass almost instantaneously through the test engines. They go in whole and come out as spray."

Fly by Wire contains a good deal of editorializing, especially about the modern Airbus design philosophy, which features sidestick controls and automation designed to override pilot control before a control input would result in a stall, a dangerous attitude or control surfaces working at cross-purposes. Boeing fly-by-wire models, the 777 and 787, do not include this feature.

Langewiesche describes the flight-envelope protection in the Airbus with striking imagery and wit. In wings-level flight, "if you slam the sidestick fully back, the airplane will pitch up rapidly, but … will impose no greater gravity load than the maximum safe 2.5 g. You can be as rough as you want, and you won't shed your wings or tail. During this maneuver, with the stick held fully back, the airplane will not go vertical and into a loop as any conventional airplane would, but will freeze its attitude at 30 degrees up and refuse to pitch any higher.

"Then, if you reverse yourself and push the stick fully forward, the nose will pitch down at a rate that will cause the airplane to pass through 0 g (weightlessness), but not exceed the negative flight load limit of minus 1.0 g. Incidentally, at minus 1.0 g, the passengers could walk around on the cabin ceiling, upside down in relation to the earth, but feeling normal. This might be amusing to them if they were in the right frame of mind."

Langewiesche knows, of course, that airline pilots flying any manufacturer's product are expected to be fully aware of the safe limits to control inputs, and that they have cockpit displays and warning systems to alert them to anomalies. His main argument for the Airbus control concept is that even qualified, very experienced pilots can lose situational awareness — rarely, but it happens, particularly in emergencies.

To illustrate his thesis, he includes an account of the American Airlines Boeing 757 crash near Cali, Colombia, on Dec. 20, 1995. The approach turned into a tragedy of errors. After noting that "the two pilots in the front that night were both former Air Force fighter pilots, each with more than 2,000 hours of experience in this type," and admitting that by all reasonable standards they were fully qualified, he says after quoting their cockpit conversation:

"To err is human, but to persist is diabolical. Maybe it should be posted in polling stations. Certainly it should be posted in cockpits. The captain was having a hard time with it that night. He never admitted that he had screwed up. He never even admitted that he and the copilot together had screwed up. Instead he said that they had gotten screwed up, as if it had been done to them by outside forces — presumably some mysterious equipment failure.

"The distinction may seem like a semantic quibble, but it fits into larger patterns at play that night and helps to explain the ongoing and maddening descent. Even now the captain did not fully accept what the navigational instruments showed — that they had overshot the entry gate, that they had proceeded into uncharted territory far to the east of the final approach course and that after all these years spent flying airplanes, this time his mental map was wrong."

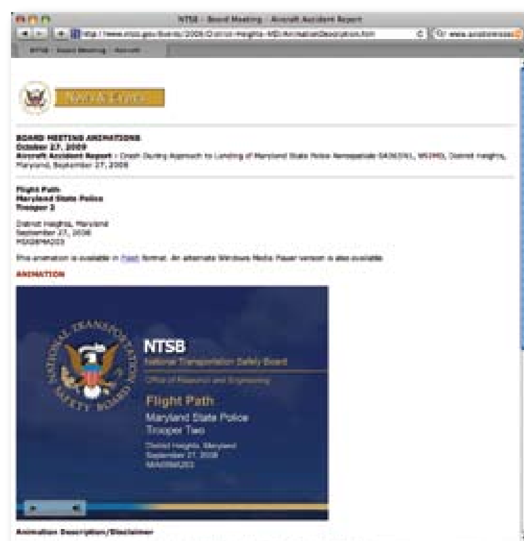
Langewiesche believes that the last-minute attempt to pull up as a mountain ridge loomed ahead might have succeeded had the speed brakes, which were still selected, been retracted when the climb was commanded. "Had [the pilots] been in a fly-by-wire design, it seems likely that everyone would have survived," Langewiesche says.

"But there is also a negative element, a paradox that pertains particularly to the Airbus and its fly-by-wire design. It is the fundamental twist in human nature that causes people to take increased risks in direct relation to feeling especially safe. Call it the Titanic Effect. If you believe that your ship is practically unsinkable, you might start charging across oceans of icebergs — and later wish that you had not. … The danger of claiming that an airplane is unusually safe has always been that pilots will then go out of their way to prove you wrong."

— *Rick Darby*

Accident Animations

U.S. National Transportation Safety Board, Accident Animations, <www.ntsb.gov/Publictn/animations.htm>



The U.S. National Transportation Safety Board (NTSB), an independent agency, is tasked with investigating accidents in civil aviation and other modes of transportation.

One resource that may not be well known is the "accident animations" section of its Web site. The NTSB has reconstructed sequences of events from significant accidents that occurred during 2004–2010 using combinations of animated flight paths, videos, transcriptions of air traffic control communications and cockpit voice recorders (CVRs), narrator voice-overs, photographs and more.

For example, the last two minutes of the Colgan Air Flight 3407 crash during approach to

Buffalo, New York, U.S., on Feb. 12, 2009, is reconstructed in three-dimensional (3-D) animation. The NTSB says, "The upper portion of the animation shows a 3-D model of the airplane and the airplane's motions during the accident sequence. In this area, selected content from the CVR transcript or other annotations are superimposed as text at the time that the event occurred. . . . The lower portion of the animation depicts instruments and indicators, which display selected FDR [flight data recorder] or calculated parameters."

Animations and videos are available online in multiple formats. Animations may contain links to additional NTSB information on a specific accident, such as testimony, the investigation docket and board meeting presentations. All resources are free.

The NTSB's main Web site at <www.ntsb.gov> gives public access to the agency's cache of information by mode of transportation. Aviation resources include a searchable database of aviation accident information, special studies on transportation safety issues of national importance, aircraft accident reports, annual reviews of aircraft accident data, safety recommendations, statistics and much more.

— Patricia Setze

Audit Results

Argus International, <www.aviationresearch.com>

Argus International performs "on-site safety audits for corporate flight departments, charter operators and commercial airlines," according to its Web site.

Argus shares some of its information with the aviation community through the "Free Data" section of its Web site. Most topics require free online registration to access the information. Once registered, a researcher can download documents about safety management systems (SMS), audits and other subjects.

The "2007–2009 ARGUS SMS Audit Results" document reports on results and recommendations following 116 audits of flight departments operating under U.S. Federal Aviation Regulations Parts 91 and 135. The

cumulative report, which covers January 2007–February 2009, says, "The goal of each audit is to seek evidence of effective and efficient operations and industry best practices, including implementation of a safety management system … as defined by [U.S. Federal Aviation Administration Advisory Circular] 120-92. The objective of this report is to highlight those common problem areas found in SMS implementation and execution."

This report graphically illustrates numbers of operators having deficiencies in particular areas — SMS training, operations manuals, risk assessment, safety committees and other areas. The report says, "The vast majority of the audit findings point to a deficient internal evaluation program (IEP). This program is especially important because it is designed to uncover latent process or program deficiencies within operations and maintenance focus areas before they become causal factors in an accident or incident."

Recommendations from the audit report covering January 2007–March 2008 are also available online at no cost. The top three recommendations identify three areas of deficiency: IEPs; on-scene accident responder protections against blood-borne pathogens, along with personal protection equipment training and Hepatitis B inoculation; and SMS manuals. Supporting statistics and illustrations are included in the report.

— Patricia Setze

Unheeded Warnings

The pilot-in-command disregarded alarms raised by the EGPWS and by the copilot.

BY MARK LACAGNINA

The following information provides an awareness of problems in the hope that they can be avoided in the future. The information is based on final reports by official investigative authorities on aircraft accidents and incidents.

JETS

Go-Around Conducted Too Low

British Aerospace 146-300. Destroyed. Six fatalities.

Lack of knowledge about the local terrain, a go-around conducted contrary to company standard operating procedures (SOPs) and inattention to more than a dozen enhanced ground-proximity warning system (EGPWS) warnings while circling to land set the stage for a collision with a hill near Wamena Airport in Papua, according to the National Transportation Safety Committee (NTSC) of Indonesia.

The accident occurred the morning of April 9, 2009, during a scheduled passenger and cargo flight from Sentani with two pilots, two flight attendants, an engineer and a loadmaster. No passengers were aboard the BAe 146.

The pilot-in-command (PIC), 56, had 8,305 flight hours, including 958 hours in type. The copilot, 49, had 12,389 flight hours, including 192 hours in type. "There was no evidence that the [pilots] had received simulator training in the operation and use of EGPWS in the BAe 146," the NTSC report said.

Wamena Airport, which is at 5,430 ft in mountainous terrain, had no instrument approach procedure. A routine weather report issued about 30 minutes before the accident indicated that surface winds were calm, visibility was 8 km (5 mi) in haze, and the base of a broken ceiling was at 300 m (984 ft).

The pilots conducted a visual approach to Runway 15, which is 1,650 m (5,413 ft) long. The final approach to the runway was obscured by low clouds. A company pilot on the ground at Wamena Airport radioed the BAe 146 flight crew that they would have a better chance of establishing visual contact with the runway if they tracked right of the extended runway centerline.

The aircraft was 790 ft above ground level (AGL), descending parallel to the extended runway centerline, when the EGPWS generated a "TERRAIN, TERRAIN" warning, followed by a "WHOOP, WHOOP, PULL UP" warning. Disregarding the warnings, the PIC turned left toward the extended runway centerline, and the copilot radioed the airport flight service specialist that they had the airport in sight.

The PIC then told the copilot that they were passing through the extended runway centerline. The EGPWS generated a "SINK RATE" warning, followed immediately by five consecutive "WHOOP, WHOOP, PULL UP" warnings. After the second warning, the copilot called, "Overshoot. Overshoot." (According to the report, "overshoot" has the same meaning as "go around.")

The PIC responded by initiating a go-around. "The aircraft was observed conducting a go-around from a low height over the runway," the report said. "It then climbed to a low height along the extended [runway] centerline to the southeast before making a right turn onto a low right downwind leg."

The EGPWS generated several terrain warnings and bank angle warnings in rapid succession.

The aircraft was flown 150 ft to 350 ft above airport elevation. On the downwind leg, the EGPWS generated eight "DON'T SINK" warnings and one "TOO LOW, TERRAIN" warning. "The flight crew did not respond to any of those alerts," the report said.

The landing gear was extended as the aircraft passed abeam the threshold of Runway 15. The PIC was turning onto a right base leg when the copilot told him, "Be careful, pak [sir]."

Investigators were not able to determine why the copilot told the PIC to be careful. "During the right base-leg turn, it was evident that the copilot became increasingly concerned about the way the PIC was handling the aircraft," the report said. "The CVR [cockpit voice recorder] provided evidence that the copilot expressed those concerns with increasing levels of anxiety."

Apparently responding to several calls by the copilot to turn left, the PIC increased power and rolled the aircraft left. The bank angle exceeded 40 degrees, and the aircraft pitched 10 degrees nose-down. The EGPWS generated a "DON'T SINK" warning, and the copilot repeated the warning.

The PIC replied, "Ya, ya."

The report said that three seconds later, the copilot likely recognized that a collision with terrain was imminent and urgently called for a left turn. The EGPWS generated several terrain warnings and bank angle warnings in rapid succession. "The copilot called, with high intonation, 'Pak, pak, pak,'" the report said.

The BAe 146 was in a 16-degree left bank and a 12-degree nose-up pitch attitude, the landing gear was being retracted, and airspeed was 146 kt when the aircraft struck terrain at 5,560 ft. The crash occurred 3.6 nm (6.7 km) northwest of the airport at 0743 local time. "The aircraft was destroyed by the impact forces and the post-impact fuel-fed fire," the report said.

The investigation revealed that the EGPWS terrain mode had been disengaged during the go-around. This inhibited the enhanced, or predictive, features of the system, causing it to revert to functioning as a basic GPWS. The flight crew operating manual (FCOM) says, "In this state, the EGPWS gives little or no advance warning of flight into precipitous terrain … particularly if the aircraft is in the landing configuration."

However, the FCOM does not provide advice about when it is appropriate to disengage the terrain mode, the report said. "The operator informed the investigation that, while there was no procedure, it was practice to activate the [terrain mode] inhibit switch when flying visually if repeated terrain warnings became a distraction."

Despite the system's reversion from an enhanced to a basic GPWS, the warnings it provided were valid, and the accident likely would not have happened if the crew had responded appropriately to them, the report said.

Premature Takeoff Causes Incursion

Boeing 747-400D, McDonnell Douglas MD-90-30. No damage. No injuries.

The airport traffic controller's use of nonstandard terminology in an advisory issued while the 747 was lined up on the runway and the 747 flight crew's misinterpretation of the advisory as a clearance to take off led to a serious incident at New Chitose Airport the morning of Feb. 16, 2008, said the Japan Transport Safety Board (JTSB).

At the time, a snowstorm was causing significant delays at the airport. Runway 01R was in use; the parallel runway was closed. Runway visual range at the touchdown zone of Runway 01R was 750 m (2,400 ft).

The 747 crew, bound for Tokyo with 446 people aboard, had taxied for 15 minutes and had held short of Runway 01R for 20 minutes before receiving clearance to line up and wait on the runway.

While receiving the clearance, the 747 crew saw an MD-90, inbound from Kansai International Airport with 126 people aboard, touch down on Runway 01R but then lost sight of the aircraft in the snow.

The MD-90 captain told JTSB investigators that he had perceived braking action as medium to poor during the landing roll and had taxied the aircraft slowly because of the runway conditions and low visibility.

More than two minutes after touching down, the MD-90 was still being taxied to its turn-off point near the departure end of the runway when the controller told the 747 crew, "Expect immediate takeoff, traffic landing roll, and inbound traffic six miles."

The 747 captain apparently heard only part of the controller's statement. He told investigators that he thought he had received clearance for an immediate takeoff. "I thought that 'immediate' meant an urgent situation," the captain said.

The right-seat pilot, a trainee, did not read back the controller's instructions and replied only with the 747's call sign and "roger." He told investigators that he had heard only the words "takeoff" and "five miles or six miles on final."

The first officer, seated behind the pilots, recalled that he was confused by the controller's use of the words "immediate takeoff." He told investigators that he was not sure whether they had received clearance to take off.

The captain selected takeoff/go-around power, and the 747, which was near the approach end of the 3,000-m (9,843-ft) runway, began to roll.

The controller recognized the conflict on his airport surface detection equipment display and told the 747 crew, "Stop immediately. Traffic on landing roll." He also told the crew of the aircraft on final approach to go around.

Groundspeed was 84 kt when the 747 crew rejected the takeoff. They applied reverse thrust, wheel brakes and speed brakes, and brought the 747 to a stop about 1,800 m (5,906 ft) from the MD-90.

The captain told investigators that he would not have initiated the takeoff if the controller had used "departure" rather than "takeoff" in the advisory. The report confirmed that "departure" is the correct term for the situation but also noted that the airline's SOPs require flight crewmembers to always confirm, among themselves and with air traffic control (ATC), that they have received a takeoff clearance.

'Beetle-Like Creature' Jams Pitot System

Boeing 757-200. No damage. No injuries.

The commander noticed that his airspeed indicator (ASI) was not functioning properly soon after initiating a takeoff from Accra, Ghana, the night of Jan. 28, 2009. "He elected to continue the takeoff using the copilot's and standby ASIs, which appeared to be functioning normally, and to deal with the problem while airborne," said the report by the U.K. Air Accidents Investigation Branch (AAIB).

The commander's ASI was reading abnormally low. On rotation, the indicated airspeed was 70 kt while groundspeed was 155 kt. The commander transferred control to the copilot and asked a company engineer aboard the aircraft to help in diagnosing the problem.

The engineer told the flight crew that the left air data computer (ADC) was unserviceable and that he had experienced the same problem several months earlier when the left pitot system in another company aircraft had been blocked by an insect.

The 757's left pitot system had, indeed, been blocked by an insect. As a result, the pressure trapped inside the pitot system remained constant while static pressure decreased as the 757 climbed. "This caused the ASI to initially under-read, then over-read at altitude," the report said.

On rotation, the indicated airspeed was 70 kt while groundspeed was 155 kt.

The aircraft was climbing through 18,000 ft when the commander resumed control and, in accordance with the quick reference handbook, reset his ADC switch to "ALTN" (alternate). His ASI reading dropped from 350 kt to 280 kt.

The crew incorrectly believed that selection of the alternate air data source had isolated the problem with the left ADC.

Despite the crew's selection of the alternate air data source, the flight management computers (FMCs) continued using the left ADC as a source for airspeed data. This is normal unless a fault in the left ADC is detected and the FMCs then automatically switch to the right ADC.

However, the pitot system blockage was not detected as an ADC fault, and the FMCs continued to use the left ADC as a source for airspeed data.

At about 32,000 ft, the erroneously high airspeed computed by the left ADC caused the FMCs to sense an overspeed condition and command the autopilot to pitch the aircraft nose-up to reduce the airspeed.

Sensing this, the commander attempted to select the vertical speed mode to reduce the increased rate of climb, but the autopilot did not respond. The copilot, who had urgently voiced concerns about the aircraft's behavior, called, "I have it," disengaged the autopilot and pushed his control column forward.

The commander transferred control to the copilot and declared an emergency, announcing that they were returning to Accra. The 757 was landed without further incident.

Company engineers examined the aircraft and "found the remains of a 'beetle-like creature' in the left-hand pitot system," the report said. "No faults were found with the ADC, the autopilots or any of the relevant systems."

After the incident, the company revised its procedures to require that pitot tubes be covered during long turnarounds.

After the incident, the company revised its procedures to require that pitot tubes be covered during long turnarounds and that takeoffs be rejected if an airspeed discrepancy is detected below 80 kt.

Surprised by Black Ice

Beech 390 Premier. Substantial damage. No injuries.

The forecast for Leesburg (Virginia, U.S.) Executive Airport the night of Feb. 12, 2008, was for little or no precipitation and rising temperatures. However, the temperature actually dropped, and black ice formed on the runway.

A notice to airmen about the runway condition was not posted. "Additionally, the airport personnel did not have the equipment or training to issue braking action reports, nor was it required," said the U.S. National Transportation Safety Board (NTSB) report.

About 2055 local time, the Premier touched down at 100 kt near the threshold of the 5,500-ft (1,676-m) runway. The pilot said that braking action was "adequate" at first but decreased to "near nil" at midfield.

"The pilot maneuvered the airplane off the left side of the runway to gain traction from the adjacent grass area, during which it impacted a drainage ditch," the report said. "The area off the end of the runway was an open field with no obstructions."

Nosewheels Not Chocked at Stand

Boeing 777-200. Minor damage. No injuries.

After landing and taxiing to the stand at London Heathrow Airport on Feb. 11, 2009, the flight crew set the parking brake, shut down both engines and left the auxiliary power unit running.

"The normal operating procedure when an aircraft is parked on a stand is for wheel chocks to be placed in front of and behind the nosewheels," the AAIB report said. "Due to two stand changes, the chocks, which [normally are] supplied by the ground handling agent, did not arrive."

After confirming indications that the parking brake was set and that hydraulic accumulator pressure was normal, the commander approved disembarkation without chocks in place.

The 14 crewmembers and 10 of the 114 passengers were still aboard when the 777 began to slowly roll backward. The parking brake valve had failed, causing a loss of hydraulic pressure.

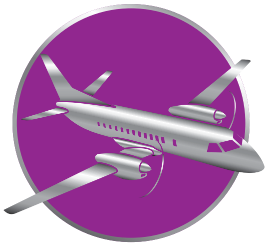
A ground engineer saw the aircraft moving and notified the operator's maintenance manager, who was on the jetway. The maintenance manager boarded the 777 and entered the flight deck.

"Both pilots were in their seats carrying out post-flight activity and were unaware that the aircraft was moving," the report said.

The maintenance manager engaged the right hydraulic system pump, which repressurized the parking brake system.

"The aircraft had moved backward approximately 2 m [7 ft], exposing the open door," the report said. "The jetty structure made contact with the side of the door, causing a minor abrasion to its surface."

Following the incident, the operator took action to ensure that wheel chocks always are available when its aircraft arrive on stand.



TURBOPROPS

Improper Reaction to Engine-Out

Mitsubishi MU-2B-60. Destroyed. One fatality.

Witnesses heard an unusual noise after the MU-2 lifted off the runway and saw the airplane roll into a steep right bank and enter a spin at less than 700 ft AGL. The airplane descended into wooded terrain about 1.5 nm (2.8 km) from the end of the runway.

Day visual meteorological conditions (VMC) prevailed when the accident occurred on June 25, 2006, during a positioning flight from Fort Pierce, Florida, U.S. In its final report, issued in December 2009, NTSB said that the pilot did not adhere to published emergency procedures after a sudden loss of thrust from the right engine.

"Examination of the right engine revealed that the ring gear support of the engine/propeller gearbox had fractured in flight due to high-cycle fatigue," the report said. "The ring gear support disengaged from the ring gear due to this failure, resulting in a disconnection in power being transferred from the engine power section to the propeller."

The right propeller was feathered manually or automatically about three seconds after the power loss. The pilot, who had logged 2,000 of his 11,000 flight hours in MU-2s, then brought the right engine power lever to the flight idle position.

This action is prohibited by the airplane flight manual (AFM) because, in this situation, the drive train disconnection had rendered inoperable the MU-2's negative torque sensing (NTS) system, which detects and feathers a windmilling propeller. With the NTS system inoperable, the decreases in fuel flow and power section rpm caused the propeller governor to sense an under-speed condition and bring the propeller out of feather.

"The pilot may not have been aware that the propeller came out of feather," the report said. "As a result of the increased drag condition on the right side of the airplane, the airplane yawed and rolled right, and entered a spin. In an attempt to control the airplane, the pilot reduced power on the opposite (left) engine. However, at this point, the airplane was not at a sufficient altitude to recover."

The report said that drive train disconnection in Honeywell TPE331 engines is "an unusual engine failure that results in substantially different engine indications to a pilot in comparison to a typical flameout event in which the NTS system is operable."

However, the report noted that the MU-2 AFM warns that the engine power lever must not be retarded after a power loss in flight. The manual says, "Place failed engine power lever to takeoff position during feathering of the propeller and leave there for remainder of the flight."

Engine Fails During EMS Flight

Beech King Air B200. Substantial damage. No injuries.

The King Air was at Flight Level (FL) 290 (approximately 29,000 ft) when the pilot noticed an increase in the inter-turbine temperature (ITT) indication for the right engine and slight fluctuations in the torque, fuel flow and N_1, or low-pressure rotor speed, indications.

"In response, the pilot reduced power on the right engine, and the ITT appeared to return to within the normal operating range, although the fluctuations persisted," said the report by the Australian Transport Safety Bureau.

The engine then surged, and, seeing smoke emerge from the cowling, the pilot shut it down. He transmitted a "pan-pan" call and diverted the flight to Broome. "The pilot then briefed the flight nurse and doctor on the situation, and they prepared the cabin for landing," the report said. "The remainder of the flight and subsequent single-engine landing were uneventful."

The incident occurred during an emergency medical services (EMS) flight from Newman to Fitzroy Crossing, Western Australia, the afternoon of May 24, 2007.

Examination of the Pratt & Whitney PT6A-42 engine revealed a major internal failure. "The engine failure was the result of the mid-span separation of one of the compressor turbine blades," the report said. "There was no prior indication in the engine logs, or to flight crews, of the impending failure."

A stress rupture resulting from exposure to excessive temperatures had caused the turbine blade to separate. The engine had accumulated 7,132 operating hours and 5,753 cycles since new, including 1,259 hours and 997 cycles since overhaul.

Pitot Heat Neglected Before Takeoff

Piper PA-46-500TP Meridian. Destroyed. Three fatalities.

Before departing the morning of June 28, 2007, the pilot received a weather briefing that called for thunderstorms and heavy precipitation on the intended route from St. Louis, Missouri, U.S., to Buffalo, Minnesota.

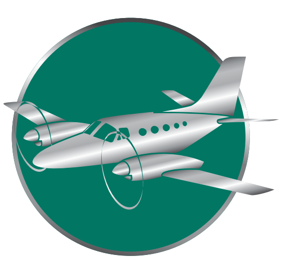
Although called for by the "Before Takeoff" checklist, the pitot heat system was not activated. The NTSB report said that the outside air temperature decreased below freezing as the single-engine airplane climbed through 15,900 ft; the pilot had been cleared to climb to FL 230.

"The primary flight display (PFD) airspeed data decreased from about 140 kt indicated airspeed (KIAS) to 0 KIAS," the report said. "During the loss of airspeed, the airplane's recorded climb rate decreased, and the airplane entered a left turn."

The air traffic controller asked the pilot if he was deviating around adverse weather. The pilot replied, "We've got problems." Radar contact with the Meridian was lost shortly thereafter.

"Recovered PFD data indicated that the airplane exceeded its maximum structural operating speed during a rapid descent, [with] vertical loads reaching 5 g," the report said.

The right wing separated, and the airplane descended into terrain in Wellsville, Missouri. "A review of available weather data indicated that there was an area of extreme precipitation associated with thunderstorms east of the accident site," the report said.



PISTON AIRPLANES

Too Heavy to Clear a Ridge

Britten-Norman Islander. Destroyed. Two fatalities, two serious injuries, six minor injuries.

Before boarding nine passengers and their baggage for a scheduled flight from Lajmoli to Pekoa, both in Vanuatu, a company agent told the pilot that the airplane would be at maximum gross weight. "The pilot was reported to have advised the agent that he was happy to continue and instructed him to load the aircraft," said the report by the New Zealand Transport Accident Investigation Commission.

"The agent added the weight of the passengers and baggage to the load sheet for the flight, but he wasn't aware of the fuel weight, so [he] omitted this from the sheet," the report said. The pilot signed the load sheet.

Investigators determined that the Islander was at least 198 kg (437 lb) over its maximum takeoff weight, with a center-of-gravity near the aft limit, when it departed from Lajmoli in day VMC the morning of Dec. 19, 2008. The pilot followed the coastline and then turned inland, toward mountainous terrain.

"Witnesses, both on the ground at Lajmoli and passengers on board, later commented that the aircraft took longer to get airborne than normal and was slower to climb," the report said. "The passengers recalled becoming increasingly concerned about the low height of the aircraft as it flew directly at a right angle toward the last ridge line."

The pilot increased power but apparently realized that the airplane would not clear the terrain. "Some of the passengers described the pilot closing the throttles and shutting down the engines as they approached the ridge line," said the report, noting that the pilot likely attempted to make a controlled landing on the 35-degree slope.

The crash occurred at an elevation of about 3,940 ft and about 75 km (41 nm) northeast of Luganville. The pilot was killed instantly. The front-seat passenger sustained critical injuries and died 13 days later.

Rescuers reached the wreckage early the next morning and found that eight passengers had left the site, traveling downhill. A helicopter crew found seven of the people together in mid-afternoon. The eighth person, who had sustained a serious head wound and a broken leg, had set out after the main group but had not been able to catch them; he was found two days after the accident by searchers from a local village.

"The survivors would have been better [off] to stay near the aircraft to wait for rescue," the report said. "By climbing the 25 m [82 ft] to the top of the ridge, they would have had a better idea of their location, discovered cell phone coverage … and been able to phone for help."

The report said that the inadequate condition of restraints contributed to at least two injuries. The front-seat passenger had been unable to latch his shoulder harness because of a missing fitting; another passenger had been unable to fasten his seat belt because it was too short.

Disorientation in Night IMC

Aero Commander 500B. Destroyed. One fatality.

Instrument meteorological conditions (IMC) — with 3 mi (4,800 m) visibility in rain and snow, a broken ceiling at 600 ft and a 1,900-ft overcast — prevailed at Tulsa (Oklahoma, U.S.) International Airport when the pilot departed from Runway 36L for an on-demand cargo flight the night of Jan. 26, 2008.

The pilot, who had logged 695 of his 4,373 flight hours in type, was cleared about two minutes after takeoff to turn left to a heading of 250 degrees. ATC radar showed that the Aero Commander turned about 60 degrees left and then entered a right turn.

When queried by the controller, the pilot said, "I think I have lost my gyros. I'm trying to level out now." About three minutes later, he reported that he was "having some trouble."

The airplane completed two steep, 360-degree spiraling turns before radar and radio contact were lost. The report concluded that the pilot had lost control of the airplane while experiencing spatial disorientation. Both wings and the tail section separated from overload before the airplane struck terrain about 2 mi (3 km) north of the airport.

"No anomalies were noted with the gyro instruments, engine assemblies or accessories," the report said.

HELICOPTERS

Control Lost in Gusty Winds

Aerospatiale/Westland SA 341G. Destroyed. Two fatalities.

The pilot had recently earned a rotorcraft license and had logged 56 of his 853 flight hours in helicopters, including 46 hours in type. Surface winds at 25 kt, gusting to 35 kt, prevailed the afternoon of Jan. 26, 2008, when he flew his newly purchased Gazelle over Knaresborough, North Yorkshire, England, where family members were shopping, and then back toward his chalet near Harrogate.

Witnesses saw the helicopter flying slowly at low altitude before it spun, pitched up and descended tail-first to the ground near the chalet. The pilot and his wife were killed.

The AAIB report said that the pilot likely had lost yaw control and then pitch control while flying the Gazelle at low forward airspeed in the strong and gusty wind conditions. "It appears that the pilot, who had limited helicopter experience, was attempting to operate in weather conditions which more experienced pilots might have chosen to avoid," the report said.

'We're in the Clouds Again'

Eurocopter AS 350B2. Destroyed. Three fatalities.

Night VMC prevailed when the EMS helicopter departed from Harlingen, Texas, U.S., to pick up a patient on South Padre Island on Feb. 5, 2008. As the helicopter neared the landing site, however, it encountered low clouds, the NTSB report said.

Witnesses saw the helicopter turn left and then right, more steeply, at about 1,000 ft AGL and 2 mi (3 km) from the landing site. The last radio transmission made by the flight nurse on the medical communications frequency was: "We're in the clouds again. We're going to abort, transfer patient by ground."

Shortly thereafter, the pilot lost control of the helicopter. "Several witnesses saw the lights of the helicopter fall almost straight down, and the helicopter wreckage exhibited damage consistent with a high-speed, port-side, inverted impact with water," the report said. The pilot, flight nurse and paramedic were killed.

Records showed that the pilot had completed an instrument competency check in a single-engine airplane in 1997. "The only instrument experience in a helicopter entered in the pilot's logbook within the past 10 years was two entries of simulated instrument time of 0.8 hours in December 2005 and 0.2 hours in September 2007."

Preliminary Reports, December 2009

Date	Location	Aircraft Type	Aircraft Damage	Injuries
Dec. 1	Trinidad, Bolivia	Fairchild Metro III	substantial	12 none
The Metro veered off the runway while landing in heavy rain and strong winds.				
Dec. 2	Kupang, Indonesia	Fokker 100	substantial	94 none
The flight crew was unable to fully extend the left main landing gear, and the Fokker veered off the runway after touchdown.				
Dec. 4	Harrison, Michigan, U.S.	Piper Cheyenne IIXL	destroyed	1 fatal
The pilot lost control of the Cheyenne shortly after being cleared to descend from 24,000 ft. Witnesses saw the airplane in a spin.				
Dec. 6	Iqaluit, Nunavut, Canada	IAI Galaxy	minor	3 none
The Galaxy veered off the runway while landing to refuel during a business flight from England to the United States.				
Dec. 7	Egelsbach, Germany	Beech King Air F90	destroyed	3 fatal
The King Air struck terrain on final approach in day instrument meteorological conditions.				
Dec. 7	George, South Africa	Embraer 135LR	substantial	33 NA
Some occupants sustained minor injuries when the airplane overran the wet, 6,562-ft (2,000-m) runway on landing.				
Dec. 9	Dorrigo, New South Wales, Australia	Bell 206L-1	destroyed	1 fatal, 1 serious
The LongRanger was on a fire-surveillance flight when it crashed in a rainforest, killing the passenger.				
Dec. 9	Saint-Honoré, Quebec, Canada	Beech King Air A100	destroyed	2 fatal, 2 serious
The King Air struck treetops and crashed during a night approach in low visibility. Both pilots were killed.				
Dec. 11	Gulf of Guinea	Aerospatiale AS 332L	minor	18 none
The Super Puma was ditched for unknown reasons during a flight from Lagos, Nigeria, to a marine vessel in the Agbami oil field.				
Dec. 13	Korkino, Russia	Technoavia Turbo Finist	destroyed	8 fatal
The single-turboprop airplane crashed on takeoff for a skydiving-training flight.				
Dec. 16	Hana, Maui, Hawaii	Aerospatiale AS 350-BA	substantial	2 serious
The tail boom separated during a hard autorotative landing on the shoreline after an actual or simulated engine failure occurred during a pilot-proficiency check flight.				
Dec. 17	Matthew Town, Great Inagua, Bahamas	Dassault Falcon 20D	destroyed	2 fatal
The Falcon struck terrain in a steep dive after radio and radar contact were lost at Flight Level 280 during a flight from Santo Domingo, Dominican Republic, to Fort Lauderdale, Florida, U.S.				
Dec. 19	Tonj, Sudan	Hawker-Siddeley 748	destroyed	1 fatal, 36 none
The airplane overran the 1,000-m (3,281-ft) sand runway on landing and struck several houses that were under construction. No one aboard the Hawker was hurt, but one person on the ground was killed.				
Dec. 22	Kingston, Jamaica	Boeing 737-800	destroyed	4 serious, 36 minor, 114 none
Surface winds were from 320 degrees at 11 kt when the 737 touched down long and overran Runway 12 while landing in heavy rain (*ASW*, 12/09–1/10, p. 1).				
Dec. 22	Moab, Utah, U.S.	Cessna 402C	substantial	1 none
The 402 veered off the runway after striking a snowbank during takeoff for a night cargo flight.				
Dec. 25	Dallas, Texas, U.S.	ATR 72	minor	45 none
The flight crew landed the airplane without further incident after the elevator jammed during approach. The left elevator down-limit stop had fractured, and the separated stop had restricted elevator movement.				
Dec. 25	Decatur, Texas, U.S.	Bell 407	substantial	2 serious, 1 minor
The helicopter touched down hard during an autorotative landing after losing engine power while taking off from a hospital helipad for an emergency medical services flight.				
Dec. 28	near Esso, Russia	Mil Mi-8T	destroyed	2 serious, 1 none
The helicopter reportedly was over gross weight and partially covered with ice when it crashed after losing power from one engine during a cargo flight.				
Dec. 29	Kiev, Ukraine	Airbus A320-230	substantial	160 none
The A320 veered off the runway and ground-looped while landing in a snowstorm.				

NA = not available

This information, gathered from various government and media sources, is subject to change as the investigations of the accidents and incidents are completed.