AeroSafety WORLD

AIRSPACE INTEGRATION
Making way for UAS

PATHOLOGICAL STARTLE
Researchers probe pilot reactions

UNLIMITED CROSSWINDS
Study challenges airline practices

BRAKING ACTION ON WET RUNWAYS

SLIP-SLIDING AWAY

THE JOURNAL OF FLIGHT SAFETY FOUNDATION

MAY 2013

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SETBACK IN Nigeria

By now you may have heard that Harold Demuren, director general of the Nigerian Civil Aviation Authority, has been fired. Demuren, who sits on the Foundation's Board of Governors, had been director general since 2005 and made significant progress in advancing aviation and aviation safety in Nigeria. The Foundation has been actively involved with public and private support for Demuren, and we are saddened by his removal.

It has been reported that Nigerian President Goodluck Jonathan removed Demuren from office because of two fatal commercial aviation accidents that occurred in Nigeria last year — reasoning that we find incomprehensible. No amount of government oversight could have prevented those tragedies. Demuren actively spoke out for reform and infrastructure improvements and set higher operational standards in Nigeria. He constantly advocated best practices for operators and worked for the development of adequate standards for better and safer service for the people of Nigeria and all of Africa.

Last July, on the occasion of the African Union Ministerial Conference on Aviation Safety in Abuja, Nigeria, the country's vice president, Namadi Sambo, on behalf of Jonathan, said the Nigerian federal government had the political will to implement all resolutions contained in the then-anticipated Abuja Declaration, the document ultimately adopted at the conference, to ensure a safe and secure aviation industry. In addition, he called on all member nations to cooperate and collaborate to achieve safer skies for Africa.

A delegation from Flight Safety Foundation participated in the conference and presented a working paper on regulatory and operational safety challenges in the African region. The Foundation has experience in gathering operational flight data from this region through our Basic Aviation Risk Standard (BARS) program. We also were at the forefront of the issues through our association with Demuren.

As I mentioned above, there has been safety and operational progress in Nigeria and throughout Africa in recent years. New control towers have been built, low level wind shear detection equipment and runway visual range monitors have been installed at some airports, and 24 new flight operations inspectors and 54 airworthiness inspectors have been hired. Thirteen African countries now exceed the International Civil Aviation Organization's standards and recommended practices as determined by the Universal Safety Oversight Audit Program.

Much of this positive momentum can be attributed to Demuren's tireless efforts. He was a strong leader who helped to bring safety issues to the forefront and promote action on them. He was able to form alliances with many entities to effect change and make progress. That type of dedication and talent will be missed. Jonathan's use of Demuren as a scapegoat is a major setback for Nigeria and for aviation safety in that country and in Africa overall.

Capt. Kevin L. Hiatt
President and CEO
Flight Safety Foundation

AeroSafetyWORLD

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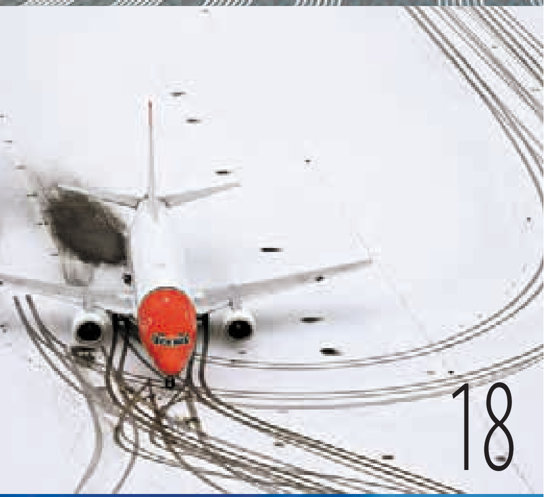

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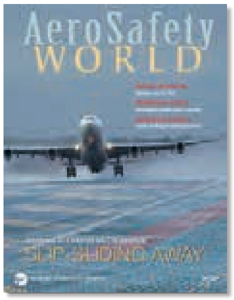

About the Cover
Protected flight recorder data reveal unprecedented insights on wet-runway braking action to a U.S. airline.
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If you have an article proposal, manuscript or technical paper that you believe would make a useful contribution to the ongoing dialogue about aviation safety, we will be glad to consider it. Send it to Director of Publications Frank Jackman, 801 N. Fairfax St., Suite 400, Alexandria, VA 22314-1774 USA or jackman@flightsafety.org.

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AeroSafetyWORLD

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FOCUS ON THE Journey

Next month, I am scheduled to give a presentation at the International Union of Aerospace Insurers' (IUAI) annual general meeting. The topic is "2012: Blip or Step-Change." This speaking engagement is significant on a number of fronts. First of all, the IUAI meeting is being held in Bermuda and, as most of you probably are aware, there are worse places to spend a few days in early June. Secondly, I recently marked my one-year anniversary at Flight Safety Foundation, so I'm interpreting Foundation President and CEO Kevin Hiatt's approval to take on this engagement as a vote of confidence.

Most important, however, is the subject. Was the much-ballyhooed safest year since the dawn of time, or least since the dawn of aviation, a blip on the continuum or does it mark a permanent change? Has the industry achieved an unmatched, sustainable level of safety excellence?

As we all know by now, the data show that 2012 was the safest year on record for commercial aviation, particularly if you just look at Western-built equipment. But as we have mentioned in *AeroSafety World*, and as was pointed out in April in Montreal at the Foundation's 58th annual Business Aviation Safety Seminar (BASS), the same stellar accident rate isn't found in all geographic regions or across all aviation sectors. The commercial aviation accident rate is significantly worse in Africa than in North America; there were more accidents involving turboprops last year than involving commercial jets; and it's tough to compare commercial aviation to corporate aviation because it's difficult to come up with accurate exposure data such as number of flights or departures in the business aviation sector.

My presentation still is in the preparation phase, and I will depend on Kevin and others here at the Foundation to vet everything before I actually step onto the podium in Bermuda, so I'm not yet ready to answer the "blip or step-change" question. But I bring up the speech because with it looming, I find myself very attuned to what others are saying about the industry's accident rate and aviation safety prospects, and because I recently returned from BASS, where, of course, the topic was much discussed.

At BASS, Steve Brown, chief operating officer for the National Business Aviation Association, said, "Safety is what defines the public perception of business aviation."

Of course, that's true of commercial aviation, as well. That perception is a positive when your accident rate is improving, but could be a negative in some sectors, such as emergency medical services, which have seen a spate of accidents recently.

Merlin Preuss, vice president of government and regulatory affairs at the Canadian Business Aviation Association, said, "It's getting harder to avoid the big one." He pointed to demographics and said that business aviation is seeing decreasing experience levels in operations personnel and increasing complexity and sophistication in the aircraft being used.

And George Ferito, outgoing chairman of the Foundation's Business Advisory Committee and an executive at FlightSafety International, said that it is inevitable that there will be accidents and that "safety is not a destination. It's a journey."

So, where are we in our journey?

Frank Jackman
Editor-in-Chief
AeroSafety World

Serving Aviation Safety Interests for More Than 65 Years

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 1,000 individuals and member organizations in 150 countries.

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Wayne Rosenkrans

Reflections

BY WILLIAM R. VOSS

A few months ago I left Flight Safety Foundation to return to a job in the U.S. federal government. I left with some regrets, but I had to give in to some practical considerations. After more than 1,000 days on the road and nearly 2 million miles in the air, I realized I needed to be home more often to get to know my family. In addition, I needed to spend just a few more years in the government so that when I retire, I receive the full value of a pension that I had paid into for 26 years. I will still be working in the safety business, but I will not be as visible for a little while.

I have written scores of *AeroSafety World* editorials and have been given credit for uncovering more than a few pearls of wisdom through these columns. As my parting insight, let me disclose the source of that "wisdom." The greatest wisdom in this business has been, and will remain, the people who read this column. To appear wise, all I ever had to do was offer a colleague in one part of the world the solutions developed by someone I had met a few days before in another corner of the globe. For the last few years, I have been little more than a mirror that reflected the insights generated in one corner to another.

I have learned to appreciate the power, capability and resilience of the people who work in aviation safety. It was my job to spend every waking hour understanding what you were doing, what was working, and what was holding you back. Every day I woke up and found myself among selfless, dedicated and talented people who couldn't wait to share their passions and insights. For me, that was an incredible honor, and when you receive that sort of honor, the jet lag and frustrations fade into the background.

Perhaps the greatest lesson I learned is that, above all else, the aviation safety system needs to function as a *community.* Our strength is in our ability to learn from each other. Our resilience is in our ability to support one another and overcome common threats. Aviation safety is not a business that generates easy-to-calculate financial returns, or makes heroes out of its leaders. Our business, on a good day, makes itself appear to be unnecessary. You can spend a career selflessly dedicating yourself to driving out risk and saving lives, only to have the world turn on you when something goes wrong. We all know that, but carry on anyway. No one acting alone can last long in such an environment. We need each other to survive, and we need each other to succeed.

That is the central purpose of this noble Foundation. It is our communication network, it is our support system, it is our community. I hope all of you support Kevin Hiatt as he leads the Foundation forward.

I thank all of you for an extraordinary six years. I have been overwhelmed by your kindness and hospitality. I have been humbled by your expertise and dedication.

Until we meet again …

MAY 13–17 ➤ SMS Theory and Principles. MITRE Aviation Institute. McLean, Virginia, U.S. Mary Beth Wigger, <maimail@mitre.org>, <bit.ly/14E7NFV>, +1703.983.5617. (Also JULY 15–18, SEPT. 16–20, DEC. 9–13.)

MAY 14–23 ➤ Aircraft Accident Investigation. University of Southern California Aviation Safety and Security Program. Los Angeles California, U.S. Raquel Delgadillo, <raquelde@usc.edu>, <viterbi.usc.edu/aviation/courses/aai.htm>, +1 310.342.1345.

MAY 14–16 ➤ Advanced Rotorcraft Accident Investigation. U.S. Department of Transportation, Transportation Safety Institute. Oklahoma City, Oklahoma, U.S. Lisa Colasanti, <AviationTrainingEnrollment@dot.gov>, <1.usa.gov/ZM138r>, +1 405.954.7751.

MAY 16–17 ➤ Air Medical and Rescue Congress. China Decision Makers Consultancy. Shanghai, China. <info@cdmc.org.cn>, <www.cdmc.org.cn/2013/amrcc>,+86 21 6840 7631.

MAY 20–24 ➤ Unmanned Aircraft Systems. Southern California Safety Institute. Prague, Czech Republic. Denise Davalloo, <denise.davalloo@scsi-inc.com>, <www.scsi-inc.com/unmanned-aircraft-systems.php>, +1 310.940.0027, ext.104.

MAY 21–23 ➤ European Business Aviation Convention & Exhibition (EBACE). European Business Aviation Association. Geneva, Switzerland. <www.ebace.aero/2013>.

MAY 21–24 ➤ Aircraft Fire and Explosion Course. BlazeTech. Woburn, Massachusetts, U.S. Albert Moussa, <firecourse@blazetech.com>, <www.blazetech.com>, +1 781.759.0700, ext. 200.

MAY 30–31 ➤ 2Gether 4Safety African Aviation Safety Seminar. AviAssist Foundation. Lusaka, Zambia. <events@aviassist.org>, <bit.ly/TtMkqD>, +44 (0)1326-340308.

JUNE 2–13 ➤ Aviation Safety Management Systems. University of Southern California Aviation Safety and Security Program. Los Angeles. Raquel Delgadillo, <raquelde@usc.edu>, <viterbi.usc.edu/aviation/courses/asms.htm>, +1 310.342.1345.

JUNE 3–7 ➤ Flight Safety Officer Course. Southern California Safety Institute. Halifax, Nova Scotia, Canada. Denise Davalloo, <registrar@scsi-inc.com>, <www.scsi-inc.com/FSO.php>, 800.545.3766, ext. 104; +1 310.517.8844.

JUNE 4–6 ➤ Advanced Commercial Aviation Accident Investigation. U.S. Department of Transportation, Transportation Safety Institute. Oklahoma City, Oklahoma, U.S. Lisa Colasanti, <AviationTrainingEnrollment@dot.gov>, <1.usa.gov/XY6yet>, +1 405.954.7751.

JUNE 6–7 ➤ Overview of Aviation SMS and Proactive Hazard ID and Analysis Workshop. ATC Vantage. Tampa, Florida, U.S. <www.atcvantage.com/sms-workshop.html>, +1 727.410.4759. (Also NOV. 7–8.)

JUNE 10–14 ➤ Decision-Making Methodology for Aviation System Block Upgrades. MITRE Aviation Institute. McLean, Virginia, U.S. Karina Wright, <khw@mitre.org>, <mai.mitrecaasd.org/asbu_course>, +1 703.983.5617.

JUNE 14 ➤ Latin America and Caribbean Conference. Civil Air Navigation Services Organisation. Willemstad, Curaçao. Anouk Achterhuis, <events@canso.org>, <www.canso.org/lacconference2013>, +31 (0)23 568 5390.

JUNE 21 ➤ Dangerous Goods Training Course for Safety Assessment of Foreign Aircraft Programme Inspectors. Joint Aviation Authorities Training Organisation. Hoofddorp, Netherlands. <https://jaato.com/courses/106/#>. (Also DEC 13.)

JUNE 21–23 ➤ Flight Attendants/Flight Technicians Conference. National Business Aviation Association. Washington, D.C. Jay Evans, <jevans@nbaa.org>, <www.nbaa.org/events/fa-ft/2013>, +1 202.783.9353.

JUNE 24–28 ➤ Safety Assessment of Aircraft Systems. Cranfield University. Cranfield, Bedfordshire, England. <shortcourse@cranfield.ac.uk>, <bit.ly/TMAE39>, + 44 (0) 1234 754192. (Also NOV. 25–29.)

JUNE 25–26 ➤ Aviation Safety Summit. Latin American and Caribbean Air Transport Association. San José, Costa Rica. <panamericansafety@alta.aero>, <www.alta.aero/safety/2013/home.php>.

JULY 10 ➤ Hazardous Materials Air Shipper Certification Public Workshop. Lion Technology. Dedham, Massachusetts, U.S. (Boston area). Chris Trum, <info@lion.com>, <bit.ly/XNDWUv>, +1 973.383.0800.

JULY 10–11 ➤ Airline Engineering and Maintenance Safety. Flightglobal and Flight Safety Foundation. London. Jill Raine, <events.registration@rbi.co.uk>, <www.flightglobalevents.com/mro2013>, +44 (0) 20 8652 3887.

JULY 23–24 ➤ Aviation Human Factors and SMS Wings Seminar. Signal Charlie. Dallas. Kent Lewis, <lewis.kent@gmail.com>, <www.signalcharlie.net/Seminar+2013>, +1 850.449.4841.

JULY 29–AUG. 2 ➤ Fire and Explosion Investigation. Southern California Safety Institute. San Pedro, California, U. S. Denise Davalloo, <denise.davalloo@scsi-inc.com>, <www.scsi-inc.com/FEI.php>, +1 310.940.0027, ext.104.

AUG. 12–16 ➤ Aircraft Performance Investigation. Southern California Safety Institute. San Pedro, California, U. S. Denise Davalloo, <denise.davalloo@scsi-inc.com>, <www.scsi-inc.com/API.php>, +1 310.940.0027, ext.104.

AUG. 19–22 ➤ ISASI 2013: Preparing the Next Generation of Investigators. International Society of Air Safety Investigators. Vancouver, British Columbia, Canada. Ann Schull, <isasi@erols.com>, <www.isasi.org>, +1 703. 430.9668.

SEPT. 29–OCT. 1 ➤ SMS/QA Symposium. DTI Training Consortium. Disney World, Florida, U.S. <symposium@dtiatlanta.com>, <www.dtiatlanta.com/Symposium2013.html>, +1 866.870.5490.

OCT. 14–16 ➤ SAFE Association Annual Symposium. SAFE Association. Reno, Nevada, U.S. Jeani Benton, <safe@peak.org>, <www.safeassociation.com>, +1 541.895.3012.

OCT. 22–24 ➤ SMS II. MITRE Aviation Institute. McLean, Virginia, U.S. Mary Beth Wigger, <mainmail@mitre.org>, <bit.ly/YJofEA>, +1 703.983.5617.

OCT. 29–31 ➤ 66th International Air Safety Summit. Flight Safety Foundation. Washington, D.C. Namratha Apparao, <apparao@flightsafety.org>, <flightsafety.org/aviation-safety-seminars/international-air-safety-seminar>, +1 703.739.6700, ext. 101.

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. Send listings to Frank Jackman at Flight Safety Foundation, 801 N. Fairfax St., Suite 400, Alexandria, VA 22314-1774 USA, or <jackman@flightsafety.org>.

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

Safety News

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'Monitoring Matters'

The aviation industry should recognize the importance of improved cockpit monitoring by flight crewmembers as a tool in reducing safety incidents, the U.K. Civil Aviation Authority (CAA) says.

The CAA said its new Monitoring Matters safety package — consisting of guidance material and five video re-enactments of actual incidents in which poor monitoring compromised safety — is aimed primarily at flight training instructors and will be of interest to all commercial pilots in multicrew operations.

"Effective monitoring really does matter on the flight deck," said Gretchen Haskins, director of the CAA Safety Regulation Group. "Pilot monitoring skills play an absolutely vital role in ensuring the safety of aircraft operations. However, we do see significant variations in the quality of this monitoring. If we are to maintain the U.K.'s excellent safety record, we need to ensure all operators are focusing the relevant components of their *ab initio* and recurrent training on high quality cockpit monitoring."

The CAA described monitoring as "the behaviour and skills used by pilots to maintain their own 'big picture' by cross-checking each other's actions and diligent observation of the flight path, aircraft system and automation modes."

The CAA said effective monitoring is a "key safety net" in preventing — and recovering from — loss of control events, which the agency cited as one of the "significant seven" risks to aviation safety. Many loss of control events can be traced to the failure of pilot training to keep pace with advances in cockpit technology, the CAA said.

Call for Action

The Canadian aviation community should "step up and find solutions on their own" to some of the most persistent safety problems plaguing the industry, Wendy Tadros, chairwoman of the Transportation Safety Board of Canada (TSB), says.

In a column written for *The Hill Times*, a weekly publication covering the Canadian government, Tadros noted that the TSB has "talked repeatedly about what needs to be done to improve safety — and by extension, save lives."

However, she added, "when it comes to implementation, progress can easily get bogged down in layer upon layer of 'consultation' and 'process,' leaving the regulatory system so slow it's almost broken."

She referred specifically to recent events involving controlled flight into terrain (CFIT), runway overruns and runway incursions — three items that have been emphasized for several years on TSB's Safety Watchlist, a document in which the agency identifies the greatest risks to transportation safety in Canada.

"Now is the time for Transport Canada to take concrete action," Tadros said, adding that industry also should act by "being proactive and adopting stricter safety measures, and no longer waiting for government to eventually legislate what best practices should be implemented."

She suggested that the industry improve approach procedures and fully utilize technology to help prevent CFIT accidents; extend runway end safety areas and provide pilots with timely information about runway conditions to help curtail runway overruns; and ensure that pilots are given warnings of collision risks to prevent runway incursions.

Risks of Corrosion Inhibitors

Aircraft operators and maintenance personnel should use caution in applying corrosion-inhibiting compounds to many structural joints, the Australian Civil Aviation Safety Authority (CASA) says.

CASA issued an airworthiness bulletin describing a recent study that found that, when applied to highly loaded or fatigue-critical joints, the compounds can reduce fatigue life by as much as half and accelerate the growth of fatigue cracks.

When used appropriately, the corrosion-inhibiting compounds can provide substantial benefits, CASA said.

Tower Closures

Some 149 airport air traffic control towers in the United States will close June 15 because of legislative requirements that the Federal Aviation Administration (FAA) cut $637 million from its budget.

The FAA originally had planned to close the facilities in April, but the agency said more time was needed to resolve legal challenges to the closure decisions.

"Safety is our top priority," said Transportation Secretary Ray LaHood. "We will use this additional time to make sure communities and pilots understand the changes at their local airports."

Epolk/Wikimedia Commons

Operators of about 50 of the airports have said that they may attempt to finance tower operations themselves, and the extra time will aid in the transition, the FAA said. Tower operations at the other airports will cease.

New Fatigue Rules in Australia

Australia's Civil Aviation Safety Authority (CASA) has adopted new rules for fatigue management for flight crewmembers, along with a timetable that calls for a three-year transition to the new rule set.

The new approach is designed as a three-tier system, designed in recognition that "fatigue is a complex aviation safety issue, that there is no one-size-fits-all solution," CASA said.

The first tier is a basic prescriptive system, with "relatively restrictive flight and duty time limitations," designed for use by operators that "do not have the capacity or experience to integrate additional risk management concepts," CASA said.

The first tier rules include requirements that a flight duty period be no longer than nine hours in any one day, with no more than seven hours of flight time; under certain circumstances, the duty period may be extended by one hour and the flight time, by 30 minutes. Flight crewmembers also must have at least 12 consecutive hours off during any 24-hour period and at least two days off during any seven-day period.

The second tier is a fatigue management system, with more flexible flight and duty time limits for pilots, and requirements for operators to identify fatigue hazards and set appropriate flight and duty time limits after taking those hazards into account.

The third tier is a fatigue risk management system (FRMS), intended for operators that "seek to demonstrate an alternative approach to fatigue management," with requirements for operators to develop appropriate policies for risk management, safety assurance and safety promotion processes.

In its discussion of the final rule set, CASA said that data from the Australian Transport Safety Bureau indicates that human fatigue was a possible contributory factor in about 78 aviation accidents or incidents in Australia between 2002 and 2012.

"Fatigue can undermine the crew's capacity to deal effectively with threats and errors," CASA said. "Crews must be adequately alert to perform competently in normal and abnormal operations, and this capacity needs to be protected at all times, regardless of how benign a flight appears to be."

Plotting Progress in India

The International Air Transport Association (IATA) is urging the Indian government and industry to cooperate on projects that IATA says will enhance aviation safety, security and efficiency throughout the country.

IATA Director General and CEO Tony Tyler praised as "a step in the right direction" the Indian government's plan to replace the Directorate General of Civil Aviation with a civil aviation authority (CAA).

He said the new CAA should consider incorporating the standards of the IATA Operational Safety Audit (IOSA) into the national safety oversight framework for airlines.

"Safety is the industry's number one priority," Tyler said, noting that IOSA has played a significant role in establishing voluntary global safety standards.

"India is the great potential market of the future, and the industry here has only just begun to realize its tremendous promise," he said. "If we are to realize that future, we must successfully overcome some major issues."

A Lion Air Boeing 737-800 sits in shallow waters of the Indian Ocean after an April 13 crash on approach to Denpasar-Ngurah Rai Bali International airport in Indonesia. All 108 people in the airplane survived the accident, but the airplane was destroyed. Rain and wind shifts were reported at the time of the approach.

Loss of Separation

The number of reported operational errors by air traffic controllers resulting in air traffic losses of separation increased more than 50 percent from 2009 to 2010, according to a report by the U.S. Department of Transportation's Office of Inspector General (OIG).

The report said the U.S. Federal Aviation Administration attributes the increase primarily to increased reporting through voluntary programs such as the air traffic safety action program and the automated traffic analysis and review program.

The OIG report, however, said the increase in reported errors "was linked, in part, to a rise in actual errors. … For example, FAA's air route traffic control centers, which have had an automated system in place for years to detect and investigate reported errors, had a 39 percent increase in operational errors during the same period."

The report also said that nearly 25 percent of the increase stemmed from a procedural change at one terminal radar approach control that resulted in the reclassification of a number of routine approach and landings as operational errors.

The FAA has adopted new policies and procedures to reduce the number of loss of separation events and to improve reporting, "but their effectiveness is limited by incomplete data and implementation challenges," the OIG report said.

In Other News …

Certification tests have been completed for the new battery system for **Boeing 787s**. Boeing next must analyze test-related data and submit materials to the U.S. Federal Aviation Administration, which grounded the 787s in January because of battery problems. … The Port Authority of New York and New Jersey will pay a **$3.5 million fine** under a settlement agreement with the U.S. Federal Aviation Administration (FAA) stemming from the FAA's allegations of aircraft rescue and fire fighting violations at four Port Authority airports. The affected airports were John F. Kennedy International Airport, LaGuardia airport, Newark (New Jersey) Liberty International Airport and Teterboro Airport.

Compiled and edited by Linda Werfelman.

Your Slip Is Showing

BY JOE VIZZONI

FOQA data can detect airports where runways are likely to be slippery and help pilots compensate.

Pilot statements such as "it was as slippery as grease" and "I thought I wouldn't be able to stop in time" would normally be associated with stopping on winter-contaminated runways. These are, rather, pilot responses upon landing in *rain* and on a *wet* runway. They form part of the pilot feedback in a test program related to aircraft braking action. In fact, the test program revealed that some wet runways have equal or worse braking action than snow- or ice-covered runways.

The Program

The braking action test program came about in 2010 at legacy Continental Airlines, which has been merged with United Airlines, and

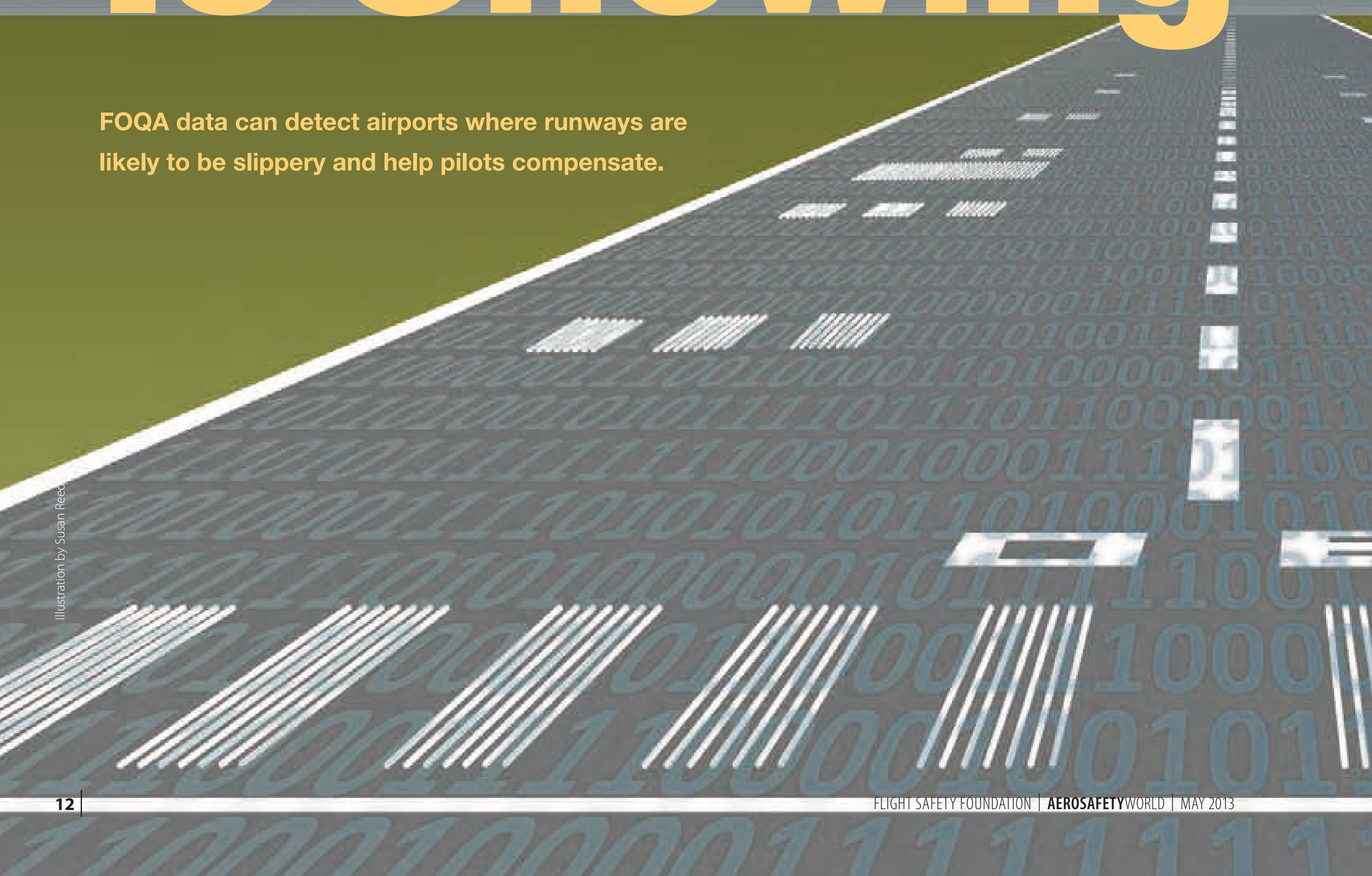


Illustration by Susan Reed

was based on using the aircraft itself and flight data to better assess braking action. In cooperation with Kongsberg Aeronautical, which possessed an algorithm developed for the purpose that it could easily be adapted and downloaded into the aircraft, the airline's flight operational quality assurance (FOQA) group saw this as an exciting safety project and subsequently initiated the test program. Due to the inherent sensitivity of FOQA data and its use, representatives of pilots as well as operational management were summoned to take part in decisions and approve the framework for the test program.

Sensitive Issues

When it came to sensitivity in the use of flight data, one factor proved essential and favorable. The algorithm and the subsequent program loaded onto the aircraft fleet did not require flight data downloading from the aircraft or any other distribution of flight data. The program was designed to obtain braking action information purely through onboard calculation processes. Only the resulting braking action information was transmitted by a downlink.

The braking action information generated by the system on the aircraft was not influenced by the pilot. The information did not reflect on the skill and airmanship of the pilot.

According to established practices, the FOQA group did not have direct contact or communication with pilots. All crew contact was through the Air Line Pilots Association, International (ALPA) as a gatekeeper.

With a clear understanding of the framework for the test program, the next step was to set up a system to assess, receive and evaluate feedback from pilots.

Management of Test Data and Pilot Feedback

Braking action data were processed, handled and communicated for feedback from pilots (Figure 1, p. 14). The following steps and phases further detail the procedure:

- The FOQA group checked daily incoming data from flights and looked for landings that qualified as being within the determined runway slipperiness threshold.
- Landings found to be within the runway slipperiness threshold were then tested against the weather conditions prevailing at the time of landing. By using METARs (the international standard code format for hourly surface weather observations) for the airport, the FOQA group could easily assess whether the landing information likely represented a slippery runway landing.
- To ensure the anonymity of the crew and avoid potential traceability, only a de-identified METAR eliminating the date was used to match the flight.
- In the next phase, the FOQA group approached the ALPA gatekeeper with the landing details. He contacted the crew to receive their feedback.
- The ALPA gatekeeper relayed the feedback and comments to the FOQA group.

The system comprising detection, verification and the final validation by the pilot worked well, and the pilot statements referred to earlier represent some of the feedback results.

'Friction-Limited' Braking Action

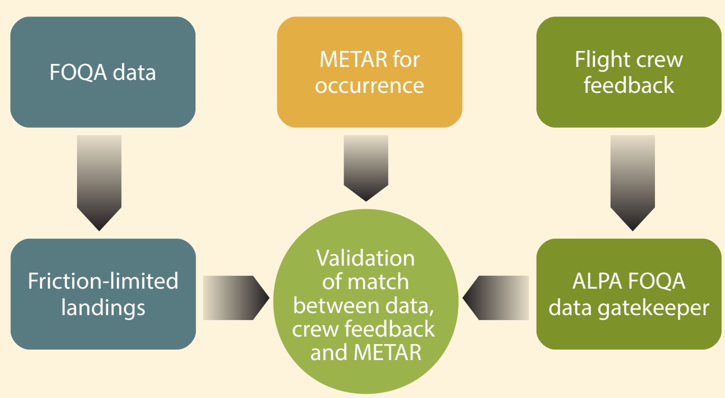
Setup of the on-board algorithm and program is, in broad terms, targeted to detect when aircraft encounter "friction-limited" braking situations. Detecting when an aircraft encounters friction-limited braking is a key constituent in determining maximum braking capability for an aircraft. The test program defined braking action as "dry," "good," "medium" (fair) or "poor" and assigned numerical equivalents of the airplane braking coefficient.

For practical purposes throughout the test program and in pilot contact, the feedback process was focused solely on landing situations in which braking action was classified as being less than "good." This was to avoid adding to pilots' workload for routine landings, when the test was designed to focus on difficult occasions.

A Pilot's Dilemma

Although it is common knowledge that wet runways may be slippery, the issue of slippery runways traditionally has been associated with winter operations and winter contaminants.

FOQA for Wet and Slippery Runways Test Program



ALPA = Air Line Pilots Association, International; FOQA = flight operational quality assurance; METAR = international standard code format for hourly surface weather observations

Source: Joe Vizzoni

Figure 1

© Tim de Groot/AirTeamImages

However, recently the wet runway issue has received increased attention, and for good reason. Early in this test, program data showed that airports where runways were neither grooved nor crowned for water drainage had increasingly higher risk of being slippery when wet. Various types of deposits on the runways compounded the problem.

Ideally, airport management should ascertain proper runway design and maintenance programs to ensure proper friction. In reality, this is not always the case, and the test program revealed substantial variations. A pilot's job is to make the right decisions and land the aircraft safely given the prevailing conditions. Therefore knowledge of, and access to, crucial information is of utmost importance for the pilot.

Test Program Findings

One unexpected outcome of the test program was the finding that a few airports recurrently presented slippery conditions. The METAR analysis confirmed conditions to be rain and/or wet runways. Pilot feedback also supported the finding that conditions were slippery. Some of the pilot statements quoted earlier originate from these airports, primarily located in Central America, where the runways are typically neither grooved nor crowned. A history of overrun accidents further added to a perception of these airports being at higher risk.

To conduct further in-depth analysis, the FOQA group plotted, using a global positioning system tool, the number of slippery landings on maps of the runways to enhance situational awareness of the problem. The photograph (p. 15) shows an example of one of the airports where aircraft encounter friction-limited situations. For practical purposes, the illustration only shows encounters at groundspeeds less than 70 kt. This also is the phase of the stopping run when engine reverse thrust and aerodynamic drag have less impact on the deceleration and leave most of the stopping to the wheel brakes. The photograph shows consistency and further supports the findings.

Satellite photo of Guatemala Airport. Magenta areas indicate positions where the on-board program recurrently indicated friction-limited braking. These positions were defined by the global positioning system, enabling comparison of multiple flights.

Google Maps

FOQA Alert

In response to a slippery landing that needed pilot feedback, the ALPA gatekeeper asked the crew for recommendations in addition to their feedback.

A frequent issue was the emphasis on idle reversers. Although never compromising safety, the company recommended, to an extent, idle reverser usage for fuel savings years ago when fuel prices were on the rise. It seemed that too many pilots relied on brakes when reverser usage was more appropriate, especially at the beginning of the landing roll.[1] What surfaced with this test program was potential increased risk with such a policy at certain airports when conditions involved rain and/or wet runways.

Finding that a significant number of pilots addressed the problem and approached it from virtually the same viewpoint, it became apparent that issue had to be pursued. In one of the company's monthly safety meetings, it was decided to bring up the issue. The safety meeting normally involves participants from ALPA, fleet managers, the safety group, etc. At the meeting, the ALPA gatekeeper presented the case supported by the pilot recommendations, the data and in-depth analysis from the FOQA group. This became then an action item.

In considering the action item, the options were to issue a pilot bulletin or insert a 10-7/FOQA alert — a notification that describes a problem and recommends a response — into the pilots' approach plate for an airport. Due to the seriousness of the issue, the pilot bulletin was considered less appropriate because it would likely be forgotten within six months. The 10-7, on the other hand, represented information in a more permanent form and was used for some of the airports revealed to be at higher risk in the test program.

The 10-7/FOQA Alert Era

The braking action test program continues at an increasing scale and according to its original intent. A little more than two years after the 10-7 implementation, there has been a substantial reduction in pilot statements such as "slipperier than grease" for those airports that were subject to the 10-7.

To further look into the impact of the 10-7 and use of idle reversers, the FOQA group has run an analysis. Where METAR data indicated rain and/or wet runway conditions in landings, their reverser usage was analyzed before and after the 10-7 implementation and showed significant changes. Thrust reverser usage has been more selective. Deployment of reversers upon landing is normal procedure, but in line with policy, the use of reverse thrust by increasing the engine revolution speed has varied. Prior to the 10-7 era, it was normal to see engine speed about 40 percent, which is virtually "idle," even when conditions were rainy or wet. After introduction of the 10-7, the standard engine speed used in rainy or wet conditions was about 80 percent, which is maximum use of reverser thrust.

This action item demonstrates encouraging results. First, it serves as a useful tool for pilots operating in airports that are less than ideal in design and maintenance. Second, in a cost-conscious environment, it also shows that

Selections From a 10-7 Issued for a Runway

- The runway is not grooved and standing water is likely to be present when raining.
- Braking action is likely to be fair–poor when the runway is wet.
- Select and use the maximum autobrake setting.
- Make every attempt to touch down at the 1,000-ft point.
- Use maximum reverse thrust.

—JV

rather than issuing generalized notifications and procedures, proper use of technology and cooperation by pilots can enable a clinical approach and more detailed procedures, better balancing safety with economic considerations.

Safety Culture and Environment

Continental Airlines had a long history of using flight/FOQA data to proactively enhance safety and efficiency, which has continued after the merger with United. Although the braking action test program and the initial 10-7 FOQA alert may seem ordinary, the process epitomized what is needed to build a platform of understanding, trust and cooperation to create the right culture and environment for working with sensitive information such as FOQA data.

For all parties in this test project, the focus has always been on safety. Nevertheless, it has been important to safeguard the corporate safety culture and environment by having proper systems, routines and procedures. When this test program surfaced, the operational management took a keen interest, provided the "green light," and then supported the test program. This was important and provided the proper framework for the project's more active participants.

ALPA and the FOQA groups have had a long relationship and developed good rapport through many years of cooperation. The intriguing part was to have a third party working within the traditional format of the FOQA group and ALPA. It has been a success.

The Future

Although there has been an increasing focus on rain and wet runways, the braking action test program was not specifically set up to find runways prone to higher risk in rain. It was part of a general move to better and more accurately assess the braking capability of aircraft, in particular during challenging winter conditions.

The on-board system developed is now downloaded onto all United's Boeing 737NGs, representing a significant network. Today, this aircraft network furnishes braking action information daily, albeit not yet for operational purposes but only for FOQA group analysis.

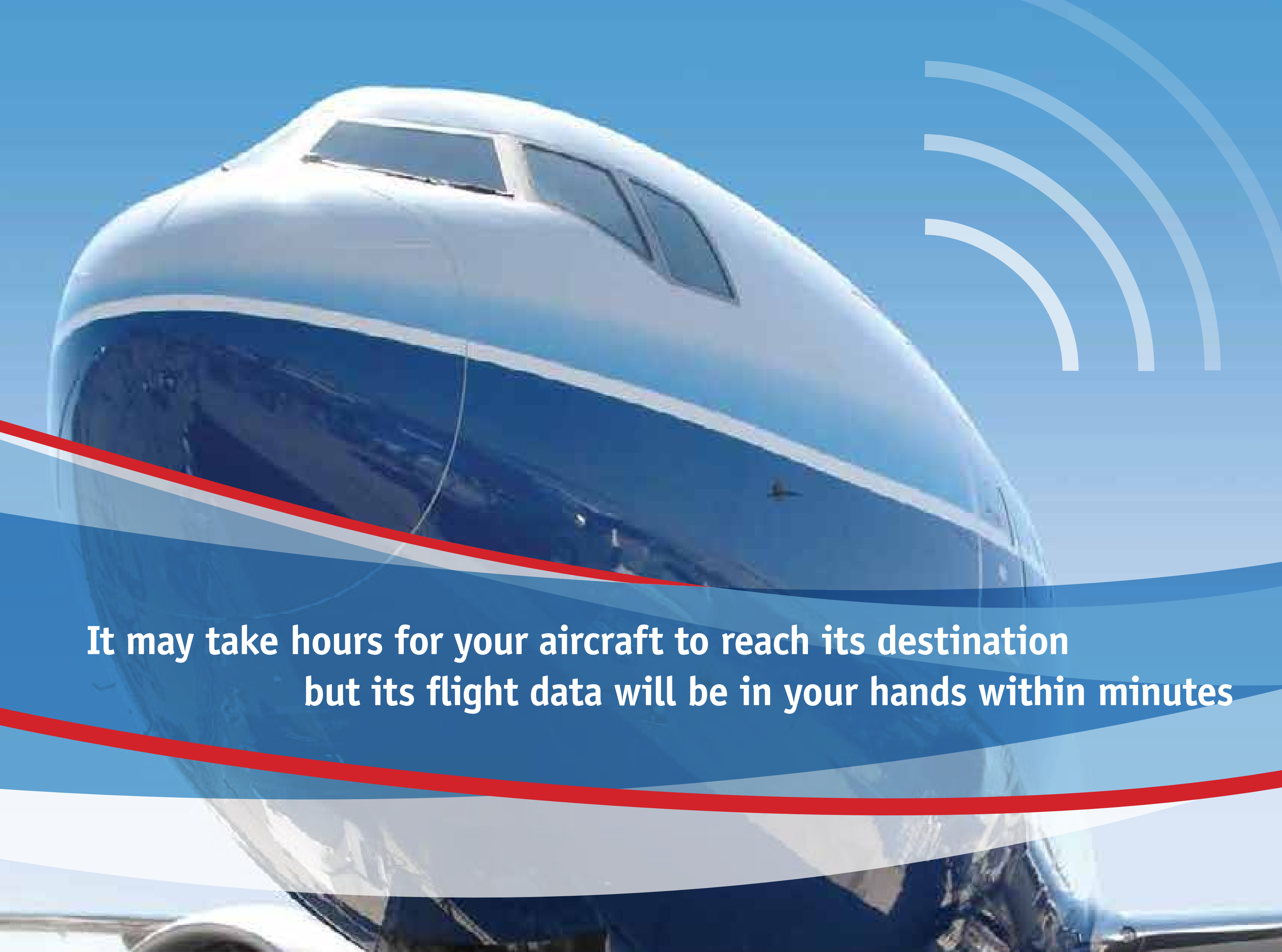
United's pilots will continue to serve a pivotal role in the system verification by providing valuable feedback. A print function has been programmed on the flight deck and activated for response, thereby simplifying participation by pilots. The test program will continue to be focused on runway conditions where braking action is assessed to be less than good by the numerical scale of airplane braking coefficient.

In terms of the future viability of the system, the algorithm and program have proved stable and reliable. Currently the system is undergoing a validation in cooperation with the U.S. Federal Aviation Administration. Access to and availability of FOQA data provide new opportunities to improve safety and efficiency of airline operations. By the same token, it is important that the necessary framework be in place to pursue desired results, such as those that have been evident in this project.

Joe Vizzoni has been a part of this test program and all the processes described from its start. He is a first officer with United Airlines on the Boeing 757 and 767 and also has experience as an aerospace engineer, of which nine of 14 years were with Boeing.

Note

1. Thrust reversers are most efficient at higher speed, so to reduce the kinetic energy of a landing aircraft, it is best to apply them at once, thus carrying forward less energy toward the end of the runway.



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BY REINHARD MOOK

GET A GRIP

Aircraft braking coefficient is affected by liquid water in frozen runway contamination.

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Lingering uncertainty associated with measured and estimated runway friction and aircraft braking coefficients can lead to landing distances or maximum landing weights that also are uncertain or inaccurate. "This has contributed to accidents and incidents where aircraft departed runways because the surface was more slippery than expected," according to the executive summary of a study released in 2011 by the Accident Investigation Board Norway (AIBN).[1]

In 30 investigated occurrences, the AIBN found that "aircraft braking coefficient (ABC) was not in accordance with the measured/estimated runway friction coefficients (FC)." In its study, the AIBN identified a number of common factors that have reduced safety margins, and factors that explain the differences between ABC and FC. "These factors are related to meteorological conditions and friction measurement uncertainty, runway treatment, operational aspects and regulatory conditions," the AIBN study said.

Among the factors is the wetness of snow, or the volume percentage of liquid water in frozen runway contamination. The author carried out a study of wetness in frozen contamination at Svalbard Airport, Spitsbergen, Norway, from 2009 through 2012 under the auspices of AIBN in order to better understand aircraft winter operations following the board's comprehensive report.

Results of the author's study show that wetness in falling snow, or recently fallen snow, decreases with surface air temperature, except for specific cases related to temperature inversions. Recently fallen snow that is not exposed to further precipitation or thawing partially dries up in the course of hours, thus improving braking conditions. In such situations, estimated aircraft braking performance based on the ABC value closely correlates with contemporary observed wetness in samples of frozen contamination.

Essential Indicators

As shown by the 2011 AIBN study, measurements of braking action by conventional devices are difficult to rely on, particularly in the critical temperature range near freezing or when there is wet, compacted frozen contamination. The present study draws attention to wetness in frozen contamination. Though interrelated, wetness and surface temperature, together with the three-kelvin-spread-rule (which indicates that a difference between dew point and METAR, the current aviation meteorological report, air temperature [2 m or 6.6 ft above the runway surface] of 3 three kelvins or less indicates that the humidity is 80 percent or more; a kelvin [K] is 3 degrees C or 5.4 degrees F), might prove to be essential indicators for braking action to be expected.[1,2]

Recent snow may contain a large proportion of liquid water. When such snow is compacted, its surface becomes coated with a film of liquid water, hence the ability to transfer shear force (that is, braking) at the microscopic level between tire and runway surface materials is reduced. Similar conditions happen when compacted snow or ice is thawing at its upper surface. Compressed snow transformed to ice disintegrates gradually when the melting point temperature is approached as the surfaces of frozen particles are enveloped by liquid water. The static stability of the ice decreases and reinforces the lubricating effect of free liquid water in contact with a decelerating tire.

Additional liquid water is generated in the footprint of tires due to the flash melting of ice caused by tire dynamics. Experience shows that the total outcome of braking as described by the ABC is partially related to the portion of liquid water in the frozen contamination. That portion might be relevant for runway management.

Moisture Measurement Challenges

To determine wetness in snow or ice, the difference in permittivity (the dielectric constant[3]) of frozen versus liquid water often is used by micrometeorologists in this area and has turned out to be useful in snow and ice research. The Denoth Dielectric Moisture Meter[4] is based on that difference and allows the proportion of liquid water to be determined when the density of the snow is known. A flat capacitive sensor was used in the author's research, with one side

Number of Cases for Classes of Wetness and Air Temperature at 2 m

Wetness Volume (%)	Air Temperature (°C) ≤ –15	–14 to –10	–09 to –05	–04 to 00	≥ 00	Total
≤ 4	6	7	1	—	—	**14**
5–9	1	2	2	—	—	**5**
10–14	2	5	6	5	—	**18**
15–19	4	3	11	14	6	**38**
20–24	—	—	5	6	11	**22**
≥ 25	—	—	—	2	2	**4**
Total	**13**	**17**	**25**	**27**	**19**	**101**

Note: Volume percent in recent snow.

Source: Reinhard Mook

Table 1

placed atop the frozen contamination and the other side left exposed to the air. The effective area covered by the sensor was about 160 cm^2 (25 in^2), and the operating frequency was 20 MHz. The sensitivity decreases strongly with distance inside the probe. This tool measures a layer of 1.0 cm (0.39 in) of compacted snow or ice. Ideally, there should be no caverns of air between the sensor and the frozen material.

The permittivity of a frozen layer can be calculated as a function of the voltage read when the sensor is placed upon the frozen contamination; the device works by comparing this to the voltage when the sensor is exposed to air, as the point of reference.To calculate liquid water content, the density of snow or ice is needed.

In field work at a runway, exposed to freezing temperatures, wind and often poor illumination, some uncontrolled errors in the measurements cannot be avoided. Compressed snow or ice rarely presents a smooth surface to make good contact with the sensor. In addition, grains of sand applied to a runway cannot be eliminated from the area to be measured, much less removed when enclosed in the frozen material. Sand affects the readings of wetness as well as the measurement of density. The depth of the contaminating layer is not constant and may include different horizons. Therefore the dielectric reading may be influenced by the permittivity of asphalt or concrete.

The challenge of attaining close contact between sensor and contaminating material was met by scraping together superficial snow or bars (studs) of snow or ice, and filling a freezing box to a depth of 6 cm (2.36 in). Thus the measurements of wetness were done at that 6-cm deep probe. The density was determined from the weight of the known volume, avoiding caverns of air. The readings were obtained in an area sheltered from wind.

Sample Readings

There is a relationship between air temperatures observed 2 m above ground (per the METAR) and wetness of snow. Compacted snow not older than one hour after precipitation, or cases with snowfall continuing at the time of wetness measurement, but after compression by traffic, were considered. Cases of blowing snow together with precipitation were excluded, as older, dried up snow might influence the results. The sample of 101 readings was the outcome of occasional observations, without equal probability for any combination of temperature and wetness.

Table 1 shows low temperatures — less than or equal to 9 degrees C (48 degrees F) — and the dichotomy in wetness observed. There are both cases of low wetness (less than or equal to 4 volume percent), as one would expect, and rather large figures of wetness (10 to 19 volume percent). When temperatures aloft at the 850 hPa (25.1 in Hg) pressure level were checked, it turned out that comparatively wet snow in low ground level temperatures was due to temperature inversions and advection or transfer of warm air above. Other cases were due to snow showers in an Arctic maritime air mass with a near moist adiabatic gradient of air temperature. Therefore, as a rule, measuring wetness of snow, which is not yet accepted as a standard practice in runway management, should not be done from ground air temperatures only. Temperatures aloft should be considered as well.

Otherwise, wetness increases with ground level air temperature. Figures for temperatures greater than or equal to 0 degrees C (32 degrees F) cover all the cases of very wet snow or snow and rain accumulating frozen material in airport ground operations. Frequently, rain only is observed when the air temperature exceeds about 3 degrees C (37 degrees F). The maximum wetness observed from 26 to 27 volume percent is limited by the ability of the frozen material to retain liquid water.

Wetness in Snow Over Time

When snowfall ends, sweeping may result in compacted snow, probably on top of older contamination. Over time, the snow will dry up due to internal freezing and crystal growth, ice bonding to material at the bottom and evaporation. All these processes depend on gradients of internal and external temperatures, together with ventilation (wind). Frequently, when precipitation has stopped and the cloud cover has dissipated, the temperature falls and the dew point to frost point spread increases. Every case is different, but the drying up in the course of time may be of interest for defined conditions, as braking action might improve.

The 17 cases considered had, at the end of snowfall, wetness between 24 and 10 volume percent. That starting wetness was assumed as 100 percent in all cases, as it turned out that drying up could be described in terms of the percent of the actual starting wetness. The development in weather terms meant scattered clouds to clear sky after precipitation and decreasing snow surface temperature as measured by an infrared sensor.

Table 2 shows as a mean value that wetness of snow was reduced by 75 percent after eight hours. In the cases observed, mean surface temperature had dropped from minus 4 degrees C (25 degrees F) to minus 11 degrees C (12 degrees F), and the spread of METAR air temperature and frost point temperature (defined for ice instead of dew point defined for liquid water) had increased to 5 K.

The general experience of pilots that friction may be poor on recent snow, but that it improves over the course of hours, is consistent with the observed drying up and decrease of surface temperature. It may be concluded that liquid water in compacted snow is relevant for braking conditions. There are interrelations among the mechanics of ice crystals, liquid water enclosed in ice aggregates, temperature and the frozen material's ability to transfer shear forces.

Wetness and Braking Coefficient

The relationship between ABC and wetness is essential for runway management involving frozen contaminants. Figures on deceleration experienced by aircraft were not available for the author's study. Therefore, such figures had to be estimated, as described previously by the author.[5] The method can easily be criticized for some subjectivity, so the given ABC should be treated as an indicator only.

The ABC derived represents cases when the mean headwind component was less than 8 kt. Otherwise, different kinds and structures of frozen contamination are represented in the sample of 62 cases. In Table 3, the independent variable

Decrease in Percent of Wetness From the End of Snowfall Through Time

Time from start (hours)	0	2	4	6	8
Percent of wetness at start (%)	100	87	51	33	24
Mean surface snow temperature (°C)	–4	–7	–8	–10	–11
Mean frostpoint spread (K)	1	3	5	6	5

Note: Actually observed liquid water volume percent put to 100. Sample cases = 17.

Source: Reinhard Mook

Table 2

Wetness in Surface Snow Related to Estimated ABC

Wetness Volume (%)	ABC	Surface Temperature (°C)	Air Temperature (°C)	Spread (K)	Number
≥ 25	0.05	0	3	1	1
24–20	0.04	0	2	2	3
19–15	0.06	–1	–1	3	6
14–10	0.07	–4	–3	3	13
9–5	0.11	–8	–6	5	24
≤ 4	0.14	–10	–9	6	15

ABC = aircraft braking coefficient

Note: Total number of cases = 62.

Source: Reinhard Mook

Table 3

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is wetness in terms of liquid water volume percent. Mean surface temperature (measured by infrared sensor) and mean air temperature (as reported in the METAR), together with spread related to dew point temperature, are given. The ABC is expressed for Boeing 737-800 aircraft. As a rule, the contaminated runway was sanded, from prior or recent application, or both. Frequently, warm sand was applied.

Though observations were made preferably when wetness was large, there was a bias toward more observations when wetness actually was small. Thawing or very wet precipitation are not frequent occasions, as compared to all the days with "dry" conditions. Flights are canceled or diverted when expected braking action is reported as poor.

Table 3 shows increasing ABC with decreasing wetness, notably when it gets less than 10 volume percent. These rather dry conditions in the sample occur together with decreasing temperatures and increasing spread. As shown in a previous study, ABC usually improves with decreasing surface temperature and increasing spread (except for polishing effects). Wetness and surface temperature turn out to be good indicators for ABC due to meteorological feedback interdependencies.

It should be noted that case studies could offer more details worth considering, although they represent unique situations. But each case study, by eliminating distracting details, might reveal insights not seen in statistical analysis alone.

Reinhard Mook, Ph.D, who retired in 2006 as a professor at the University of Tromsø in Norway, is an independent consultant and researcher. He has conducted micrometeorological field work as an independent researcher at Norway's Svalbard Airport Longyear and analyses of slippery runway incidents for the AIBN, SAS Scandinavian Airlines and the former Norwegian airline Braathens SAFE.

Notes

1. AIBN (2011) *Winter Operations, Friction Measurements and Conditions for Friction Predictions.* Accident Investigation Board of Norway (Statens Havarikommisjon for Transport), Lillestrøm, Norway.
2. Mook, R. "Valuable Intelligence." *AeroSafety World* Volume 6 (November 2011):16–19.
3. The velocity of the propagation of electromagnetic waves relative to the velocity in a vacuum, depends on that constant. It is specific for any substance, except ferromagnetic material not propagating electromagnetic waves. The constant respective velocity for ice is significantly different from liquid water, a property applied. Velocity and refraction are linked together, as is well known from the spectral colors of sunlight in ice crystals due to refraction.
4. Denoth, A. (1994) "An electronic device for long-term snow wetness recording." *Annals of Glaciology*, 19, 104–106.
5. Mook, R. "Treacherous Thawing." *AeroSafety World* Volume 3 (October 2008):14–19.

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BY LINDA WERFELMAN

Finding Their Place

Governments and the aviation industry are finding ways to incorporate unmanned aircraft into shared airspace.

Civil aviation authorities on three continents are mapping strategies for integrating a surge of unmanned aircraft systems (UAS) into civil airspace, preparing to designate research sites where the vehicles will be permitted to operate and examining safety and privacy concerns.

As the systems have advanced, the terminology used to describe them has changed. Previously known as unmanned aerial vehicles or drones, the U.S. Federal Aviation Administration (FAA) refers to them as UAS, while the International Civil Aviation Organization (ICAO) and the European Commission (EC) have begun calling them remotely piloted aircraft or remotely piloted aircraft systems (RPAS).

ICAO, in the 2013 revision of its *Global Aviation Safety Plan*, says the notion of having RPAS fully integrated into shared airspace will soon be a reality and that related information and data will evolve rapidly.

An earlier ICAO document predicted that the integration process would be "a long-term activity with many stakeholders adding their expertise on such diverse topics as licensing and medical qualification of … crew, technologies for detect-and-avoid systems, frequency spectrum (including its protection from unintentional or unlawful interference), separation standards from other aircraft and development of a robust regulatory framework."[1]

50 Site Applications

In the United States, current activity centers on the FAA's preparations to select six UAS test ranges — required by a 2012 law — that will be used to "develop a body of data and operational experiences to inform integration and the safe operation of these [UAS] aircraft in the National Airspace System." At the same time, the FAA has set a late April deadline for receiving public comment on its proposed methods of addressing privacy concerns associated with UAS operations within the test site program.

The FAA says it received 50 applications for test sites in 37 states (map). Rules governing the site selection process preclude the FAA from disclosing details of the applications, but the agency has said that its goal is to select six sites that will enable the study of UAS operations under all types of conditions — in a wide variety of geographical locations and climate conditions, for example — and in areas with varying air traffic density and ground infrastructure. Varying research needs also will be considered.

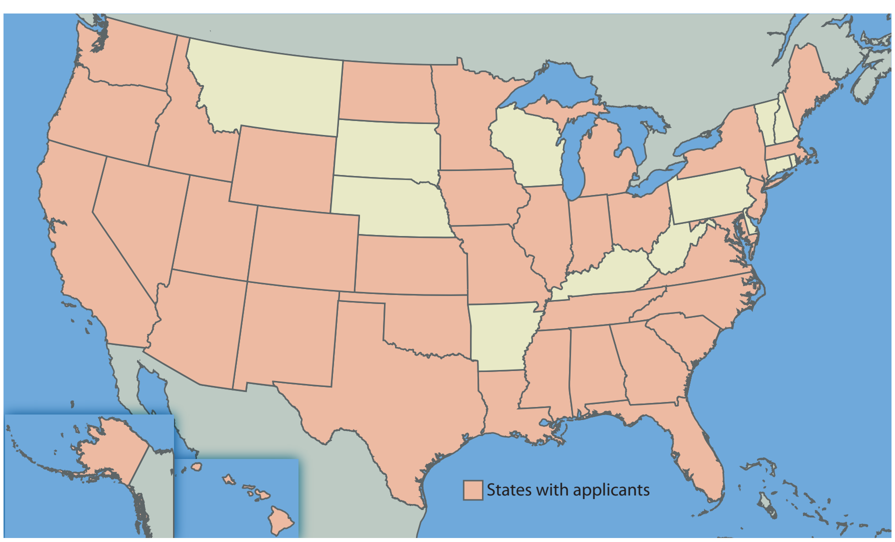
Site selections are expected to be announced late this year.

Meanwhile, state officials and others representing UAS concerns have outlined their proposals.

For example, Oklahoma, which vowed to "compete aggressively" to host one of the FAA UAS test sites, said in a 2012 report by the Oklahoma UAS Systems Council that it already had at least 15 private companies "involved in all facets of UAS," along with related research and development programs, education and training, and a detailed plan to develop the UAS industry in the state.[2]

Among the UAS projects under consideration in Oklahoma are those involving oil and gas pipeline inspection, weather monitoring and several areas of radar development, including radar aeroecology, which uses radar to detect the behavior of birds and other airborne animals — a technology that might eventually help prevent bird strikes.

Ohio, which joined with Indiana in applying for an FAA test site designation, in 2012 established the Ohio UAS Center and Test Complex, described by James Leftwich, the state's special adviser for UAS initiatives, as "a problem-solver and door-opener for anyone who needs airspace, access to ground facilities, research and analytic support and everything else it takes to move the UAS frontier forward safely, successfully and steadily."[3]



UAS Markets

A study released in March by the Association for Unmanned Vehicle Systems International (AUVSI) estimated that, in the first three years after the planned 2015 integration of UAS into U.S. airspace, the industry will create 70,000 new jobs. By 2025, the number will top 100,000, according to projections.[4]

The study projected the largest market for UAS in the United States would be the precision agriculture industry, which would use UAS to monitor crops and apply pesticides. Another major market would be in public safety.

Some public safety uses, including surveillance, have prompted objections from critics who cite privacy concerns, including the American Civil Liberties Union (ACLU), which warns that "routine aerial surveillance would profoundly change the character of public life in America.

"Rules must be put in place to ensure that we can enjoy the benefits of this new technology without bringing us closer to a 'surveillance society' in which our every move is monitored, tracked, recorded and scrutinized by the government."[5]

Some state legislatures are considering action to regulate the use of UAS in surveillance, and at least one — Virginia,

© Scheibel

another of the states seeking a UAS test site designation — already has passed legislation calling for a two-year moratorium on law enforcement use, with exceptions for search-and-rescue operations. The legislation does not apply to UAS used in research by universities and other research organizations.

As the legislation was being debated earlier this year, the Virginia Technology Alliance for Public Safety formed to promote what it considers the economic development and public safety benefits of UAS.

Alliance member Robert Fitzgerald, president of Bosh Global Services, which designs and builds UAS-related operations and technology services, said the public safety uses of UAS are "greatly misunderstood" and that the small, lightweight systems now being developed can help assess "natural disasters, fires, hazardous spills and other dangerous situations remotely, without putting additional lives at risk."[6]

Nevertheless, the ACLU said, safeguards should be in place to limit law enforcement use of UAS to emergencies and other specific situations, and to prohibit retention of UAS-derived images unless "there is reasonable suspicion that they contain evidence of a crime or are relevant to an ongoing investigation or trial." In addition, the ACLU called for written usage policies to be developed by "the public's representatives," not law enforcement authorities, and for UAS use to be subject to oversight, including open audits.

Michael Toscano, president and CEO of AUVSI, said the UAS industry also is concerned about privacy issues.

"Safeguarding people's privacy is important to my industry as well," Toscano said in testimony in March before the U.S. Senate Judiciary Committee. "Last year, AUVSI published a code of conduct explicitly directing users to respect individual privacy. … AUVSI strongly opposes any misuse of UAS technology."

Toscano noted the "robust legal framework already in place" to regulate the use by law enforcement of any type of technology, "whether it is unmanned aircraft, manned aircraft, thermal imaging GPS [global positioning systems] or cell phones."

The FAA acknowledged that the integration of UAS into U.S. airspace raises privacy issues, which it plans to address "through engagement and collaboration with the public." In addition to accepting written comments from the public, the agency also held an online session.

The FAA's initial privacy proposal calls for operators of the test sites to enter into an agreement with the FAA on the terms and conditions — including privacy conditions — under which they will operate the test sites. The proposed privacy requirements would direct site operators to ensure that publicly available privacy policies exist to cover all site activities, including UAS operations.

Another proposal says that site operators must comply with federal, state and other laws on individual privacy protections; if an operator is found to have violated privacy laws, the FAA may end its operational authority.

The proposed privacy requirements are intended specifically for the test sites, the FAA said, and "are not intended to pre-determine the long-term policy and regulatory framework under which commercial UASs would operate. Rather, they aim to assure maximum transparency of privacy policies associated with UAS test site operations in order to engage all stakeholders in discussion about which privacy issues are raised by UAS operations and how law, public policy and the industry practices should respond to those issues in the long run."

Controlled Conditions

UAS have been in U.S. skies in limited numbers since the FAA first authorized their use in 1990. Typical uses have included fire fighting, disaster relief, search and rescue, law enforcement, border patrol, military training, scientific research and environmental monitoring.

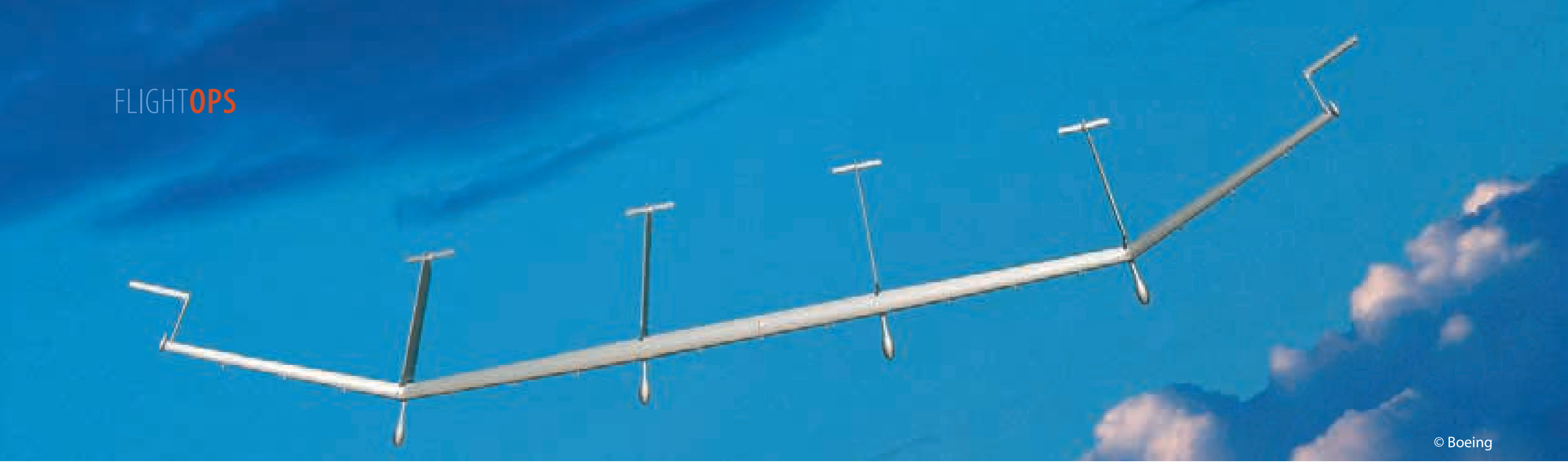
Today, they operate "under very controlled conditions," usually not in large urban areas, the FAA said.

Operators of civil UAS must obtain an experimental airworthiness certificate; most active civil UAS are involved in research and development, flight and sales demonstrations or crew training.

Public UAS, operated by government agencies, must have a certificate of waiver or authorization and typically operate under mission-specific requirements such as only during daylight, with a transponder and/or in coordination with an air traffic control facility. Because these aircraft cannot comply with see-and-avoid rules, they must be accompanied by "a visual observer or … chase plane [that] must maintain visual contact with the UAS and serve as its 'eyes' when operating outside airspace restricted from other users," the FAA said.

Demonstration Projects

In Europe, the Single European Sky Air Traffic Management Research (SESAR) Joint Undertaking (SJU) is planning to



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authorize 10 demonstration projects aimed at exploring how remotely piloted aircraft systems will be integrated into the aviation community by 2016.[7]

The SJU has established a May 31 deadline for demonstration project proposals, including "integrated pre-operational flight trials activities." The projects, which will involve various types and sizes of remotely piloted air systems, must be performed in European Union or Eurocontrol member states between October 2013 and March 2015.

The EC said the development of remotely piloted aircraft systems has "opened a promising new chapter in the history of aerospace."

Civil aviation has yet to follow the military in its widespread use of unmanned aircraft, the EC said.

When it does, the EC added, unmanned aircraft "can offer a wide range of civil applications for the benefit of European citizens and businesses. … [The aircraft] can perform tasks that manned systems cannot perform, either for safety or for economic reasons."

Among those tasks are long-duration monitoring, crisis management, border control, fire fighting and operations in clouds of volcanic ash, the EC said. "RPAS can also deliver profitable commercial aerial services in various areas, such as in precision agriculture and fisheries, power or gas line monitoring, infrastructure inspection, communications and broadcast services, wireless communication relay and satellite augmentation systems, natural resources monitoring, media and entertainment, digital mapping, land and wildlife management, [and] air quality control and management."

'Less Onerous'

In Australia, the Civil Aviation Safety Authority (CASA) is planning the gradual implementation of regulations for remotely piloted aircraft.

Regulations will be proposed for different categories of remotely piloted aircraft, and authorities are considering simplifying the certification process for those that will be used in less complex and less risky operations. In many instances, non-binding guidance material will be introduced first, followed by adoption of regulations, CASA said.

In a February speech to the Association for Unmanned Vehicle Systems Australia, Director of Aviation Safety John McCormick said that — because 90 percent of the remotely piloted aircraft operated in Australia weigh less than 7 kg (15 lb) and because of their many capabilities — "it is impossible for CASA to effectively regulate all of them."

Instead, McCormick said, "we have to address the current reality. There is no point in CASA writing regulations that can't be enforced. … Consequently, CASA is now looking at introducing a weight limit to make it less onerous for commercial operators to use small remotely piloted aircraft."

The agency's goal is to emphasize safety throughout the development of new regulations, McCormick said.

"This means ensuring the safety of any other airspace user, as well as the safety of persons and property on the ground," he said. "Development of the complete regulatory framework for remotely piloted aircraft will be a lengthy effort. This is not a knee-jerk reaction, it is an evolutionary process, with regulations being added or amended gradually."

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Pathological Reactions

BY WAYNE MARTIN, PATRICK MURRAY AND PAUL BATES

Researchers explore pilot impairment from severe startle, freezing and denial during unexpected critical events.

For decades, the world has benefited from continual improvement in commercial air transport safety. However, in some high-profile accidents over the last few years, airline pilots failed to react as expected when suddenly surprised by critical situations. In some cases, these pilots reacted ineffectively or inappropriately — or even failed to react at all in a timely manner.

Recent interviews with Australian airline pilots, a flight simulator experiment, analysis of selected reports on airline accidents and serious incidents, and a literature review including insights from neuroscience and psychology suggest that pathological reactions induced by severe startle — or by consequent acute stress reactions called *freezing* and *denial* — may occur more often than the aviation community realizes. Some subject specialists label extreme startle as *strong* or *serious.*

Any such inaction-type behavior potentially has significant effects on aviation safety, possibly resulting in undesired aircraft states, serious incidents or accidents. A doctoral thesis by this article's primary author (Wayne Martin) concludes that further research — especially

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development of interventions suitable for future training — is warranted. Such additional work could validate the assumption that by exposing pilots in the simulator to unusual critical events, they are likely to develop both specific and generic strategies for dealing with them. Ideally, such exposure also would engender a greater sense of self-efficacy, in turn making pilots significantly less likely to experience acute stress reactions after real-world severe startle.

Humans are particularly susceptible to acute stress reactions, and unexpected, threatening and critical events often present circumstances in which some individuals fail to cope well. The physiological stress reaction has been shown to have severe effects on working memory and other cognitive functions, with constructive thoughts being replaced by task-irrelevant, anxious thoughts. Acute stress reaction, which is associated with an appraisal of threat, can create situations in some people in which they are overwhelmed and freeze, or institute a coping mechanism such as freezing or denial.

Paralyzed With Fear

Acute stress reactions are common during life's emergencies. One only has to see human behavior shown on the six o'clock evening news as a disaster unfolds somewhere around the world. Earthquakes, floods, fires, ship sinkings, oil rig disasters or train wrecks often turn up a mixture of behaviors. Studies by several researchers,[1,2,3] through eyewitness accounts and interviews with survivors, have looked at why some people survived a disaster and others did not. The survivors often have reported seeing people who were apparently paralyzed with fear and incapable of movement, even when such movement would have helped them survive.

Inaction in the face of imminent threat especially raises concern from the aviation safety perspective. Airline passenger behavior during aircraft accidents, for example, has followed similar patterns, with some researchers[4,5] finding that even in simulated evacuation trials, behavioral inaction was displayed by a number of the passengers. One study suggests that 10 to 15 percent of people typically display such pathological behavior when faced with life-threatening situations,[3] and real-life examples exist such as a fatal aircraft fire[6] after a rejected takeoff known to have involved passive inaction among passengers.

This inaction, which is most likely an acute stress reaction to an overwhelmingly threatening stimulus, may be due to an elementary freezing mechanism within the brain[7,8] or indeed to a coping/defense mechanism that seeks to deny the existence or severity of the threat.[9,10] Inaction also may be the result of the severe startle, and experiments by other researchers have shown that cognitive and dexterous (that is, hand/foot dexterity) impairments could last for up to 30 seconds following this degree of startle.[11,12,13,14]

While these reactions could be considered typical among a small fraction of the "innocent" participants in an unfolding non-aviation disaster, people expect that professional pilots — who are generally well trained, very experienced and presumably endowed with the "right stuff"[15] — will nonchalantly, competently and flawlessly deal with critical emergencies to avoid disaster. Unfortunately, this may not be the case.

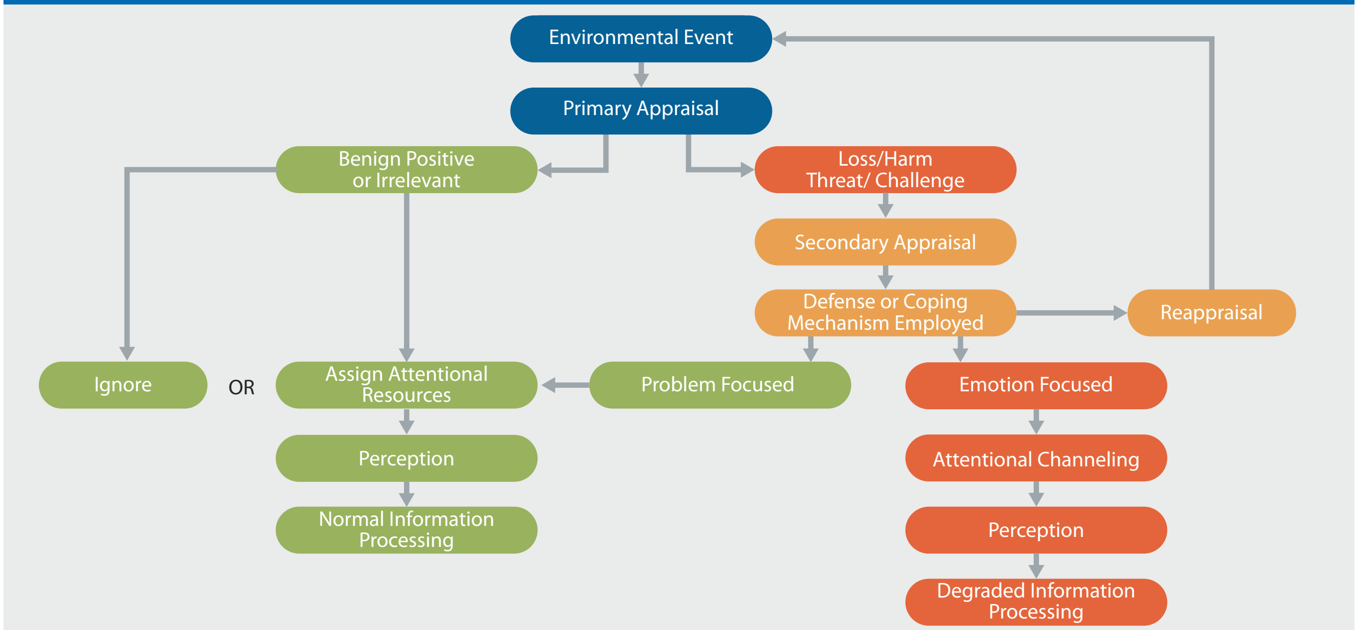
Extremely high aircraft reliability has become the norm, so official findings after an aircraft accident or serious incident more often are peppered with human failings involving the pilots. In some relatively recent fatal accidents, the findings showed that flight crews mishandled critical events and failed to recover the aircraft [*ASW,* 8/12, p. 14; *ASW,* 6/10, p. 32; *ASW,* 3/10, p. 20; *ASW,* 4/11, p. 46]. Typically, there was some delay in acting, or incorrect action taken, which exacerbated the problem.

Although airline pilots routinely practice engine failures, engine fires, depressurizations and major system malfunctions, the types of critical events that prevail in recent accident data are commonly regarded as "black swan" events, that is, highly unusual.[16] They involved unexpected situations in which pilots became very surprised and/or overwhelmed. Moreover, the response to severe startle — or subsequent acute stress reactions of freeze or denial — is sometimes exacerbated by the flight crew's conditioned expectation for things never going wrong. This unintentional sense of complacency is born of the ubiquitous normality in line operations, week-in and week-out for long periods of time.

Reaction Process

Central to the acute stress reaction is the person's appraisal that some particular stimulus is threatening. Some researchers[17] have described appraisal as "an evaluative process that determines why and to what extent a particular transaction or series of transactions between the person and the environment is stressful." They further have suggested that appraisal involves two distinct processes: primary appraisal, which determines level of threat, and secondary appraisal, which determines an appropriate method of coping. This process is very rapid and appears to precede conscious-thought processing in the cortex of the

Conceptual Model of Threat, Appraisal and Information Processing



Note: When pilots appraise a situation as overwhelmingly threatening, there is a possibility that an emotion-focused coping method — largely negative/pathological in its effect — will interfere severely with their information processing, problem solving and decision making.

Source: Wayne Martin, Patrick Murray and Paul Bates

Figure 1

brain.[18,19] This fact is clearly advantageous in situations when immediate action is required but may induce a pathological acute stress reaction that is unwarranted.

If they appraise their situation as threatening, humans involuntarily will apply some form of unconscious emotional homeostatic (stress-relieving) coping or conscious defense mechanism. This may take the form of trying to fix the problem. That is an entirely appropriate method, which is employed by most pilots in most situations. If no immediate fix is at hand, however, or the situation is appraised as being overwhelming, then the possibility exists that some form of emotionally focused coping mechanism will be employed.

Emotionally focused coping, however, is largely pathological and may include elements such as avoidance, denial, self-deception or reality distortion.[17,20,21] These coping mechanisms can have severe effects on the constructive processing of information, problem solving and decision making. In the aviation context, this is very problematic in critical situations. One useful conceptual model (Figure 1) illustrates this flow of threat, appraisal and information processing.[22]

Startle

The startle reflex is a normal and universal human response to some unexpected/surprising stimulus. When a person appraises the stimulus as threatening, activation of the sympathetic nervous system triggers widespread and rapid changes in the body. This arousal, which is also associated with the acute stress reaction, is generally known as the *fight or flight response* and has been shown to have significant effects on cognitive and psychomotor processes.

The startle reflex invokes a pattern of aversive movement (that is, away from the stimulus) and aligns attentional resources to the source of the stimulus. This process is remarkably fast, with first signs of reaction occurring in as little as 14 milliseconds (ms) in some tests on humans.[26,27] Given that cognitive processing of new stimuli takes more than 500 ms,[28] that "quick and dirty" reflexive reaction is clearly an innate process for avoiding harm.

The brain's amygdala region, which is strongly associated with emotional memory of fear, appears to be where initial appraisal of threat is made. Projections from the amygdala then initiate the startle reflex and, if the threat persists, the full startle or surprise reaction.[7,8] Essentially, this is still the fight or flight response, the same process invoked during acute stress reactions.

The rapid changes in the body's systems result from arousal of the sympathetic nervous system. Changes include increasing heart and respiration rates, routing more blood flow to vital organs, and introducing hormones such as adrenaline (epinephrine) into the bloodstream.[29,30] Other characteristic changes are blinking and contraction of arm and leg muscles.

As noted, other research[11,12,13,14] has shown that cognitive and dexterous impairment can last for up to 30 seconds during reaction to severe startle. This has significant implications for aviation because sudden, unexpected and critical events are typical of aircraft emergencies. A significant number of accidents and serious incidents reviewed for the thesis — in which pilots performed less than optimally during critical events but startle/acute stress reaction was not an official cause — were cases in which startle may have contributed to a poor outcome.

The simulator experiment involved an airline's large commercial jet simulator flown by a sample of 18 type-rated pilots. This part of the study found that seven of the 18 performed very poorly during a critical event when startled (Figure 2, p. 32). In the experiment, a startling stimulus was introduced 40 ft above decision altitude on an approach where the cloud base was 100 ft below the minima. While five pilots performed nominally and six displayed some slight reactionary delay, the seven showed either impulsive behavior (immediate go-around) or significant delays in reactions.

Three pilots continued descent to below 100 ft above ground level (AGL), and two pilots continued to land despite severely unstable approaches. Enhanced ground proximity warning system "PULL UP" warnings resulted on two of the three approaches that had become unstable and had continued below 100 ft AGL. While this was a relatively small sample size, the results were both statistically and qualitatively significant, with the majority of pilots admitting to having experienced physiological and cognitive effects following the startle.

Freezing

Freezing is an acute stress reaction that may be a conscious or subconscious method of dealing with an overwhelming stressor. One study[3] defined it as "a stress coping mechanism entailing a subconscious mechanism for stress relief, or a conscious disbelief that the phenomenon is actually occurring." Freezing is generally a major breakdown in the normally integrated cognitive processes within the brain. Sometimes the people affected remain aware of what is going on around them, but are incapable of taking any participative behavioral and/or cognitive action.

This reaction has been relatively common during non-aviation disasters and also has been noted in real-life and simulated aircraft accidents and evacuations. It appears that in freezing, the cognitive processes required to initiate action are overcome by an acute sense of dread, with the working memory being consumed by irrelevant thoughts of fearful outcome. "Paralyzed" or "petrified with fear" have been common recollections from some people who have survived such critical situations.

Unlike denial, which is quite difficult to quantify, most people are familiar with the concept of freezing under conditions of acute stress. Like "a deer caught in the headlights," a popular analogous phrase for this phenomenon, freezing is not uncommon in aviation accident and incident data.

Freezing also has been described as a response to overwhelming threat in which, at the rudimentary subconscious level, the brain is unable to cope with the complexity and danger presented by sudden circumstances. Reports from survivors[3] of an oil rig fire and a ship sinking, for example, described people who were simply frozen or paralyzed and unable to save themselves, despite encouragement or abuse from other passengers.

Similarly, the known aviation cases include pilots who have simply frozen during critical events. In one accident, the captain apparently experienced freezing after commencing a rejected takeoff.[24,25] He closed the thrust levers, but failed to brake or select reverse thrust, simply staring straight ahead. The aircraft ran off the end of the runway at 70 kt, killing two people.

During part of the data collection for the thesis — interviews with a sample of pilots who had experienced critical events/emergencies during airline operations — one pilot recalled an actual event in which the captain froze during an approach, having set up a high rate of descent. The aircraft continued to descend well below glide path until becoming visual at very low level on a collision course with an apartment building. Fortunately, once visual, the captain recovered, and a last-minute evasive maneuver narrowly avoided the building. The first officer, who repeatedly had tried to alert the captain to the glide path deviation, also tried several times to take over control and even resorted unsuccessfully to hitting the captain to gain control.

Another of these interviewees described a situation in which a military pilot under instruction, while practicing spins with high rotation rate, simply froze during recovery from a spin. The

Results of Startle Experiment in Boeing 737 Simulator

Stimulus Altitude (AGL)	Approach 1 Lowest Alt During Go-Around With Stimulus	Approach 2 Lowest Alt During Go-Around Without Stimulus
240 ft	170	170
240 ft	170	140
240 ft	170	190
240 ft	160	110
240 ft	160	170
240 ft	150	180
240 ft	150	160
240 ft	150	170
240 ft	150	170
240 ft	140	170
240 ft	140	160
240 ft	200	170
240 ft	220	160
240 ft	86	140
240 ft	66	150
240 ft	56	180
240 ft	0 (landed)	150
240 ft	0 (landed)	190

Alt = altitude, AGL = above ground level

Note: The 18 participating type-rated pilots descended 36.1 ft on average during their delayed reaction to the startle stimulus induced by the researchers on their first approach.

Source: Wayne Martin, Patrick Murray and Paul Bates

Figure 2

student became unresponsive, and the instructor pilot had to physically hit the student to get him to release his iron grip on the controls. A successful recovery was finally made close to bailout altitude.

Denial

Denial also is an emotionally focused coping mechanism, and, like freezing, a very rudimentary human process. If a person appraises the stimulus as being particularly threatening, and this mechanism is implicitly invoked, then the stressful stimulus may simply be ignored.

Denial also appears to have a subconscious strategic purpose. This is remarkably common, particularly in people with life-threatening illnesses. Many would ignore the symptoms for some time rather than confront the stressful issue of their mortality.

Denying the threat's existence can be very effective in relieving stress; however, continual reappraisal and *dynamic denial* are required for this coping mechanism to persist. Dynamic denial occurs when the flow of critical information is not continually processed as part of this pathological, acute-stress coping mechanism.

While this could be problematic when situations such as deteriorating weather or aircraft status compound the threat, the more immediate stressors — those conducive to dynamic denial — generally are of greater concern in critical events. So dynamic denial could have severe implications in airborne critical events because of the careful analysis and logical problem solving required.

The airline pilot interviews for the thesis revealed that short-term denial was relatively prevalent during these events, with participants reporting that some level of denial had been experienced in 15 of the 45 events they recalled. This was generally short-term denial, and it did not turn out to be of catastrophic consequence. However, it raises the question of how many fatal accidents have involved denial, with the pilots never achieving recovery or with recovery being delayed too long.

The pilots' interview responses also indicated that such brief periods of denial were not unusual, although in all of the situations that interviewees discussed, denial was quickly overcome as rational processing kicked in. Dynamic denial, if it had persisted, could have been particularly detrimental to the outcome of the situation, although it is impossible to tell from accident data whether denial was involved. However, there are several examples of instances in which pilots took no action at a time when intervention was required, indicating that dynamic denial is at least a possibility. Further research in this area is required.

One subject specialist[23] even has described a pathological taxonomy of seven different stages: denial of personal relevance, denial of urgency, denial of vulnerability, denial of affect, denial of affect relevance, denial of threatening information and denial of information. While the early stages are mildly concerning in the aviation context, the latter stages — when threatening information or all information is denied — are particularly worrisome in the aviation safety context.

In summary, if a critical situation arises during flight operations but an individual pilot's brain unconsciously and involuntarily ignores the cues for threats presented, then the chances of recovering are substantially reduced.

Wayne L. Martin, a Boeing 777 first officer for Virgin Australia Airlines, has submitted a doctoral thesis on this subject to Griffith University, Brisbane, Australia. His career includes work in human factors and airline pilot training, and he is a member of the International Pilot Training Consortium Working Group on Training Practices. Patrick S. Murray, an associate professor and director of the Griffith University Aerospace Strategic Study Centre, is a member of the Line Operations Safety Audit Collaborative currently conducting research on regional airline safety. His career includes experience as a military pilot and airline pilot, and in a senior position at the Australian Civil Aviation Safety Authority. Paul R. Bates, an associate professor and head of aviation at Griffith University, chairs the Outreach Committee of the International Civil Aviation Organization Next Generation of Aviation Professionals Task Force.

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BY LINDA WERFELMAN

Rewrite

A fatal accident involving a Robinson R22 has prompted a call for revised certification requirements for light helicopters.

Regulatory authorities should alter the certification requirements for light helicopter designs to reduce the risk of accidents involving loss of main rotor control, the U.K. Air Accidents Investigation Branch (AAIB) says.

The AAIB included its recommendations to the European Aviation Safety Agency (EASA) and the U.S. Federal Aviation Administration (FAA) in its final report on the Jan. 6, 2012, crash of a Robinson R22 Beta near Ely, Cambridgeshire, England.

The accident killed the 50-year-old pilot — a flight instructor in airplanes with nearly 5,000 flight hours who was trying to increase his 58 hours in helicopters so that he could earn a commercial helicopter license and a license to instruct in helicopters. The helicopter was destroyed.

The AAIB report said the cause of the accident was "main rotor divergence resulting in mast bumping" — a condition in which the main rotor hub contacts the main rotor mast. As the rotor blades continue to "flap," each contact becomes more violent, and the result can be damage to the rotor mast or separation of the main rotor system from the helicopter.

The accident flight began at 0958 local time, when the helicopter left Manston Airport for a flight to Fenland Airfield, about 240 km (130 nm) northwest.

The pilot told air traffic control, as the R22 passed east of Cambridge Airport at 1118, that the helicopter was flying at 1,400 ft. That was the last radio transmission received from the pilot. The helicopter continued northwest, toward Fenland, and disappeared from radar about 1125.

Witnesses on the ground southwest of the accident site said they saw the helicopter rapidly pitch and roll left and heard a "pop, as if it was a paper bag you banged in your hands," the report said. Two witnesses also said that they saw objects separate from the helicopter before it fell, inverted, to the ground.

The wreckage was found in a field 2 nm (4 km) southwest of Ely. The helicopter was inverted and there were few ground marks, indicating that the helicopter had little horizontal speed just before the impact. Both main rotor blades had separated from the hub and were found several hundred meters from the main wreckage. One tail rotor blade also had separated and was not found, but the other was still attached. There was no indication that the main rotor had struck the tail boom, the accident report said, noting that "tail boom separation following main rotor contact has been a characteristic of a number of R22 in-flight structural failures."

Accident investigators said that weather conditions at the time of the accident included visibility of 30 km (19 mi), few clouds below 25,000 ft and a light, westerly wind that was not considered strong enough to have generated low-level turbulence. They said either wake turbulence or a need for a sudden maneuver to avoid another aircraft was highly unlikely.

The accident helicopter was manufactured in 1988; at the time of the accident, the airframe had been in operation for 6,407 hours and the engine, for 1,595 hours. The last maintenance check was a 50-hour check completed Dec. 6, 2011 — 28 flight hours before the accident. No significant defects were found, the report said.

Maintenance records included no mention of any disturbance of the pitch control links during the year before the accident and showed that the last "known disturbance" of the rotor system occurred in April 2010, when the main rotor blades were removed for replacement of the spindle bearings.

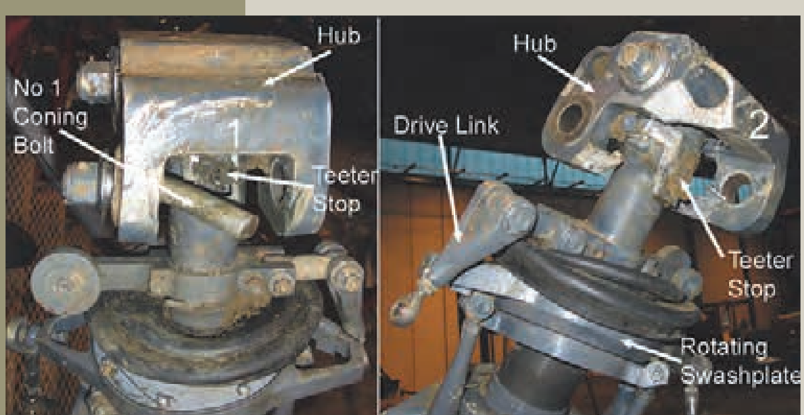
Examination of the wreckage found damage to the main rotor that showed that the main rotor blades had "flapped to extreme up and down angles prior to separation," the accident report said.

This condition — known as main rotor divergence — has several causes in helicopters such as R22s, which have "teetering, two-bladed rotors," the report said, citing low-g maneuvers, low-rotor rpm, turbulence and "large abrupt control inputs."

The report said it was "possible that a combination of low rpm, an abrupt control input and low-g caused the main rotor divergence. … If carburetor ice caused a loss of rotor rpm, this would have triggered the low rpm audio warning, and this warning sounds like the stall warning in some light fixed-wing aircraft. The response of a fixed-wing pilot to a stall warning is often to push forward on the controls to unstall the wing. This would be an inappropriate response from the pilot in these circumstances but understandable given that the vast majority of his flying was in fixed-wing aircraft."

The report said that low rotor rpm "could explain why the pitch link failed in the way that was observed" — with the separation of the no. 1 pitch link and indications that the attached bolts had failed because of overload resulting from the application of considerable force.

The teeter stops, shown in the photographs below, had split because of mast bumping, which occurs when rotor blades "flap downwards to an extreme angle and strike the mast," the AAIB says.



U.K. Air Accidents Investigation Branch

In addition, the report said, "the forward deflection of the cyclic, leading to a low-g flight condition, could explain the rapid roll, but only if the witnesses were mistaken and the roll was, in fact, to the right."

The report also cited previous studies, including a 1996 study by the U.S. National Transportation Safety Board (NTSB), that linked "large, abrupt control inputs" to mast bumping.[1]

NTSB Study

The report noted the NTSB's 1996 recommendation calling on the FAA to require helicopter manufacturers to "provide data on the response of helicopters to large, abrupt cyclic inputs as a part of the certification process."

The FAA implemented part of the recommendation by modifying Advisory Circular (AC) 27.661, *Rotorblade Clearance*, to require manufacturers to conduct a blade flapping survey.

FAA and EASA certification requirements … are less stringent than equivalent military requirements.

"However, the AC did not define what the control deflections should be or what the rate of input should be," the AAIB report said. "It specified that margins should be determined, but it did not specify what the margins should be."

The NTSB eventually closed out the recommendation and characterized the FAA's response as "acceptable," but the AAIB said that the NTSB action was influenced by the decline in the number of accidents involving main rotor loss of control in the mid-1990s.

"The NTSB attributed this to the increased training and experience requirements imposed by the FAA," the report said. "However, since the 1996 NTSB study, there have been at least a further 16 fatal R22 accidents involving loss of main rotor control."

Precise causes of many of these accidents have been difficult to determine, the report said, "because the pilot's control inputs leading up to the divergence are rarely known."

Nevertheless, the report added that some of the 16 accidents probably resulted from a loss of rotor rpm that followed a power loss "without the pilot lowering the collective quickly enough. In the R22, the pilot must react to a loss of power by lowering the collective in less than about 1.5 seconds in the cruise, or one second in the climb, to prevent rotor stall."

As a result, EASA has begun a study of the effect of increasing the required reaction times, the report said.

Handling Qualities

The report said that handling qualities are another probable factor in a number of R22 crashes involving loss of main rotor control.

"Only light control forces are required to apply full cyclic deflection in the R22, making it easy inadvertently to enter a low-g situation or to make an abrupt and rapid control input leading to rotor stall and mast bumping," the report said.

FAA and EASA certification requirements, which have changed little in recent decades, are less stringent than equivalent military requirements, the report said.

The document noted that a 2005 study by the U.S. National Aeronautics and Space Administration Ames Research Center included a recommendation calling on helicopter manufacturers to "explore the feasibility of designing a low-cost, lightweight stability augmentation system, which would also provide benefits for the reduction of low-speed and hovering helicopter accidents."

In addition, the AAIB report said that a stability augmentation system "would provide some control force feedback, thereby making large abrupt cyclic inputs less likely, as well as recovering the aircraft to a safe attitude should the pilot release the cyclic control."

Safety Notices

Robinson Helicopters included a series of safety notices in the R22 *Pilot's Operating Handbook* that discussed, among other topics, the dangers of failing to maintain rotor rpm and the importance of avoiding a rotor rpm stall.

"As the rpm of the rotor gets lower, the angle-of-attack of the rotor blades must be higher to generate the lift required to support the weight of the helicopter," one safety notice says. "As with the aeroplane wing, the blade aerofoil will stall at a critical angle, resulting in a sudden loss of lift and a large increase in drag. The increased drag on the blade acts like a huge rotor brake, causing the rotor rpm to rapidly decrease, further increasing the rotor stall."

The AAIB report noted that in an airplane, a pilot would react to a stall warning horn by moving the control column forward to reduce the wings' angle-of-attack and adding power. A similar response in a helicopter, however, can result in the low-g condition associated with an uncontrollable right roll and mast-bumping.

Lightweight Data Recorders

The report noted that Robinson Helicopters has agreed that additional information is needed "to fully understand the causes of accidents involving main rotor divergence." The company was considering the installation of a small lightweight flight data recorder in its aircraft to help provide more data on pilot control inputs in the moments preceding a main rotor divergence, the report said.

"The pilot's control inputs leading up to the divergence are rarely known," the report said. "If the helicopter manufacturer succeeds in developing a lightweight flight data recorder for the R22 that includes recordings of control positions, it is likely that there will be new insights into the causes of main rotor divergence.

"The technology already exists to create a small lightweight recorder that includes solid-state three-axis gyros, three-axis accelerometers, GPS [global positioning system] and an altitude pressure sensor, but one of the challenges is to develop a lightweight and non-invasive means of measuring control positions."

The company also plans research on the likely effectiveness of combating carburetor icing by installing a heated throttle butterfly in the carburetor, the report said.

Other design solutions also could help reduce the potential for accidents involving loss of main rotor control, the report said.

Robinson R22

© Chris Hallewell/Flickr

The Robinson R22 is a light, two-seat helicopter first flown in 1975. The R22 Beta was certificated in 1985.

It has a two-blade main rotor with a tri-hinged underslung rotor head designed to limit blade flexing and rotor vibration, and a two-blade tail rotor.

The R22 has one 119-kw (160-hp) Textron Lycoming O-320-B2C piston engine, and a 72.5 L (19.2 gal) fuel tank. The empty weight is 374 kg (824 lb), and maximum takeoff and landing weight is 621 kg (1,370 lb).

Maximum rate of climb at sea level is 1,200 fpm; maximum level speed is 97 kt; and range at sea level with auxiliary fuel, maximum payload and no fuel reserves is 592 km (319 nm).

Source: *Jane's All the World's Aircraft, U.K. Air Accidents Investigation Branch Report EW/C2012/01/01*

"Therefore, the certification requirements for future helicopter designs should be updated and improved to reduce the risk of loss of control and loss of main rotor control accidents," the report added. "It is desirable that the EASA and FAA cooperate in this task."

This article is based on AAIB Accident Report No. EW/C2012/01/01, published in the February 2013 "AAIB Bulletin."

Note

1. NTSB. *Special Investigation Report — Robinson Helicopter Company R22 Loss of Main Rotor Control Accidents*, NTSB/SIR-96/03. 1996.

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BY WAYNE ROSENKRANS

Strong Gusty Crosswinds

Two focused studies challenge today's variations in airline practices and flight crew decision making.

Challenging encounters with strong gusty crosswinds during the approach and landing phase in commercial air transport — never routine for flight crews and sometimes underestimated by air traffic control (ATC) — involve some risk because of systemic gaps, mismatches and misconceptions, says Gerard van Es, senior consultant for flight operations and flight safety, National Aerospace Laboratory Netherlands (NLR).

He explained the impetus for further study of the factors involved and a few of NLR's recently developed recommendations during Flight Safety Foundation's International Air Safety Seminar in Santiago, Chile, in October 2012. In April, van Es updated *AeroSafety World* about industry responses to the complete report that he and a colleague, Emmanuel Isambert, prepared as advisers to the European Aviation Safety Agency (EASA).[1]

Difficult surface wind conditions[2] have confronted pilots since the flights of Wilbur and Orville Wright, and one of the many recent examples was a serious incident in Germany in 2008 (see "Serious Incident in 2008 Prompted German and EASA Analyses," p. 41) that motivated German accident investigators, and subsequently EASA, to dig deeper into the causal factors and to update mitigations. A German recommendation — calling for assessment of all measuring systems that detect the presence of near-surface gusts and how pilots integrate various wind data into landing/go-around decisions — led to the NLR study for EASA, van Es said.

Crosswind-related regulations originated in a period from a few years after World War II to 1978, when demonstrated crosswind in airworthiness-certification regulations became fixed for industry use, van Es said.[3]

© Daan Krans/AirTeamImages

NLR's scope included querying operators about understanding of aircraft certification for crosswind and relevant policies and procedures; a brief review of factors in crosswind-related occurrences; a review of measurement technologies; and the salience of wind instrument precision.

"First of all, we noticed that the way of arriving at and presenting the [crosswind] information varies between the manufacturers and even between the aircraft models," van Es said. "Most [manufacturers] don't mention any kind of gusts, but also the way they've derived the [demonstrated crosswind value] during the flight test can be very different, giving different results. And they are allowed to, and the regulations on the means of compliance [allow them] this opportunity. Limits, real hard limits, are very rare, nor are they required to be established. Typically, it's up to the operators to decide if they transfer a demonstrated value into a hard limit. … This all can result in a possible mismatch [between] what the operator is using and what the data from the manufacturer is telling [us]."

'Limits, real hard limits, are very rare, nor are they required to be established.'

The NLR survey was sent to 115 operators from Asia, Europe and North America, and yielded 36 operator responses. "Basically they were telling a story that we were expecting, to some extent," van Es said, especially regarding the variability in practices. "They were very keen to see what others were doing and what the issues were," given their anecdotal knowledge of many crosswind-related occurrences.[4]

Wind Data Sources

Operators and pilots have several disadvantages as they integrate complex factors. "First of all, there is no common interpretation of the manufacturer's crosswind," he said. "[Respondents] operate similar models, and they have a different view of what was told to them or what was written in the manuals provided to them. When it came to reported gust values in their operation — the wind reports, how to deal with gusts — some operators said, 'We don't take into account the gusts when we look at the reported wind values.' Others said, 'Yes, we do, and we do it this way.' Others said, 'We do, but we don't specify how to deal with the gusts.'"

Each type of wind information has advantages and limitations. "FMS [flight management system–derived] wind is something that you have to be very careful in using, especially during the approach," van Es said. "[Yet] some operators … said use of FMS wind is encouraged and [indicates] good airmanship. Others said, 'It's strictly prohibited because we had incidents where we nearly lost the aircraft by using FMS winds.'" Problems in relying on this source in this context include lack of system correction for side slip, its use of an average value and its applicability to winds at altitude — not at the surface.

Some respondents' pilots request from ATC a series of instantaneous wind reports during approach. "These are snapshots — the actual [real-time] wind that is available as measured at the airport," he said. "Typically, you get an average [two-minute] wind, but some airports allow you to ask for an instantaneous wind [report]." Some respondents promote the use of instantaneous winds; overall, there was no common way of determining the components either in tailwind or in crosswind.

The survey also found that 75 percent of respondents use a combination of demonstrated and advised crosswinds, and a number of these set maximum crosswind values lower than the manufacturer's demonstrated/advised crosswinds; 82.9 percent use the crosswind values as hard limits; 67 percent have procedures for how their pilots should calculate the crosswind component, with 58 percent of these specifying how the pilots should take gusts into account; and 33 percent do not include gusts in their crosswind values. "A small number of the respondents left the decision — to include gusts or not — up to the captain," the report said.

Risk of Confusion

NLR researchers usually found that in occurrence reports, only the wind data reported on the automatic terminal information service (ATIS) had been considered by the flight crew in

Serious Incident in 2008 Prompted German and EASA Analyses

Freezing rain caused a two-hour delay in the Airbus A320's departure from Munich, Germany, for a scheduled flight with 132 passengers and five crewmembers to Hamburg the afternoon of March 1, 2008.

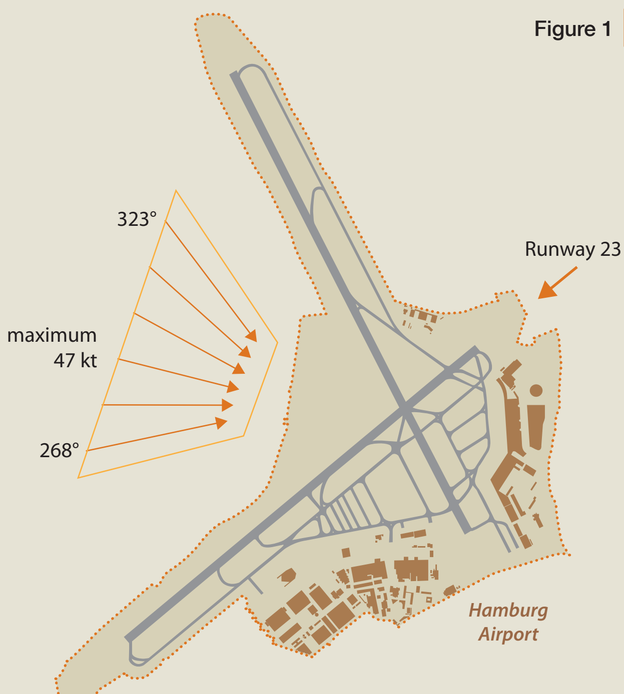
During cruise, the flight crew received a Hamburg automatic terminal information system report of winds from 280 degrees at 23 kt, gusting to 37 kt. They planned for — and later received clearance for — an approach and landing on Runway 23, which is equipped with an instrument landing system (ILS) approach, said the report by the German Federal Bureau of Aircraft Accident Investigation (BFU).

When the crew reported that they were established on the ILS approach, the airport air traffic controller said that the wind was from 300 degrees at 33 kt, gusting to 47 kt.

The report said that a decision to go around would have been reasonable because the controller's report indicated that the winds exceeded the maximum demonstrated crosswind for landing, which was "33 kt, gusting up to 38 kt" and presented as an operating limitation in the A320 flight crew operating manual.

The captain asked for the current "go-around rate," and the controller replied, "Fifty percent in the last 10 minutes." The controller offered to vector the aircraft for a localizer approach to Runway 33, but the captain replied that they would attempt to land on Runway 23 first.

Figure 1



German Federal Bureau of Aircraft Accident Investigation (BFU)

The crew gained visual contact with the runway at the outer marker. The copilot, the pilot flying, disengaged the autopilot and autothrottles about 940 ft above the ground. She used the wings-level, or crabbed, crosswind-correction technique until the aircraft crossed the runway threshold and then applied left rudder and right sidestick to decrab the aircraft — that is, to align the fuselage with the runway centerline while countering the right crosswind.

The A320 was in a 4-degree left bank when it touched down on the left main landing gear and bounced. Although the copilot applied full-right sidestick and right rudder, the aircraft unexpectedly rolled into a 23-degree left bank. It touched down on the left main landing gear again, striking the left wing tip on the runway, and bounced a second time.

The crew conducted a go-around and landed the aircraft without further incident on Runway 33. The left wing tip, the outboard leading-edge slat and slat rail guides were found to have been slightly damaged during the serious incident, the report said, but the ground contact was not detected by the flight crew.

The BFU, in its final report, listed the immediate causes: "The sudden left wing down attitude was not expected by the crew during the landing and resulted in contact between the wing tip and the ground. During the final approach to land, the tower reported the wind as gusting up to 47 kt, and the aircraft continued the approach. In view of the maximum crosswind demonstrated for landing, a go-around would have been reasonable. System-level causes were: "The terminology *maximum crosswind demonstrated for landing* [italics added] was not defined in the Operating Manual (OM/A) and in the Flight Crew Operating Manual (FCOM), Vol. 3, and the description given was misleading. The recommended crosswind landing technique was not clearly described in the aircraft standard documentation. The limited effect of lateral control was unknown."

In the relevant time period, the surface wind at Hamburg was being measured by German Meteorological Service anemometers located near the thresholds of Runways 23/33 and 15, and was logged at 10-second intervals. Air traffic controllers also had data on maximum veer angle and peak wind speed for the preceding 10 minutes. "In the final 10 minutes prior to the occurrence, the wind direction varied between 268 degrees (minimum) and 323 degrees (maximum)," the report said. "In this period, the maximum gust speed recorded was 47 kt [Figure 1]."

When the controller later gave the crew clearance to land on Runway 33, the information included wind from 300 degrees at 33 kt gusting to 50 kt (two-minute mean value). Four additional

Continued on p. 42

wind reports were issued to the crew before touchdown, the final one for wind from 290 degrees at 27 kt gusting to 49 kt.

"The investigation showed that wing tip contact with the runway was not due to a single human error, a malfunction of the aircraft or inadequate organisation; rather, it was due to a combination of several factors," the report said, citing the automatic transition from lateral flight mode to lateral ground mode control laws when the left gear first touched down, resulting in half of full travel in response to full side-stick deflection.

"The fact that there were no significant gusts during the decrab procedure explains that the aircraft was not brought to this unusual and critical attitude by direct external influence. … The BFU is of the opinion that the captain as pilot-in-command did not reach his decision using … reasoning [regarding lower crosswind component on Runway 33], because he did not regard the value maximum crosswind demonstrated for landing as an operational limit for the aircraft. Civil air transport pilots were generally poorly informed about the effects of crosswinds in weather conditions such as these."

During this investigation, 81 pilots holding air transport pilot licenses and employed by five different airlines provided anonymous survey responses in which they were about evenly divided in understanding maximum demonstrated crosswind as a guide versus a limit. Significant differences in understanding also were found concerning the practical application of maximum demonstrated crosswind.

The serious incident involving the Airbus A320-211 at Hamburg on March 1, 2008, and related events were analyzed and safety recommendations about landing in strong gusty crosswind conditions were issued by the German Federal Bureau of Aircraft Accident Investigation in Investigation Report 5X003-0/08, March 2010.

— Mark Lacagnina and Wayne Rosenkrans

preparing for an approach, while all respondents cited control tower wind reports as their primary source. "So the reported wind that they got just before landing was not taken into account [in the occurrence reports]," van Es said. "And what happened in the 30 minutes that [elapsed as they] were planning the approach [was that by] the actual landing, the wind had changed. That happens all the time; the wind encountered is completely different from what is reported. They got a much stronger wind."

Frequently in cases selected, the pilot flying used an incorrect crosswind technique, not following the manufacturer's recommendation. Even low-velocity crosswind/gusts can be very difficult if the flight crew fails to correctly apply the procedure.

Figure 1 from the NLR work gives a sense of the pilots' expectations versus the reality they encountered in comparable models/types of large commercial jets. "For several cases — excursions, hard landing, tail strikes, wing/pod strikes — what we see is that more than half of these occurrences [take place in crosswind conditions that are less than] what was demonstrated," he said.

The two most prevalent wind sensors approved for airport runways with accurate gust-measurement capability are the cup/propeller type with a wind vane, and the ultrasonic type (often called *sonic* type). Both measure data within 2 to 4 percent of the correct value.

"The normal [ATIS/control tower] wind report that you get is an average," van Es said. "It is a forecast of the wind that you're supposed to expect. Many pilots think it is an actual [real-time] measurement; it is not. It is a two-minute average, and they came up with this [to provide users] a good balance between the mean error and the absolute error in the forecast."

The NLR report published by EASA includes a list of recommended mitigations for the issues identified, and van Es discussed some examples. "First of all … include gusts when decomposing reported wind into the crosswind component and take the gust component [as] fully perpendicular to the runway," he said. In the United States in the 1950s and 1960s, this practice was mandatory, NLR found. Flight crews always should use the most recent wind report in decision making.

Despite the willingness of controllers to provide a series of instantaneous wind reports on request during an approach involving strong gusty crosswinds, NLR researchers advise against using this source. "[In] several incidents … the pilot was asking for … the instantaneous wind every 10 seconds," he said. "And [these values] went all over the place until [one was] below his company limit, and then he said, 'Yeah, going to land.' He went off [the runway]."

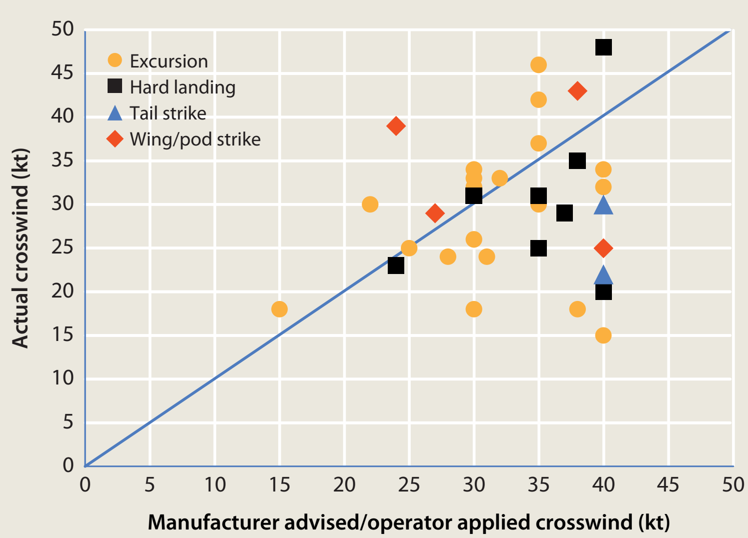
As noted, applying the manufacturer's crosswind-handling technique for the specific aircraft type/model/size is the best practice in risk management. But even this cannot be 100 percent successful, given the unique and dynamic forces in play. "The poor pilot … is confronted with all kinds of confusion and issues when he has to decide whether or not to land in a gusty crosswind," van Es said. "It should be company policy that you can ask for another runway or divert if you don't feel comfortable — if the wind conditions are unfavorable — because that is a very good defense in these cases."

Since the release of the 2010 and 2012 reports, with further EASA–NLR communication through industry forums and pending articles for airlines' safety magazines, a number of operators say they will revisit their policies and procedures, van Es told *AeroSafety World.* Convincing civil aviation authorities, however, is likely to take more time.

"The regulatory [part] is always difficult in terms of who is taking the lead in this case, especially because it's a multiactor issue," he said, and this involves the initiative of operators, manufacturers, regulators and the aviation meteorology community. "The regulators are hesitating to go left or right. They don't know exactly what to do."

Basically, the problem they face is some degree of mismatch in certification of aircraft versus operational use of aircraft. "What EASA has said is that they are looking to publish … a sort of safety bulletin on this topic," van Es said. "But changing regulations? I think that's a step too far for them. There are big advantages in educating the pilots because they often have great difficulties in understanding … wind report [sources]. There is a lot of misconception within crews about how the systems work. … The best experience is the real experience, but for an average line pilot, to have a lot of these landings could be quite rare."

Actual Events Involving Strong Gusty Crosswind Conditions vs. Guidance to Pilots



Notes: Occurrences studied by NLR included some that happened when crosswind components exceeded the values in guidance to flight crews, and others below those values.

Source: G.W.H. van Es and Emmanuel Isambert, NLR

Figure 1

Notes

1. EASA. *Near-Ground Wind Gust Detection.* Research Project EASA. 2011/08 NGW. Van Es, G.W.H. "Analysis of Existing Practices and Issues Regarding Near-Ground Wind Gust Information for Flight Crews". NLR Report no. NLR-CR-2012-143, October 2012.

2. Citing World Meteorological Organization (WMO) WMO-No. 731, the NLR report published by EASA says, "A gust can be defined as the difference between the extreme value and the average value of the wind speed in a given time interval. A gusty wind is characterized by rapid fluctuations in wind direction and speed. At airports, gustiness is specified by the extreme values of wind direction and speed between which the wind has varied during the last 10 minutes."

3. For example, EASA's internationally harmonized regulation (Part 25.237, "Wind Velocities") states, "For landplanes and amphibians, a 90-degree cross component of wind velocity, demonstrated to be safe for takeoff and landing, must be established for dry runways and must be at least 20 kt or 0.2 V_{SO}, whichever is greater, except that it need not exceed 25 kt. Note that V_{SO} means the stall speed or the minimum steady flight speed in the landing configuration."

4. The report said, "Since 1990, there have been more than 280 approach and landing [accidents] and 66 takeoff accidents/incidents investigated with [Part] 25–certified aircraft operated in commercial operations worldwide in which crosswind or tailwind was a causal factor. Occurrences related to gusty wind conditions are also very common in Europe. … The wind in these occurrences was often very gusty."

BY RICK DARBY

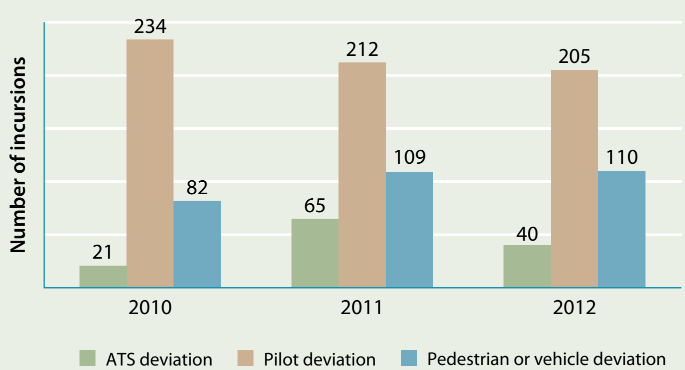
Canadian Sum Set

Canada's runway incursions decreased in 2012, and runway excursions decreased even more.

Runway incursions at Canadian airports decreased in 2012 compared with 2011, according to a report by NAV Canada, the country's air traffic services (ATS) provider.[1,2] The decrease included incursions attributed both to pilot deviations[3] and ATS deviations,[4] the report says. There were no "extreme risk" incursions in 2012.

The report also indicates that runway excursions, which are less frequent than incursions but are statistically responsible for more fatalities, were reduced year-over-year throughout the study period 2010–2012.

Canadian Runway Incursions, 2010–2012



ATS = air traffic service

Source: NAV Canada

Figure 1

ATS deviations were reduced from 65 in 2011 to 40 in 2012, a 38 percent drop (Figure 1). Pilot deviations declined by 3 percent, from 212 to 205. Pedestrian or vehicle deviations[5] showed almost no change from year to year.

Overall, the 2012 numbers were higher than those for 2010. ATS deviations were 90 percent more frequent than in 2010, although fewer than in 2011 — when the increase from 2010 more than tripled. The decrease in pilot deviations from 2010 to 2012 was 12 percent; from 2011 to 2012, 3 percent. Pedestrian or vehicle deviations were nearly unchanged from 2011 to 2012, but up 34 percent from 2010.

Risk Factors

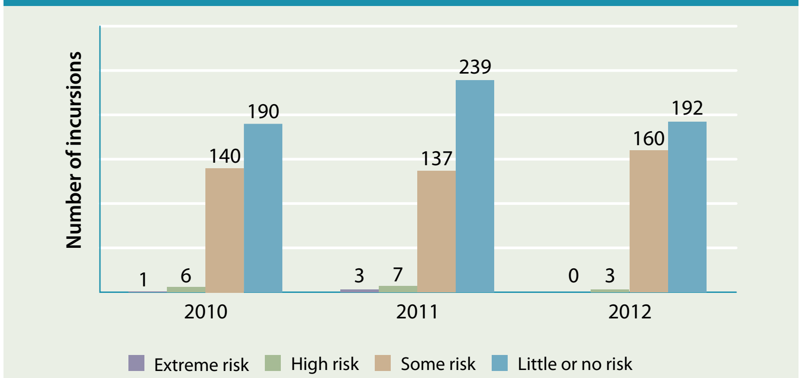
Not all incursions are created equal. NAV Canada has four risk categories, ranging from A to D.

In Category A, "extreme risk," participants narrowly avoid a collision by taking instantaneous action — for example, rejecting a takeoff or initiating a go-around while above the runway threshold. There were no Category A incidents in 2012, compared with three the previous year and one two years earlier.

Similarly, the number of Category B incursions, "high risk," was lower in 2012 than in either of the preceding two years (Figure 2). "High risk" is characterized as having "a significant potential for collision." For example, action must be taken to remove an aircraft or vehicle from a runway because of traffic taking off or landing.

Category C, "some risk," describes incursions in which "there is ample time and distance to avoid a collision." The number of Category C incursions, 160, represented a 17 percent increase from the 137 in 2011. Incursions in Category D, "little or no risk," were 20 percent fewer in 2012 than in the previous year, and about the same as in 2010.

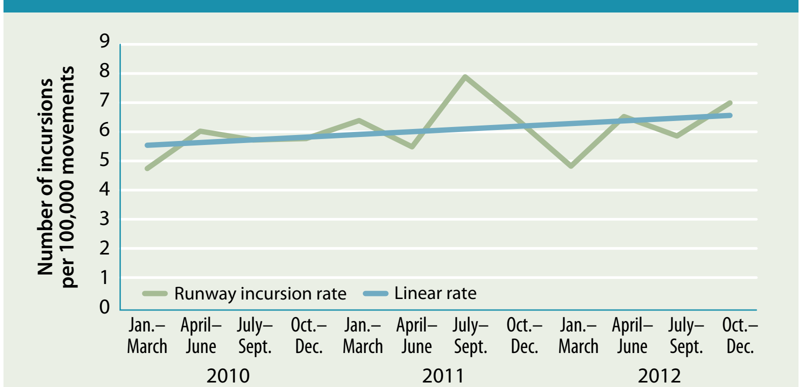
Severity of Canadian Runway Incursions, 2010–2012



Source: NAV Canada

Figure 2

Canadian Runway Incursion Rates, 2010–2012



Note: Rates are per 100,000 aircraft movements, which include arrivals, departures, and touch-and-go procedures at airports where NAV Canada provides control or advisory services.

Source: NAV Canada

Figure 3

Pilot Deviations

The report categorizes numbers of incursions associated with pilot deviations according to operational type. Airline pilot deviations remained nearly constant over the three-year study period: 78 in 2010, 76 in 2011 and 78 in 2012. There was a wider variation in civil aviation, and an improving trend: 177 in 2010, 167 in 2011 and 141 in 2012.[6] In civil aviation, then, there was a 20 percent reduction in pilot-related incursions over three years.

Monthly Variation

In the absence of data, it might be assumed that more incursions would occur in winter because weather would often reduce visibility. The report shows no such effect. Over the 2010–2012 study period, the fewest incursions were in January, February and March (65, 68 and 70, respectively). The most deviations occurred in June and July (123 and 124, respectively). The report does not speculate about the reason for this counter-intuitive finding, but a varying number of flights in different seasons may have contributed to the effect.

There was a reasonably close monthly correlation in 2010 and 2012 in the numbers of incursions. 2011 was the odd year out. In February, for example, there were 33 incursions in 2011, 16 in 2010 and 19 in 2012. In May, the equivalent numbers were 30, 16 and 31; in August, 29, 50 and 29.

The rate of incursions per 100,000 movements — landings, takeoffs and touch-and-go practices — rose during the study period when quarterly variations were mathematically smoothed (Figure 3).

Excursions Reduced

Annual numbers of runway excursions[7] declined during the study period (Figure 4). Landing excursions were reduced from 78 to 49, a 37 percent drop. Takeoff excursions were down from 10 to 6, and "undetermined" excursions — for which it was not possible to determine from reports which phase they occurred in — fell from 10 to 2. In total, the number of excursions from 2010 to 2012 decreased from 98 to 57, or 42 percent.

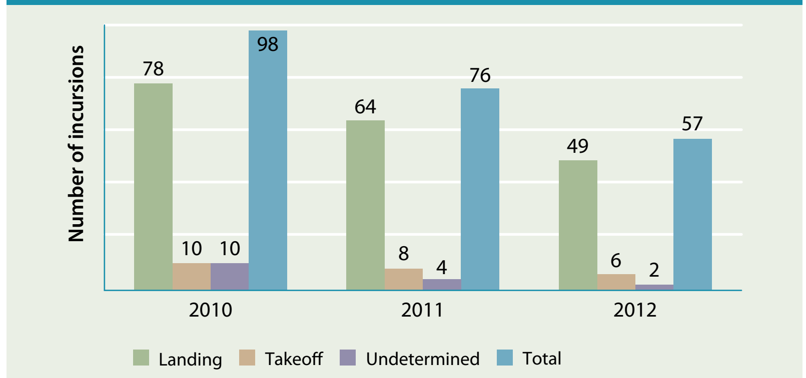
In each year, landing excursions outnumbered takeoff excursions by a considerable margin.The majority of excursions — including both takeoff and landing excursions — were classified as "loss of directional control" in each of the study period's three years, but the number was reduced each year (Figure 5). The fewest overruns, both on takeoff and landing, occurred in 2011.

The number of excursions diminished each year in the Edmonton, Toronto and Montreal flight information regions.[8]

Notes

1. NAV Canada. *Quarterly Runway Safety Report*. <bit.ly/16MOnx0>.
2. The report defines a runway incursion as "any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designated for the landing and takeoff of an aircraft."
3. In the report, a pilot deviation is defined as "an action of a pilot that results in noncompliance with an ATC [air traffic control] instruction/clearance or a violation of a Canadian Aviation Regulation."
4. The report defines an ATS deviation as "a situation which occurs when air traffic services are being provided and when a preliminary investigation indicates that safety may have been jeopardized, less than minimum separation may have existed, or both."
5. A pedestrian or vehicle deviation is defined in the report as "a situation that occurs when a vehicle operator, a non-pilot operator of an aircraft or a pedestrian proceeds without authorization onto the protected area of a surface designated for landing or takeoff. This classification includes security breaches but excludes animals."
6. The report does not define the distinction between civil and airline operations.
7. The report defines a runway excursion as occurring "when an aircraft fails to confine its takeoff or landing to the designated runway. This may occur during the takeoff roll if the aircraft leaves the runway other than by becoming fully airborne or if an attempted landing is not completed within the confines of the intended runway."
8. A flight information region (FIR) is an airspace of defined dimensions extending upward from the surface of the earth, within which a flight information service and an alerting service are provided. The Canadian Domestic Airspace is divided into the Vancouver, Edmonton, Winnipeg, Toronto, Montreal, Moncton and Gander domestic FIRs. The regions are shown visually in the *Designated Airspace Handbook* <bit.ly/bEVDBu>, published by NAV Canada, p. 177.

Canadian Runway Excursions, 2010–2012

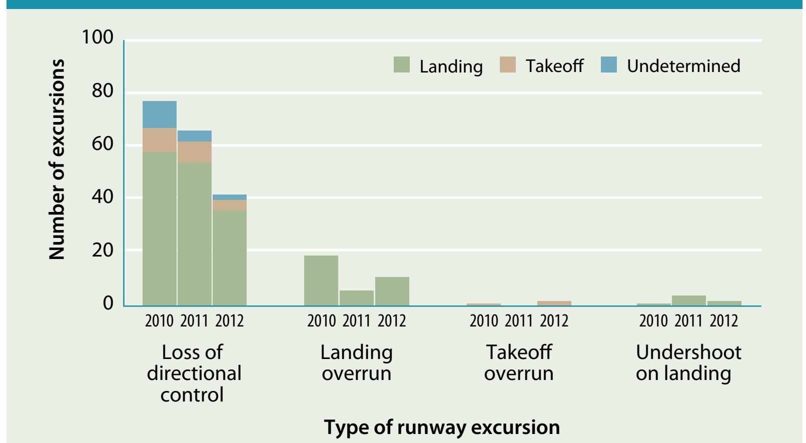


Note: An excursion is categorized as "undetermined" when the report did not give sufficient information to determine the phase in which the excursion took place.

Source: NAV Canada

Figure 4

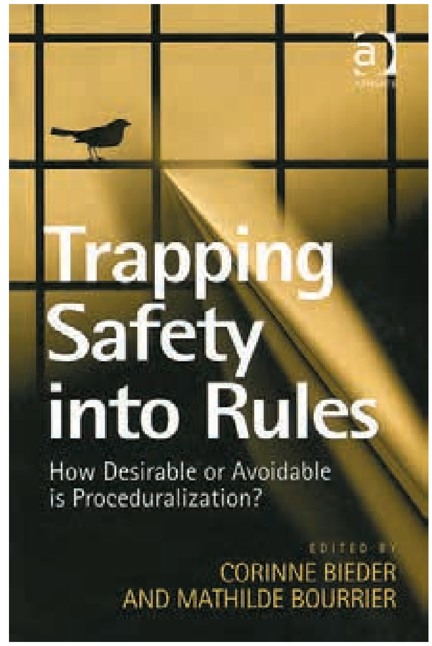
Canadian Runway Excursions, by Type, 2010–2012



Source: NAV Canada

Figure 5

Proceed With CAUTION



Is over-specification of procedures a potential safety hazard?

BY RICK DARBY

A Never-Ending Story

Trapping Safety into Rules: How Desirable or Avoidable is Proceduralization?

Bieder, Corrine; Bourrier, Mathilde (editors). Farnham, Surrey, England and Burlington, Vermont, U.S: Ashgate, 2013. 300 pp. Figures, tables, references, index.

Trapping Safety into Rules — there is a title as provocative as you are likely to see this year in books aimed at aviation safety professionals.

No one needs a definition of rules. Bieder and Bourrier describe "proceduralization" as "firstly, the aim of defining precise and quantified safety objectives, and secondly, the aim of defining a process, describing and prescribing at the same time how to achieve such objectives." Unfortunately, "these two aspects are usually not defined by the same entity. Some inconsistencies may even exist between the two types of procedures."

Questioning the role of rules and proceduralization goes to the heart of commercial aviation, one of the most heavily rule-bound industries. Almost every aspect of the industry is covered by regulations (a subset of rules), standard operating procedures, standards and best practices. Accident investigation reports usually conclude with recommendations for new regulations and procedures.

The remarkable safety record of the industry is due in large part to effective procedures. They are the result of lessons learned from accidents and incidents, as well as research and predictive analysis.

But can there be too much of a good thing in the aviation rulebook?

The editors think so. Bieder and Bourrier say that proceduralization of safety is part of a general trend toward "the bureaucratization of everyday life. … Even commonplace consumption or simple emotions are rationalized and subject to prescribed procedures, notably at the workplace. In addition, the dangerous link between bureaucratization and administrative evil has also long been established. The key role played by technical rationality in this irresistible and sometimes dangerous push always combines scientific method and procedures.

Therefore, it requires us to stay alert and vigilant in front of constant re-engagement towards more rules and regulations."[1]

Personnel do not have infinite attention capacity. Under a regime of excessive proceduralization, they must devote an increasing amount of their attention to keeping up with and following rules and regulations. The corollary is that some time and energy must be debited from attention to the real-world working environment.

Trapping Safety into Rules is a collection of chapters examining various aspects of the theme. Part I is "Where Do We Stand on the Bureaucratic Path Towards Safety?" Part II is about "Contrasting Approaches to Safety Rules." Part III includes chapters under the heading "Practical Attempts to Reach Beyond Proceduralization," and Part IV is "Standing Back to Move Forward."

Claire Pélegrin, in her chapter, "The Never-Ending Story of Proceduralization in Aviation," traces the evolution of the phenomenon.

"At the beginning of aviation, the designer, the engineer and the pilot were the same person, thus there was no real need for procedures," she says. It was not long before specialization began, yet even then, pilots determined their own procedures and tried for self-enforcement.

World War II brought the need to train large numbers of pilots quickly and efficiently — as well as, in some cases, getting pilots ready for action without optimum training time. Standard operating procedures and checklists were among the tools for achieving the goal.

Commercial aviation after the war maintained and expanded the procedural approach. "For years, everybody shared the same idea that safety would be guaranteed if pilots were selected and trained to strictly apply procedures," Pélegrin says. Of course, safety was hardly guaranteed — for one thing, postwar commercial pilots lacked the benefits of today's technological innovations such as terrain awareness and warning systems (TAWS), traffic-alert and collision avoidance systems, and weather radar. But the procedural emphasis seemed promising.

So it grew, becoming more sophisticated and elaborate. "Cockpit tasks have been organized through checklists, do lists and procedures," Pélegrin says. "The philosophy behind [them] is very stringent, dictating the accurate way of configuring [and] flying the aircraft and communicating."

Next in the "never-ending story" came crew resource management (CRM). Among other principles, "CRM training emphasized that [crewmembers] support a shared action plan and shared awareness, which is essential because it creates a mental image to act, synchronize action and manage time. … Procedures also play an important role in interpersonal relationships and in conflict management because they are seen as a neutral reference: In case of disagreement, following the procedures is one way to solve conflict. This is taught in many CRM courses."

In due season, proceduralization became generalized to the organization, encompassing flight operational quality assurance and today's widely adopted safety management systems (SMS).

Pélegrin acknowledges the benefits, even the necessity, of many aspects of proceduralization. But they bring drawbacks as well, she says:

"Organizations in aviation are in a vicious circle with the proceduralization approach. They started to focus on technical performance of the technical system (safety analysis and reliability) to become now focused on the safety of the socio-technical system. This is not exactly the same problem and not the same methodology. Liability aspects are part of the overproceduralization. The tendency is to use written procedures as a legal reference in case of legal suit … and push for more procedures. This may become counterproductive, the main difficulty being that everybody may become lost with all these safety requirements."

Airlines have to balance an inherent contradiction. Pélegrin says, "Standard operating procedures promote the idea of uniformity and standardization at the risk of reducing the human role. At the same time, pilots are seen

Procedures also play an important role in interpersonal relationships and in conflict management because they are seen as a neutral reference.

as 'far more intelligent than the procedures.' Pilots are considered 'better' than the procedure because they have a certain amount of autonomy in their decisions, especially in case of abnormal situations and emergencies (even if, in some airlines, they have to justify that decision afterwards)."

How far the experience and expertise of a pilot should be allowed free exercise is a question that seems to have no absolute answer, because there is no way to take account in advance of the pilot's ability to fully know and understand the situation, the pilot's state of mind, the pilot's judgment abilities, the time pressure, and other variables. "There have been long discussions in many airlines and in international committees to decide if the first officer should take a decision/action in contradiction to the captain," such as calling for a rejected takeoff or taking control of the aircraft, Pélegrin says.

Organizations are caught between encouraging individual responsibility and defining its limits. "If an airline promotes the idea that everyone should be engaged in safety, then there should be consistent policies (including training, procedures and practices)," Pélegrin says. "For example, you cannot promote the idea that everyone must play a role in safety and not allow them to act in safety situations."

The implication is that the captain is conscious and capable of communicating, but speaking or acting irrationally, endangering the flight.

But when an organization *orders* a pilot to take extraordinary action under some circumstances, the long arm of the law reaches into the cockpit. Pélegrin says, "The Indian aviation authority has established a new rule: the copilot needs to shout two warnings to the commander if the aircraft is in danger during its approach to the runway. If the commander doesn't listen, then the copilot has to take charge of all operational functions. The circular[2] noted the new actions would happen 'only in case of total or subtle incapacitation' of the commander and also 'those actions must be inducted from about 500 ft.'"

It would be hard to find a better example of trying to have it both ways, mixing judgment and initiative with proceduralization.

There have been too many accidents in which the captain appeared to have lost situational awareness and the first officer failed to compensate. Such accidents continue (*ASW*, 3/13, p. 16). But consider the copilot's dilemma, despite acting under a rule that intends to make his or her position clear.

According to the author's description, the rule applies only on approach. What if the wrong heading has been entered for the initial climb, a mountain ridge lies ahead, the TAWS is warning of the collision course with terrain and the captain appears oblivious to the risk. Is the copilot authorized to take charge?

But that is only the first decision the copilot must make. He or she is to shout two warnings to the captain. How should they be phrased, what balance struck between respect for the captain's rank and the second-in-command's assumed right to avoid an impending accident? How much time needs to be granted for the captain's response?

First, the rule says that "if the captain doesn't listen," the copilot must take charge. That is unambiguous. But the rule also says the action is to happen "only in case of total or subtle incapacitation." Total incapacitation, likewise, is clear and hardly needs to be embedded in regulation — any copilot in his proper mind would take over if the captain were suffering a medical emergency and completely unable to continue command.

What is subtle incapacitation? The implication is that the captain is conscious and capable of communicating, but speaking or acting irrationally, endangering the flight. To put it paradoxically, how overt must "subtle" be? This theme was central to the classic novel of World War II, *The Caine Mutiny*, in which the ship's officers had to decide what to do about the behavior of Capt. Queeg, a crackpot whose eccentricities might or might not have exceeded a captain's authority.

And what is the copilot to make of "these actions *must* [emphasis added] be inducted from about 500 ft"?

The rule illustrates the negative side of proceduralization. Undoubtedly, its intentions were good: to protect the lives of the passengers in the case of a captain unable to perform duties adequately in a critical phase of flight; to stiffen the spine of the copilot who has to take the decision to deviate from the normal authority gradient; and perhaps to offer the copilot legal protection *ex post facto*. But it also adds a series of rules the copilot must remember and analyze while dealing with a pressing safety-of-flight issue.

Several of the book's chapters suggest that the actual effects of procedures at the "sharp end" must be studied as carefully as their abstract validity. In "Working to Rule, or Working Safely," Andrew Hale and David Borys say, "Rules and procedures are seen as essential to allocate responsibility and to define and guide behaviour in complex and often conflicting environments and processes. Behind this logical, rational obviousness lies another 'truth' about the reality of safety rules and their use."

They cite a study of Dutch railway workers' attitudes to safety rules: "Only 3 percent of workers surveyed used the rules book often, and almost 50 percent never; 47 percent found them not always realistic, 29 percent thought they were used only to point the finger of blame, 95 percent thought that, if you kept to the rules, the work could never be completed in time, 79 percent that there were too many rules, 70 percent that they were too complicated and 77 percent that they were sometimes contradictory."

The authors present two contrasting models of safety rules. Model 1, popular among those with an engineering background or way of thinking, "sees rules as the embodiment of the one best way to carry out activities, covering all contingencies. They are to be devised by experts to guard against the errors of fallible human operators, who are seen as more limited in their competence and experience, or in the time necessary to work out that one best way."

Model 2, derived more from sociology and psychology, perceives rules as "behaviour emerging from experience with activities by those carrying them out. They are seen as local and situated in the specific activity, in contrast with the written rules, which are seen as generic, necessarily abstracted from the detailed situation."

Hale and Borys discuss many studies of both models of rulemaking. Each model has researchers who take a stand basically for or against them; other researchers advocate a balanced position.

95 percent thought that, if you kept to the rules, the work could never be completed in time.

The authors themselves conclude, "The review of the two models and their development and use has resulted in the definition of a broad set of concerns and dilemmas. The picture that emerges is of a gap between the reality of work and its routines and the abstraction of the written rules that are supposed to guide safe behaviour. We have described contrasting perceptions of deviations from those written rules, either as violations to be stamped out or as inevitable and sometimes necessary adaptations to local circumstances to be used and reinforced. …

"Model 1 is more transparent and explicit than the tacit knowledge and emerging set of routines characterized by model 2. This makes it more suitable for trainers, assessors and improvers, but at the cost of creating a gap between work as imagined in the rule set and work as carried out in practice. … Rules may be imposed from above, but they must be at least modified from below to meet the diversity of reality. …

"Model 2 fits best with complex, high-uncertainty, high-risk domains with great variety and need for improvisation. However, in these activities, there is scope for making guidance and protocols more explicit, usable and used, by specifying them as process rules rather than action rules."

Notes

1. Citations of research literature contained in the book have been omitted here for stylistic and space reasons.
2. Directorate General of Civil Aviation, Republic of India. Operation circular 15, Aug. 5, 2010.

‘Hazardous Proximity’

An airliner on go-around and a business jet on departure came close together in an airport hot spot.

BY MARK LACAGNINA

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

JETS

Late Go-Around Cited

Airbus A320, Bombardier Learjet 60. No damage. No injuries.

The absence of air traffic control (ATC) procedures ensuring separation between aircraft going around from one runway and entering the flight path of aircraft departing from a different runway contributed to an incident that placed the A320 and the Learjet in “hazardous proximity” at Las Vegas McCarran International Airport in Nevada, said the U.S. National Transportation Safety Board (NTSB).

“The closest proximity of the two aircraft was approximately 0.3 nm [0.6 km] laterally and 100 ft [30 m] vertically,” said the NTSB’s final report on the near midair collision, which occurred at 1225 local time on April 26, 2012.

The A320 was inbound to Las Vegas on a scheduled passenger flight from Boston, Massachusetts, and the Learjet, of Mexican registration, was departing from McCarran. The report did not specify the Learjet’s destination or how many people were aboard either of the two aircraft.

Day visual meteorological conditions (VMC) prevailed, with winds from the south at 19 kt, gusting to 26 kt. McCarran has two sets of parallel runways. Aircraft operations on Runways 25L and 25R, located on the south side of the airport, were being coordinated by a controller at the “local control 1” (LC1) position; operations on Runways 19L and 19R, on the west side of the field, were being coordinated by a different controller at the “local control 2” (LC2) position.

The A320 crew was conducting a visual approach to Runway 25L and had been cleared to land by the LC1 controller. Shortly thereafter, the Learjet crew was cleared for takeoff from Runway 19L by the LC2 controller.

The departure thresholds of the runways are about 1,600 ft (488 m) apart. “The two runways do not physically intersect,” the report said. “However, the flight paths of the runways intersect approximately 0.32 nautical miles [0.59 km] past the departure end of Runway 19L.” Runway 25L is 10,526 ft (3,208 m) long, and Runway 19L is 9,775 ft (2,979 m) long.

The A320 was about one-third of the way down Runway 25L when the crew reported that they were going around. The LC1 controller acknowledged, saying in part: “Roger, on the go, and traffic will be at your two o’clock and one mile, a Learjet.” The controller also shouted “go around,” a normal practice to alert the other controllers on duty in the tower cab that a go-around was in progress.

The Learjet was on initial climb about halfway down Runway 19L when the LC2 controller, alerted by the LC1 controller's announcement of the go-around, advised the crew that there was "traffic, an Airbus, ahead and to your left." The LC2 controller also said, "You have him in sight? Go low."

The Learjet crew replied that they had the Airbus in sight but did not acknowledge the instruction to "go low." This radio transmission included the background sound of the airplane's stick shaker (stall-warning system), indicating that the airplane was at a high angle-of-attack. Recorded radar data confirmed that the airplane was in a rapid climb. The LC2 controller again told the Learjet crew to "go low" and to "maintain visual separation." The crew did not acknowledge the instructions.

The controllers described the incident as a 'fluke' and as the result of a 'perfect storm' of contributing factors.

The LC1 controller then advised the A320 crew that the Learjet was "immediately off your right. He is climbing as rapidly as he … actually, I don't know what he's going to do for the climb, but it looks like he's coming right at, turning to your right." At this time, the Airbus was still over Runway 25L, heading west, and the Learjet was nearing the departure threshold of Runway 19L, heading south.

The A320 was nearing the departure threshold of Runway 25L when the crew asked the LC1 controller if she wanted them to turn left. The controller replied, "Turn left now. Turn left." She then assigned a heading of 180 degrees. The Airbus was in the turn a few seconds later when the controller asked the crew if they had the Learjet in sight. The crew replied that they had the Learjet in sight and were told to maintain visual separation with the airplane.

As the A320 completed the turn to 180 degrees, it briefly flew parallel to the Learjet, which was on a heading of about 190 degrees. The airplanes came to their closest proximity at this time. "There was no damage reported to either aircraft, or any injuries to passengers or crew," the report said.

The LC1 controller issued vectors to the A320 crew for another approach, and she asked them why they had initiated the go-around: "Was that for, ah, wake turbulence or for, ah, wind shear?" The crew replied "affirmative" and said that they had encountered "a good gust."

During post-incident interviews by investigators, several controllers said that there had been similar conflicts in the hot spot between the runways but that the conflict between the A320 and the Learjet was the closest they could recall. They said that it likely was due in part to the "late" go-around by the Airbus crew; most pilots, they said, initiate a go-around before reaching a runway's approach threshold.

The controllers said that they had resolved previous conflicts by alerting the pilots, issuing headings when necessary and instructing the pilots to maintain visual separation after they had confirmed that the traffic was in sight. One controller said that "after a go-around, controllers really don't have any form of separation and that the important thing was to just get the aircraft to see each other."

"Another 'out' [separation tool used by the controllers] was to instruct aircraft to 'go low' or 'go high,' but this was only done during a 't-bone' (crossing conflict) situation," the report said. One controller told investigators that the Learjet crew apparently had not understood their instruction to "go low" and had initiated a maximum-performance climb after seeing the Airbus.

The controllers described the incident as a "fluke" and as the result of a "perfect storm" of contributing factors. Several said they believed that awareness, discussion and training had prepared them to handle similar situations.

Nevertheless, NTSB concluded that the probable cause of the incident was "Federal Aviation Administration procedures that do not ensure separation in the event of a go-around during simultaneous independent runway operations on runways that do not physically intersect but whose flight paths intersect."

Roller-Coaster Ride

Boeing 737-700. No damage. One serious injury, one minor injury.

The 737 was about 20 nm (37 km) northwest of Bob Hope Airport in Burbank, California, U.S., and was descending in VMC to land at the airport the afternoon of Feb. 13, 2010. The approach controller told the flight crew to fly a heading of 190 degrees and to descend to 6,000 ft.

"The captain [the pilot flying] stated that he set a 190-degree heading in the heading window and selected 6,000 feet in the altitude window of the airplane's mode control panel (MCP), used to set autopilot functions," the NTSB report said. The captain said that these actions were confirmed by the first officer.

The approach controller then advised the crew of traffic at their 11 o'clock position and about 4 nm (7 km) away. "The captain said that the flight crew began scanning for the traffic and received a traffic [alert and] collision avoidance system (TCAS) traffic advisory (TA), which identified that the traffic was about 500 feet below their airplane's altitude," the report said. "The captain stated that he began to shallow the airplane's rate of descent … to avoid the traffic."

The 737, meanwhile, had deviated about 27 degrees from the assigned heading. The controller told the crew to check their heading. "The captain said that he noticed that he had inadvertently allowed the airplane to turn to a 163-degree heading and immediately initiated a turn back to the assigned heading of 190 degrees," the report said. "During the turn, the crew received a TCAS resolution advisory (RA) to descend at 1,500 to 2,000 feet per minute (fpm), followed by a command to climb at 2,000 fpm."

The report said that the captain's responses to the RAs, a 2,000-fpm descent followed by a 2,000-fpm climb, were abrupt. All 80 passengers were seated with their seat belts fastened, but the three flight attendants were standing in the aft galley, completing their preparations to land. One flight attendant suffered a broken scapula (shoulder blade). Another flight attendant sustained unspecified minor injuries, and the third flight attendant was not hurt.

The captain told investigators that while responding to the climb RA, the first officer and he saw an aircraft about 2 nm (4 km) ahead and slightly higher, and he made a shallow right turn to avoid the traffic.

Glide Path Distraction

Boeing 737-800. No damage. No injuries.

During the flight from Shannon, Ireland, with 125 passengers and six crewmembers the afternoon of Feb. 7, 2012, the flight crew briefed for the instrument landing system (ILS) approach to Runway 08R at London Gatwick Airport. Later, however, ATC told the crew that the ILS approach was not available and that they would receive radar vectors for a visual approach, according to the report by the U.K. Air Accidents Investigation Branch (AAIB).

VMC prevailed at Gatwick, with visibility limited by haze. The crew conducted the descent with the 737's autopilot and autothrottle in the "LVL CHG" (level change) mode, in which engine thrust remains at idle while the pitch attitude is adjusted to maintain the selected airspeed. They also programmed the flight management system for a 3-degree final glide path to the runway.

ATC subsequently asked the crew if they could accept an early turn onto the final approach course, and the crew replied that they could. As a result, the aircraft was turned onto the final approach course at a higher altitude than the crew had anticipated. "The pilots used a combination of flap and speed brake to increase the rate of descent" to capture the 3-degree glide path from above," the report said, noting that this distracted the pilots and added to their workload.

The 737 was descending at 1,500 fpm when it reached the programmed final glide path. Although the pilots noticed indications of this, they neglected to change from the "LVL CHG" mode to the "VNAV" (vertical navigation) mode, which would have caused the autopilot to capture the 3-degree glide path.

"The aircraft continued to descend through the glide path until, at approximately 1,000 ft, the EGPWS [enhanced ground-proximity warning system] generated a terrain caution and the pilots saw the PAPIs [precision approach path indicators]," the report said. The pilots later said that the haze prevented them from seeing the PAPI lights sooner.

"ATC informed them that the aircraft appeared slightly low and asked them if they were 'visual,'" the report said. "The PF [pilot flying] disconnected the autothrottle and autopilot, reduced the rate of descent and, after re-establishing the correct approach angle, continued the approach. The aircraft landed without further incident."

Unresolved Brake Warning

Embraer Phenom 100. Minor damage. No injuries.

After starting one engine in preparation to depart from Tucson, Arizona, U.S., the morning of Sept. 10, 2010, the pilots saw a crew alerting system (CAS) warning of a brake failure. They attempted unsuccessfully to reset the system and decided to continue with their planned flight to Brenham, Texas, the NTSB report said.

The CAS message stayed on throughout the flight. The pilot conducted the global positioning system (GPS) approach to Brenham's Runway 16 and then transferred control to the copilot for the landing on the 6,003-ft (1,830-m) runway.

"After touchdown, the copilot … discovered that the brakes did not work, and the airplane began skidding when he pulled the emergency parking brake handle," the report said. "The airplane was moving about 50 to 60 kt when both tires blew."

The airplane veered about 120 degrees left, skidded off the left side of the runway and came to a stop after the right main landing gear collapsed in soft ground. The pilots, alone in the airplane, were not injured.

"A post-accident examination of the brake control unit (BCU) revealed a fault on the printed circuit board that led to an open circuit for a component installed on the board," the report said. "The open circuit caused the failure of the BCU and the loss of normal braking."

Collision With a Tug

Airbus A300-B4. Substantial damage. No injuries.

The scheduled cargo flight from East Midlands Airport in Derby, England, to Paris, the afternoon of April 14, 2012, also was to serve as a training flight. The captain-in-training was to fly the A300 from the left seat, under the supervision of the training captain/commander in the right seat, the AAIB report said.

After receiving ATC clearance to start the engines, the PF used the flight interphone to advise the ground crew headset operator that the aircraft was ready to be pushed back from the stand. During the pushback, the flight crew started the no. 2 engine.

When the headset operator advised the flight crew that the pushback was complete, the PF engaged the aircraft's parking brake. "The headset operator then stood by while the no. 1 engine was started," the report said. "When both engines were running, the PF told the headset operator to disconnect the tug and that he would look for his hand signals on the left side of the aircraft."

The headset operator was unable to remove the pin securing the tow bar to the tug and asked the tug driver for assistance. "Between them, they withdrew the pin and disconnected the tow bar from the tug," the report said. "The headset operator then disconnected the tow bar from the aircraft, turned his back on the aircraft and started to push the tow bar to an area forward of the aircraft, to reconnect it to the rear of the tug. At the same time, the tug driver reversed the tug away from the aircraft before driving forward to pick up the tow bar."

Meanwhile, the flight crew completed the "After Start" checklist, and the PF asked the commander to request taxi clearance from ATC. After taxi clearance was received, the PF illuminated the taxi light and, without receiving the appropriate hand signal from the ground crew, increased thrust to begin taxiing. "It is likely that the tug and ground crew were not visible to the pilots when the aircraft started to taxi," the report said.

The headset operator said that he felt the aircraft looming above him. He pushed the tow bar clear of the A300's nosewheels and watched the aircraft pass in front of him. The tug driver saw the aircraft moving and attempted unsuccessfully to drive clear. The aircraft struck the left rear side of the tug and pushed it a short distance before coming to a stop.

The collision caused substantial damage to the A300's nose landing gear and minor damage to the tug, but none of the flight crewmembers or ground crew was hurt.

TURBOPROPS

Power Lever Jams

Piaggio P180 Avanti. Substantial damage. Four minor injuries.

The Avanti was climbing through 22,000 ft during a fractional ownership flight from Detroit, Michigan, U.S., to West Bend, Wisconsin, the morning of Nov. 16, 2011, when the flight crew noticed that the torque indication for the left engine had decreased to 94 percent. When the captain attempted to move the power lever forward, he felt mechanical resistance. The first officer commented, "That's what it was doing the other day, too."

The captain applied additional pressure to the power lever and heard a pop as the lever moved full forward, the NTSB report said. The lever jammed in this position, causing engine torque and temperature to exceed limits.

The pilots shut down the left engine, declared an emergency and diverted the flight to Bishop International Airport in Flint, Michigan. "After the engine shutdown, both primary flight displays went blank," the report said. "The captain reset the right generator, and the flight displays regained power." However, the displayed heading information was erroneous because the gyros had been reset. The report said that the crew did not check the headings against the magnetic compass.

VMC prevailed at the Flint airport, with surface winds from 290 degrees at 18 kt. The pilots were cleared by ATC to land on Runway 27 but became confused about their heading and location while circling to land. The airport traffic controller then cleared the crew to land on any runway. The first officer replied, "We're taking this one here. We're turning base to final."

The Avanti touched down long on Runway 18, which is 7,848 ft (2,392 m) long. "At the point of touchdown, there was about 5,000 feet [1,524 m] of runway remaining for the landing roll," the report said.

The captain applied reverse thrust from the right engine, and the airplane began turning right. He then reduced reverse thrust and applied full left rudder and left brake, but the airplane veered off the right side of the runway and flipped inverted. The pilots and the two passengers sustained minor injuries.

"Examination of the left engine revealed that the Beta clevis pin was installed in reverse [during maintenance], which caused an interference with a fuel control unit interconnect rod," the report said. "Due to the interference, the power lever control linkage was jammed in the full-forward position."

Control Lost During EMS Flight

Pilatus PC-12/45. Destroyed. Ten fatalities.

Two physicians and a nurse were aboard the PC-12 when the flight crew landed the emergency medical services aircraft in Patna, India, the night of May 25, 2011. After a critically ill patient and an attendant were boarded, the aircraft departed from Patna for the return trip to Delhi.

"Weather in Delhi started deteriorating as the flight came close to Delhi," said the report by the Committee of Inquiry formed by the Indian Directorate General of Civil Aviation. "Widespread thunderstorm activity was seen north-northeast of the Delhi airport [and] moving south."

The PC-12 was nearing the airport and descending through 12,500 ft when ATC radar showed abrupt and rapid altitude changes to 14,100 ft, 13,100 ft and 14,600 ft before groundspeed decreased substantially; the aircraft then entered a steep right turn and descended at rates nearing 11,600 fpm. During this time, ATC received two weak radio transmissions from the crew, both indicating that the aircraft was "into bad weather." Radar contact was lost at 1,600 ft, and attempts to hail the crew by radio were unsuccessful.

The aircraft had struck a house in a residential area of Faridabad, about 15 nm (28 km) from the airport. All seven people aboard the aircraft were killed, as were three people in the house.

The PC-12 was destroyed by the impact and a subsequent fire. Examination of the wreckage revealed that the aircraft was intact before it struck the house, and there was no sign of mechanical failure.

"It is probable that a series of up- and downdrafts, turbulence (moderate to heavy) and the dark night conditions [had] caused the crew to become disoriented," the report said. "The subsequent mishandling of [flight] controls caused the aircraft to [stall and] enter a spin."

Gear Lubrication Neglected

Beech 99. Substantial damage. No injuries.

After dropping parachutists near Cedartown, Georgia, U.S., the morning of April 10, 2011, the pilot turned back toward the

The pilots … became confused about their heading and location while circling to land.

airport. He attempted to extend the landing gear, but the down-and-locked annunciator light for the left main landing gear did not illuminate.

"The pilot confirmed that he had an unsafe gear indication on the left main landing gear," the NTSB report said. "He then actuated the test switch, and all three lamps illuminated, demonstrating that he did not have a burned-out indicating lamp."

The pilot cycled the gear, but the problem persisted. He said that while subsequently using the backup manual gear-extension system, "the pressure required to pump the gear down became greater and greater until something gave way," and the annunciator for light the left main gear did not illuminate.

"The pilot completed the landing on the nose and right main landing gear, which resulted in substantial damage to the left wing and fuselage," the report said.

Examination of the left main landing gear revealed that the supports for the actuator bearings lacked adequate lubrication and were worn. Investigators were unable to determine whether the actuator had not been lubricated properly during installation 31 months earlier or subsequent inspections did not detect a loss of lubrication.

PISTON AIRPLANES

Engine Fails on Takeoff

Beech E18S. Destroyed. One fatality.

Shortly after taking off from Runway 09L at Opa-Locka (Florida, U.S.) Executive Airport for a cargo flight to the Bahamas the morning of May 2, 2011, the pilot told ATC that he was turning downwind, rather than departing to the east, as planned.

"According to witnesses, the airplane did not sound like it was developing full power," the NTSB report said. "The airplane climbed about 100 feet, banked to the left, began losing altitude and impacted a tree, a fence and two vehicles before coming to rest in a residential area." The pilot, alone in the airplane, was killed, but no one on the ground was hurt.

Investigators found that the pilot "had been having problems with the no. 2 [right] engine for months [but] continued to fly the airplane," the report said, noting that the Twin Beech had been parked outside in a moist environment.

Examination of the right engine revealed several discrepancies that would have caused "erratic and unreliable operation," including internal corrosion preventing both magnetos and the fuel pump from functioning properly, and low compression in four of the nine cylinders.

The report also said that the engine likely had lost power on takeoff and that "there was no evidence that the pilot attempted to perform the manufacturer's published single-engine procedure, which would have allowed him to maintain altitude. Contrary to the procedure, the left and right throttle control levers were in the full-throttle position, the mixture control levers were in the full-rich position, neither propeller was feathered, and the landing gear was down."

Parking Brake Overlooked

De Havilland DHC-2 Beaver. Substantial damage. No injuries.

After landing the single-engine airplane at a base camp on the Tahiltna Glacier in Alaska, U.S., on May 22, 2012, the pilot raised the landing skis, placing the Beaver on its wheels, and set the parking brake to prevent the airplane from sliding.

Later, while preparing to depart from the base camp, the pilot lowered the skis but forgot to release the parking brake, the NTSB report said.

The parking brake was still set when the pilot conducted a wheel landing on a hard-surfaced runway in Talkeetna. The Beaver came to an abrupt stop and pitched nose-down; the horizontal stabilizer was substantially damaged when it fell back onto the runway. The pilot and four passengers were not hurt.

HELICOPTERS

Control Lost During Search

MD Helicopters MD902. Destroyed. Three serious injuries.

The pilot, flight engineer and forward-looking infrared radar (FLIR) operator aboard the state police helicopter were searching for a missing person near Engelsbrand, Germany, in night VMC on May 10, 2011. The helicopter was circling about 600 ft above a hill when the radar operator announced that the FLIR was showing an unidentified heat source.

The pilot and flight engineer donned night vision goggles (NVGs). The pilot then maneuvered the MD902 close to the displayed heat source and reduced speed to place the helicopter in a hover. "Suddenly, the helicopter yawed to the right," said the report by the German Federal Bureau of Aircraft Accident Investigation. "He responded [by] actuating the left pedal up to the mechanical stop."

However, the helicopter continued to yaw right and then descended out of control into the forest. All three occupants sustained serious injuries. The radar operator exited the wreckage unaided; the pilot and flight engineer were rescued by police ground crewmembers.

The report concluded that visual restrictions resulting from the use of the NVGs, distractions caused by the search for the missing person, and a "loss of spatial perception" were among factors that likely contributed to the accident.

"It is likely that while trying to position the helicopter as close as possible to the identified heat source, an unnoticed loss of altitude and backward movement of the helicopter occurred," the report said. "It is highly likely that the restricted spatial perception of the pilot due to the NVGs contributed to the occurrence; the same is true for crewmembers whose attention was focused on the search."

Distracted by Radio Call

Eurocopter AS350 B2. Substantial damage. Three minor injuries.

The pilot, who had recently purchased the helicopter, was receiving training by a certified flight instructor (CFI) at Alliance Airport in Fort Worth, Texas, U.S., the morning of May 29, 2011. "During practice traffic pattern work, the helicopter's hydraulic system was turned off to simulate hydraulic failure on the flight control system," the NTSB report said.

During the subsequent approach, the CFI and the pilot may have been distracted when an airport traffic controller advised that they were using an incorrect radio frequency, the report said. While the instructor was setting the correct frequency, the helicopter slowed and entered an uncommanded left yaw.

"The CFI tried to regain control by adding right pedal, trying to gain forward airspeed, and reducing power," the report said. "The helicopter did not respond to the CFI's control inputs, descended and impacted terrain." The pilot, CFI and passenger sustained minor injuries.

Loose Nut Causes Power Loss

Bell 206B. Substantial damage. No injuries.

After the JetRanger's engine lost power during an aerial-application flight near Burbank, Washington, U.S., on May 30, 2012, the pilot conducted an autorotative landing in an apple orchard. "During the landing, the rotor blades impacted the trees and the tail boom separated from the main fuselage," the NTSB report said.

Maintenance records showed that the helicopter had been flown six hours since the engine bleed air valve was replaced. Investigators determined that maintenance personnel had not applied sufficient torque to secure a B-nut that attaches the compressor discharge pressure air tube to the engine. The B-nut had backed off the stud during the accident flight, causing the air tube to detach and the engine to lose power.

Preliminary Reports, March 2013

Date	Location	Aircraft Type	Aircraft Damage	Injuries
March 1	Broomfield, Colorado, U.S.	Aero Commander 500B	substantial	2 none
The pilot landed the Commander gear-up on a golf course after both engines lost power on takeoff for a test flight.				
March 2	Papua New Guinea	Hughes 369HS	substantial	1 fatal, 1 serious
The pilot of the fish-spotting helicopter circled over a fishing vessel before placing the 369 in a hover to deploy a radio buoy. The helicopter was struck by the vessel and descended out of control, killing the observer.				
March 2	Ciales, Puerto Rico	Robinson R44	destroyed	1 minor
The R44 struck power lines and crashed after rotor speed decreased during cruise flight.				
March 4	Goma, Democratic Republic of Congo	Fokker 50	destroyed	7 fatal, 3 serious
The Fokker crashed in a residential area during approach in adverse weather conditions.				
March 4	Annemasse, France	Beech Premier 1A	destroyed	2 fatal, 1 serious
Day visual meteorological conditions prevailed when the airplane struck a house and crashed in a field shortly after takeoff.				
March 5	Danville, California, U.S.	Bombardier Q400	minor	51 none
The Q400 was climbing through 20,000 ft when the flight crew heard a bang and received a no. 2 engine fire warning. The crew activated the fire extinguishers, but the fire warning persisted. They shut down the engine and returned to San Jose.				
March 6	Roskilde, Denmark	Partenavia P68 Observer	destroyed	2 fatal
The aircraft was on a bird-control flight when it crashed under unknown circumstances on approach.				
March 6	Matibamba, Peru	Beech King Air B200	destroyed	9 fatal
The King Air struck a hillside during a charter flight to a gold-mining site.				
March 8	Aleknagik, Alaska, U.S.	Beech 1900C	destroyed	2 fatal
Instrument meteorological conditions prevailed when the cargo airplane struck rising terrain shortly after the flight crew requested and received clearance to enter a holding pattern at an initial approach fix, to check on runway conditions at Dillingham.				
March 9	Turangi, New Zealand	Robinson R66	destroyed	1 fatal
The turbine helicopter crashed in mountainous terrain under unknown circumstances.				
March 12	Almerin, Brazil	Embraer 821 Caraja	destroyed	10 fatal
The EMB-821, a version of the Piper Navajo, crashed under unknown circumstances during a charter flight.				
March 12	Katowice, Poland	Boeing 737-800	none	185 none
No injuries or damage occurred when the 737 overran the runway on landing.				
March 14	Eagle Nest, New Mexico, U.S.	Robinson R44	substantial	2 none
The flight instructor conducted an autorotative landing on an open field after the engine lost power during cruise flight. The main rotor blades struck and severed the tail boom on touchdown.				
March 15	Fort Lauderdale, Florida, U.S.	Piper Cheyenne	destroyed	3 fatal
The Cheyenne was departing for a post-maintenance check flight when the pilot declared an emergency and attempted to return to the airport. A witness said that the airplane appeared to stall before rolling 90 degrees and descending into a parking lot.				
March 15	Lake Charles, Louisiana, U.S.	Sikorsky S-76A	substantial	3 fatal
The pilot declared an emergency and said that he would conduct an off-airport landing shortly before the S-76 crashed during a post-maintenance check flight.				
March 17	South Bend, Indiana, U.S.	Beech Premier 1A	destroyed	2 fatal, 3 serious
The pilot reported an electrical system problem before the airplane stalled on approach and crashed in a residential area. One person on the ground was seriously injured.				
March 23	Vostochnaya, Russia	PZL-Mielec An-2R	destroyed	1 fatal, 1 serious
The aircraft crashed in a pond when the engine lost power during a test flight.				
March 24	Jeddah, Saudi Arabia	Boeing 747-400	substantial	317 none
An "explosion" and fire occurred when the no. 4 engine was started after pushback from a gate. Initial examination of the 747 revealed thermal damage to the outboard flap and jackscrew fairing.				

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