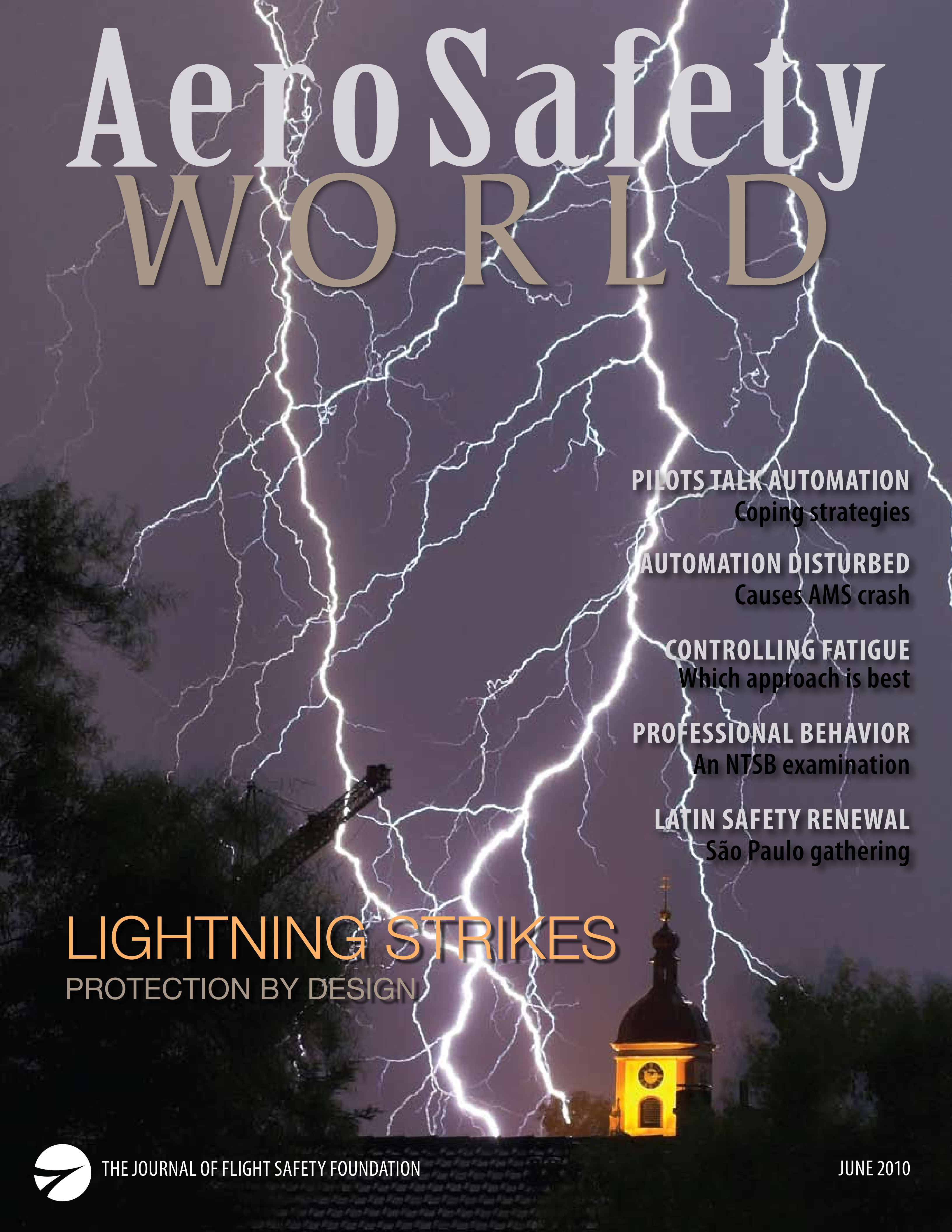

AeroSafety WORLD

PILOTS TALK AUTOMATION
Coping strategies

AUTOMATION DISTURBED
Causes AMS crash

CONTROLLING FATIGUE
Which approach is best

PROFESSIONAL BEHAVIOR
An NTSB examination

LATIN SAFETY RENEWAL
São Paulo gathering

LIGHTNING STRIKES
PROTECTION BY DESIGN

THE JOURNAL OF FLIGHT SAFETY FOUNDATION

JUNE 2010

GENTLEMEN'S Agreement

I think it is time for us to be honest with ourselves. With all that is going on in the world today, is aviation safety really that much of a priority? I find the answer to that depends on who you ask. If you put a television camera in the face of a politician or an airline CEO, then, of course, safety is the number one priority. But once we get past that public reflex, to be honest with ourselves, we must admit that safety improvements are publicly mandated, but privately discouraged. The system is entering a new age, and it is time to adapt.

Take a look at how fatigue regulation is progressing in the United States and Europe. Improved fatigue regulations have been a public priority since the Colgan Air accident near Buffalo, New York, U.S., in early 2009 (*ASW*, 3/10, p. 20). But the poorly concealed truth is that vital regulatory initiatives are hitting an economic wall. Regulations have costs that, in many countries, must be offset by verifiable benefits. Aviation is now so safe that there is little chance a new rule might immediately prevent an accident and save a life. This cost-benefit hurdle is not a U.S. anomaly. It is common in many countries around the world.

Of course, the same type of analysis doesn't apply to security regulations, and that leads to an odd situation. It is OK from a regulatory perspective to spend a nearly infinite amount of money to keep a human life from being lost due to hostile action; it is not OK to spend money as freely to protect that same life from the consequences of human error. This is a distinction not appreciated by those who have lost loved ones in accidents.

We have to find new tools. The idea of using regulations to ensure safety is wearing thin. It is time for the industry to think hard about how safe it wants to be, and to establish the standards by which it can be measured.

This isn't a new idea. Many industries, including medicine, civil engineering, shipping and mining, set their own standards and measure themselves by those criteria. It isn't even a new idea in aviation. The bolts that hold the wing on are built to an SAE standard. Airlines qualify for International Air Transport Association (IATA) membership with an IATA Operational Safety Audit, and corporate flight departments prove their safety management system competencies with an International Standard for Business Aircraft Operations (IS-BAO) registration.

All of these are standards established by industry for industry. This type of standard setting will be central to our future. Why do such a thing? Because the industry has no real choice.

Today, many leading airlines go far beyond the minimum regulatory requirement. That is great, until another company does the regulatory minimum and threatens to run the others out of business by undercutting them on costs.

If an industry wants to raise safety standards, it must do so jointly, and publicly, and it has to call out those who refuse to go along. There has always been a gentlemen's agreement among airlines that they will not speak ill of another's safety efforts, but those days may soon be over. Clearly, some airlines maintain a higher level of safety and it may be time to admit it. We are left with two choices: Set our own standards and celebrate them, or risk having market pressures erode standards to the regulatory minimum.

William R. Voss
President and CEO
Flight Safety Foundation

AeroSafety WORLD

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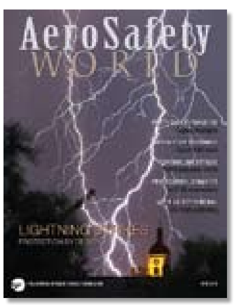

About the Cover
Lightning poses challenges
to composite aircraft design.
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If you have an article proposal, manuscript or technical paper that you believe would make a useful contribution to the ongoing dialogue about aviation safety, we will be glad to consider it. Send it to Director of Publications J.A. Donoghue, 601 Madison St., Suite 300, Alexandria, VA 22314-1756 USA or donoghue@flightsafety.org.

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WORST-CASE Scenarios

Last year I bought a parachute, not because I wanted to jump out of a perfectly good airplane, but just in case my airplane suddenly was no longer perfectly good.

I fly gliders most weekends, and my Pilatus is a nice aircraft with decent performance. I enjoy the sport and I have few safety concerns if I pay attention to what I'm doing. The one major concern I do have is about the risk of a mid-air collision. Our club's base is just west of the Chesapeake Bay, north of Baltimore, and a lot of north/south traffic cruises through the area. Plus, there is always the threat of collision with another glider while working the same thermal, even though our wariness about that situation verges on paranoia.

When I bought the 'chute from Alan Silver, a wise and experienced parachutist and rigger, he talked with me in some detail about my approach to the 'chute. It is important, he counseled, that I rehearse the act of bailing out of my aircraft should it become crippled. The rehearsal should not only be in my mind — walking myself through the procedure of jettisoning the canopy, unbuckling my five-point harness, getting clear of the fuselage, pulling the ripcord and guiding the 'chute to a good landing — but I also should physically work my way through that process as much as possible while sitting in the cockpit.

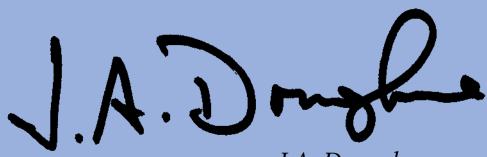
For someone who has never wanted to jump out of any aircraft into thin air, it was a sobering process, but the benefit in coming to grips with the reality of the event before it happens is quite clear.

I started to relate this thinking to some of the accidents I read about and came to the perhaps unsurprising conclusion that in many accidents pilots had become so dedicated to landing on a runway they did not seriously consider the idea that at some point, when things started to go bad for whatever reason, they had to accept the fact that the airplane was going to get bent, perhaps badly, and that the survival of those on board had to be the sole focus of what was done next.

When we learn to fly, we all practice forced landings; for the most part, that involves a total loss of power, and in that event, there is little question about priorities. But we see over and over again tales of pilots losing engines and systems or experiencing onboard fires that make flying difficult, at best, who end up impacting the ground in an uncontrolled manner, and that never turns out well. In an emergency version of get-home-itis, pilots want to land normally, even when that seems nearly impossible.

In probably the most popular accident of all time — if there can be such a thing — Chesley "Sully" Sullenberger made an early decision that he would destroy an aircraft in order to give his passengers the best possible chance of survival. Although he briefly sought alternatives, he immediately turned toward a survivable solution and didn't waver.

So, this isn't a complicated training point or procedure, but rather a mental exercise. Walk through a number of emergency scenarios in your mind, with a variety of situations and alternatives, and get your head to accept the fact that, sometimes, bending the airplane is the better choice if everyone walks away.



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

Serving Aviation Safety Interests for More Than 60 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 1,040 individuals and member organizations in 128 countries.

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JUNE 14–18 ➤ Aviation SMS Course and Workshop Taught in Spanish. Prism Training Solutions. Denver. John Darbo, <John.Darbo@argus.aero>, <www.aviationresearch.com>, +1 513.852.1057.

JUNE 15–17 ➤ Cabin Safety Workshop. U.S. Federal Aviation Administration Civil Aerospace Medical Institute. Oklahoma City, Oklahoma, U.S. Lawrence Paskoff, <lawrence.paskoff@faa.gov>, <www.faa.gov/data_research/research/med_humanfacs/aeromedical/cabinsafety/workshops>, +1 405.954.5523.

JUNE 21–22 ➤ ICAO Global Civil Aviation Search and Rescue Forum. United Arab Emirates General Civil Aviation Authority. Abu Dhabi, United Arab Emirates. Brian Day, <bday@gcaa.ae>, +971 50 9353617.

JUNE 21–23 ➤ Seminar: "Learning From Investigations." United States Society of Air Safety Investigators. Oklahoma City. Troy Jackson, <troy.airsafety@gmail.com>, +1 405.819.7641.

JUNE 21–25 ➤ Fatigue Risk Management. Prism Training Solutions. Denver. John Darbo, <John.Darbo@argus.aero>, <www.aviationresearch.com>, +1 513.852.1057.

JUNE 22 ➤ New Projects Developing Avionic Systems and Flight Deck Operations, and Their Contribution to Future Air Traffic Management. ALICIA. Brussels. <alicia@dblue.it>, <www.alicia-project.eu/CMS/events.html>, +39 06 8555208.

JUNE 23–24 ➤ Aviation Safety Management Systems Overview. PAI Consulting. Alexandria, Virginia, U.S. <SMS@PAIconsulting.com>, <www.paiconsulting.com>, +1 703.931.3131.

JUNE 24–25 ➤ Safety Management System Course in Spanish. Total Resource Managment. Toluca, Mexico. Víctor Manuel del Castillo, <info@smsenespanol.aero>, <www.factoreshumanos.com>, +52 722.273.0488.

JULY 7–11 ➤ Accident/Incident/Hazard Investigation Training. Prism Training Solutions. Denver. John Darbo, <John.Darbo@argus.aero>, <www.aviationresearch.com>, +1 513.852.1057.

JULY 12–23 ➤ Aircraft Accident Investigation. Southern California Safety Institute. San Pedro, California, U.S. Sharon Morphew, <registrar@scsi-inc.com>, <www.scsi-inc.com/AAI.php>, +1 310.517.8844.

JULY 13–15 ➤ CAE Flightscape 2010 Users Conference. CAE Flightscape. Gatineau-Ottawa, Quebec, Canada. <conference@flightscape.com>, <www.flightscape.com/about/conferences.php>, +1 613.225.0070.

JULY 18–20 ➤ Airports Conference of the Americas. American Association of Airport Executives. Panama City, Panama. Joan Lowden, <joan.lowden@aaae.org>, <events.aaae.org/sites/100704>, +1 703.824.0500, ext. 137.

JULY 19–23 ➤ IOSA Auditor Training. Argus Pros. Denver. John H. Darbo, <www.pros-aviationservices.com/iat_training.htm>, +1 513.852.1057.

JULY 19–25 ➤ Farnborough International Airshow. Farnborough International. Farnborough, England. <enquiries@farnborough.com>, <www.farnborough.com/Site/Content/Farnborough2010/default.aspx>, +44 (0)1252 532800.

JULY 26–30 ➤ Human Factors for Accident Investigators. Southern California Safety Institute. San Pedro, California, U.S. Sharon Morphew, <registrar@scsi-inc.com>, <www.scsi-inc.com/HFAI.php>, +1 310.517.8844.

AUG. 2–6 ➤ Advanced Accident Investigation Course. Embry-Riddle Aeronautical University. Prescott, Arizona, U.S. Sarah Ochs, <case@erau.edu>, <www.erau.edu/academic/ep-case.html>, +1 386.226.6928.

AUG. 3–5 ➤ Cabin Safety Workshop. U.S. Federal Aviation Administration Civil Aerospace Medical Institute. Oklahoma City, Oklahoma, U.S. Lawrence Paskoff, <lawrence.paskoff@faa.gov>, <www.faa.gov/data_research/research/med_humanfacs/aeromedical/cabinsafety/workshops>, +1 405.954.5523.

AUG. 9–13 ➤ Crew Resource Management Instructor Training Course. Integrated Team Solutions. London. <sales@aviationteamwork.com>, <www.aviationteamwork.com/instructor/details_atticus.asp?courseID=7>, +44 (0)7000 240 240.

AUG. 16–20 ➤ Advanced SMS. Prism Training Solutions. Denver. John Darbo, <John.Darbo@argus.aero>, <www.aviationresearch.com>, +1 513.852.1057.

AUG. 24–25 ➤ The Just Culture Public Course. Outcome Engineering. Dallas. +1 214.778.2038.

AUG. 26–27 ➤ Introduction to Aviation SMS Workshop. ATC Vantage. Tampa, Florida, U.S. <info@atcvantage.com>, <www.atcvantage.com/>, +1 727.410.4759.

SEPT. 1–3 ➤ Dangerous Goods Inspector Initial Training. U.K. Civil Aviation Authority International. London Gatwick. Sandra Rigby, <training@caainternational.com>, <www.caainternational.com/site/cms/coursefinder.asp?chapter=134>, +44 (0)1293 573389.

SEPT. 6–9 ➤ ISASI 41st Annual Seminar. International Society of Air Safety Investigators. Sapporo, Japan. Mamoru Sugimura, < www.isasi.org/annualsem.html>, +81 3 5253 8814.

SEPT. 13 ➤ Airworthiness Surveyor Theory Course. U.K. Civil Aviation Authority International. London Gatwick. Sandra Rigby, <training@caainternational.com>, <www.caainternational.com/site/cms/coursefinder.asp?chapter=134>, +44 (0)1293 573389.

SEPT. 14–15 ➤ Regulatory Affairs Training Course. JDA Aviation Technology Solutions. Bethesda, Maryland, U.S. Josh Plave, <jplave@jdasolutions.aero>, <www.jdasolutions.aero/services/regulatory-training.php>, +1 301.941.1460, ext. 170.

SEPT. 14–16 ➤ Cabin Safety Workshop. U.S. Federal Aviation Administration Civil Aerospace Medical Institute. Oklahoma City, Oklahoma, U.S. Lawrence Paskoff, <lawrence.paskoff@faa.gov>, <www.faa.gov/data_research/research/med_humanfacs/aeromedical/cabinsafety/workshops>, +1 405.954.5523.

SEPT. 20–24 ➤ Accident/Incident/Hazard Investigation Training. Prism Training Solutions. Denver. John Darbo, <John.Darbo@argus.aero>, <www.aviationresearch.com>, +1 513.852.1057.

SEPT. 27–OCT. 1 ➤ Crew Resource Management Instructor Training Course. Integrated Team Solutions. London. <sales@aviationteamwork.com>, <www.aviationteamwork.com/instructor/details_atticus.asp?courseID=7>, +44 (0)7000 240 240.

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

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

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

Safety News

Data Fusion Directions

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Timely warnings to global aviation leaders about low-frequency, hard-to-identify safety threats soon will be routine, say leaders of the U.S. Commercial Aviation Safety Team (CAST) and the U.S. Federal Aviation Administration (FAA) Aviation Safety Information Analysis and Sharing Program (ASIAS).

ASIAS plans to share high-level hazards and trends — and to exchange parameters, aggregate data and analytical protocols such as database-fusion techniques —while CAST develops and refines safety enhancements, said Margaret Gilligan, briefing journalists in mid-June as government co-chair of CAST and the ASIAS executive board, along with Don Gunther, industry co-chair of CAST and the ASIAS executive board; and Jay Pardee, director of the FAA Office of Aviation Safety Analytical Services.

De-identified data archived from 7.2 million flights captured by flight operational quality assurance (FOQA) programs at 12 of 30 ASIAS-participating airlines now can be matched to 17,000 de-identified reports from 30 aviation safety action programs and some of 44 other databases (*ASW,* 5/08, p. 25, and 8/09, p. 32), they said. In one example, flight crew noncompliance with resolution advisories from traffic-alert and collision avoidance systems (TCAS) improved from 2.0 percent to 0.5 percent in 10 months at one airline.

ASIAS priorities include tools "to help target resources in the future if current solutions are not effective" and a robust "vulnerability-discovery capability" to detect unsafe changes during transition to the Next Generation Air Transportation System, Pardee said.

CAST uses ASIAS capabilities to revisit safety enhancements, such as those for pilot interaction with aircraft automation, mode confusion and energy-state awareness, Gunther added. ASIAS lately has tackled loss of separation during standard instrument departures with area navigation (RNAV) off-the-runway procedures on closely spaced parallel runways; runway excursions; high-energy rejected takeoffs; unstabilized approaches; and further study of non-safety-critical TCAS alerts, Pardee said.

— *Wayne Rosenkrans*

Charity Flights

Pilots who conduct charitable medical flights should be required to present proof of their currency before every flight, the U.S. National Transportation Safety Board (NTSB) says.

The NTSB told The Air Care Alliance — a league of humanitarian flying organizations whose volunteer pilots conduct public benefit flights for disaster relief, patient transport and other public service missions — that it should require voluntary pilot organizations to verify pilot currency. These organizations operated under U.S. Federal Aviation Regulations Part 91, "General Operating and Flight Rules," and were not subject to oversight by the U.S. Federal Aviation Administration.

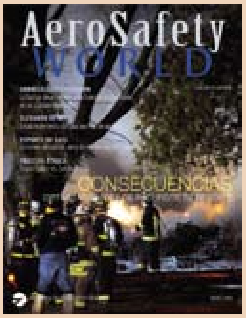
Other recommendations called on the alliance to require voluntary pilot organizations to tell their passengers that their charitable medical flights are "not conducted under the same standards that apply to a commercial flight" and to require them to implement written safety guidance to address "at a minimum, aeronautical decision making; proper preflight planning; pilot qualification, training and currency; and self-induced pressure."

The NTSB cited four fatal accidents in 2007 and 2008 that involved charitable medical flights. In each case, the NTSB said that the probable cause of the accident involved either improper pilot decision making, a pilot's spatial disorientation or a lack of instrument currency.

"The NTSB is concerned that these pilots did not provide the passengers with the basic level of safety that passengers in these circumstances have a right to expect," the NTSB said.

U.S. Air Force

En Español



A Spanish translation of *AeroSafety World* is now available on the Flight Safety Foundation Web site, at <flightsafety.org>.

Translation of six issues of *ASW* is being sponsored by the Federation of Latin American Pilots (FLAP), which represents the region's members in the International Federation of Air Line Pilots' Associations (IFALPA).

"It is our hope that we can keep this process going beyond the initial six translations," said Carlos Arroyo Landero of FLAP.

Chinese translations of some issues of *ASW*, made possible through the Foundation's partnership with the General Administration of Civil Aviation of China (CAAC), also are available on the Web site.

'Loose Equipment'


© Josh Beasley/Flickr

The U.S. Federal Aviation Administration (FAA), citing a recent fire in a Mitsubishi MU-2B, has warned aircraft owners and operators of "potential hazards and airworthiness concerns" associated with loose equipment in the cockpit — especially on the glare shield above the instrument panel.

In a special airworthiness information bulletin, the FAA said, "Loose equipment on the glare shield or in the cockpit can present a hazard, particularly for aircraft with a windshield heater system installed where electrical terminal strips may be exposed and subject to short circuit."

Loose equipment on the glare shield also can obscure the pilots' field of view, become a hazard in case of turbulence and might affect the accuracy of a magnetic compass, the FAA said.

After the recent MU-2 fire, investigators found that a hand-held global positioning system (GPS) receiver and antenna had been placed on the glare shield. A metal portion of the GPS antenna contacted a windshield heater terminal strip, causing a short circuit.

"The resulting current flow caused the loose equipment to burn, resulting in smoke in the cockpit," the FAA said. The crew conducted an emergency landing. The FAA information bulletin provided no further details about the event.

Engine Inspections

Citing four recent uncontained engine failures, the U.S. National Transportation Safety Board (NTSB) is calling for immediate blade borescope inspections of low-pressure turbine stage 3 disks on General Electric (GE) CF6-45/50 turbofan engines.

The inspections should be repeated at specific intervals until the disk is redesigned and the new version is installed, the NTSB said in a letter to Randy Babbitt, administrator of the U.S. Federal Aviation Administration.

Investigations of the engine failures have found that the disk "can fail unexpectedly when excited by high-pressure rotor unbalance vibration resulting from localized high-pressure turbine blade material loss," the NTSB said. "A turbine disk failure can release high-energy engine debris capable of damaging an airplane and endangering its passengers."

The NTSB said that, although the failure mode was identified in the 1970s, the first uncontained failure occurred in 2008 in a Saudi Arabian Airlines (Saudia) Boeing 747-300 after takeoff from Jeddah.

The other failures involved an Arrow Cargo McDonnell Douglas DC-10F about 30 minutes after takeoff from Manaus, Brazil, on March 26, 2009; a Jett8 Cargo Boeing 747-200F climbing through 7,000 ft above ground level after takeoff from Changi, Singapore, on Dec. 17, 2009; and an ACT Cargo Airbus A300B4 accelerating for takeoff at Manama, Bahrain, on April 10, 2010.

No injuries were reported in any of the events. Investigations of all four events are continuing.

Wikimedia

Crash Kills Mining Officials

The entire board of Sundance Resources, an Australian mining company, has been killed in the crash of a chartered CASA 212 in the Republic of Congo.

The company said that all 11 people in the airplane, including six Sundance officials, were killed in the June 19 crash in a mountainous area near the border with Gabon; the airplane had been flying from Yaoundé, Republic of Cameroon, to Yangadou, Republic of Congo. The wreckage was found June 21. News reports said that an investigation into the cause of the crash was continuing.

Sundance said that its officials had been visiting the company's Mbalam iron ore project in Cameroon and Congo and meeting with government representatives from both countries.

The airplane was operated by Aero Service, which — along with all other air carriers certified in the Republic of Congo — is named on the European Union (EU) "blacklist" of air carriers prohibited from operating in the EU because of safety concerns.

Flight Safety Foundation earlier this year launched its Basic Aviation Risk Standard (BARS) program, aimed at establishing common safety standards for aviation operators that serve the mining and resources industry. Many of these operators work in areas with inadequate infrastructure and inconsistent safety standards, and before the BARS program was introduced, resource companies had no clear industry benchmarks for evaluating the safety of operators hired to transport their employees.


© Fotero/Flickr

NextGen Milestones

The U.S. Federal Aviation Administration has reached what FAA Administrator Randy Babbitt calls a major milestone in developing the Next Generation Air Transportation System known as NextGen.

Babbitt referred to the FAA's announcement of performance requirements for the aircraft tracking equipment that will be required under NextGen. The avionics will enable increased accuracy in controlling and monitoring aircraft with automatic dependent surveillance–broadcast (ADS-B). Aircraft in some airspace will be required to broadcast their positions via ADS-B Out capability by 2020.


© James Thew/iStockphoto.com

Babbitt noted that the technology "represents another step forward in our ability to make America's skies the safest in the world."

The U.S. Transportation Department Office of Inspector General, however, said that "a number of critical actions" are required to successfully implement NextGen.

"Among them, and perhaps most important now, is setting realistic expectations and firm requirements for what can be achieved in the mid-term and assessing associated risks," the Inspector General's Office said in a report issued in mid-June. "Thus far, FAA has not fully leveraged partner agencies' existing research and development that could significantly enhance NextGen development and reduce costs. While FAA has made some progress in engaging the private sector to develop NextGen and shape related policies, it must … ensure demonstration projects are more outcome-focused."

In Other News …

Officials from the European Union and the Latin American Civil Aviation Commission have signed two joint declarations calling for increased **cooperation** between the two regions. They agreed to identify more specific actions before the end of 2010. … **Earl Weener**, a Flight Safety Foundation fellow and former chief engineer at The Boeing Co., and **Mark Rosekind**, chief scientist and president of Alertness Solutions, a fatigue management consulting firm, have been sworn in as members of the U.S. National Transportation Safety Board. … Australia has allocated AU$14.5 million for transport safety authorities to continue their efforts to help strengthen aviation safety in **Indonesia**. Their work is aimed at improving the enforcement of higher safety standards in Indonesia's aviation and maritime sectors.

Compiled and edited by Linda Werfelman.

The Foundation would like to give special recognition to our Benefactor, Patron and Contributor members. We value your membership and your high levels of commitment to the world of safety. Without your support, the Foundation's mission of the continuous improvement of global aviation safety would not be possible.

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Experienced airline pilots have evolved strategies against automation complacency.

BY HEMANT BHANA

TRUST *but* VERIFY

Automation refers to control of a process or system by a machine or electronic device. Each automated system requires a different level of monitoring by the user. Some require extensive operator input and monitoring, while others are almost completely independent. For example, entering an elevator car and selecting the desired floor requires minimal monitoring. Once the operator selects a floor, the elevator starts a complex process that delivers the car to the desired location and opens the doors when appropriate — all with minimal operator involvement.

Human-machine researchers have defined eight levels of automation, ranging from systems where the operator must

One of the dominant themes that emerged was a wide-ranging lament about the effect of automation on maintaining hand-flying skills.

do everything with little help from the automation to those where the automation does everything, ignoring the operator.[1] In aviation, automation designed for pilots falls in the middle of this spectrum. This automation level "executes the suggestion automatically, then necessarily informs the human."[1] Aviation's position along the spectrum has fluctuated over time as avionics and airplane systems have advanced. Compare an early model Boeing 727 with the new Boeing 787. The 727, introduced into airline service in 1964, required extensive pilot involvement and contained modest automation. This level of automation tasked the pilots with computing almost every performance and navigation solution. In comparison, the 787's advanced flight management system (FMS) can compute solutions far more accurately than a human can, and is more in line with the machine performing the actions while advising the operator.

As automation has gained in sophistication and systems integration, the role of the pilot has shifted toward becoming a monitor or supervisor of the automation. Instead of actively controlling many of the processes, pilots are increasingly tasked with evaluating the computed solution and either stopping automated control or allowing it to continue. The paradigm shift is significant, as it requires a different pilot skill set to be added to the traditional "stick and rudder" skills.

Pilots now need to learn new coping and automation management techniques to quickly and accurately interpret the high volumes of automation-generated data in real time and turn them into useful information. The trend on the level of automation will continue in only one direction. With the proliferation of automation-centric technologies such as RNP/AR (required navigation performance/authorization required),[2] any idea of "un-automating" aircraft will not be practical if the aviation industry is to meet its goals of increased airspace system capacity, noise mitigation and carbon-emission reduction.

Measuring pilot attitudes about automation and collecting information about automation coping strategies were part of a study by the author on how boredom affects automation complacency in modern airline pilots.[3,4] The survey used in the boredom study contained several open-ended questions to pilots about how they perceived the automation and what individual coping strategies they used in connection with it.

The sample group of 273 airline pilots was roughly 4.5 percent of the total pilot population in the major airline from which the sample was drawn. Each pilot was experienced in a highly automated aircraft. The bulk of the sample group — 54.4 percent — were between the ages of 41 and 50, with the next highest group — 28.1 percent — between the ages of 51 and 60. Thirty-six percent flew wide-body aircraft internationally. Finally, 76.8 percent had flown their airplane type for more than two years — which, significantly, allowed time for the pilots to become comfortable in it and establish individual automation attitudes and coping strategies.

Attitudes About Automation

One of the dominant themes that emerged from the question about automation in general was a wide-ranging lament about the effect of automation on maintaining hand-flying skills.

Of the 105 responses to this question, 33 percent indicated that a degradation of traditional flight skills is a significant issue in their daily flying, including how they deal with increasingly complex aircraft and operations. One pilot wrote, "As I hand-fly less, I become more dependent on the automation." Another pilot described a side effect of automation dependency: "When the automation screws up, trying to play catch-up is hard to do because most pilots have relaxed too much and are not 100 percent in the loop as to where they are." Yet another wrote, "Too many of my co-pilots fly with automation way too much. Their skills suffer from not hand-flying as much as they should."

A pilot said, "As experience levels decrease overall in many companies, the automation and the decrease in 'hand-flying' training will continue to kill crews and passengers." One pilot described the role change: "It has forced us to become system monitors more than pilots. I must force myself to be actively engaged. Huge decrease in job satisfaction."

A pilot summed up the unwanted effect of automation: "I am a line check airman with 36 years in high-performance jets. The majority of pilots that I fly with do not back up the automation with raw data. Basic airmanship has dropped out of the training program. This is reflected by complacency on the flight deck and an unwarranted trust in the automation."

The level of trust that a pilot can place in automated systems emerged as an issue in roughly 16 percent of the 105 responses on the subject. One principal factor that influences the level of trust is the perceived reliability of the system in question.[5–7]

Mistrusting Automation

Reflecting on this issue, one pilot said, "I use automation but I don't trust it." Other pilots echoed this sentiment in comments such as, "I try never to totally trust the automation, and I make every attempt to verify that the automation is doing what I expect." One pilot reported treating automation as if it were "a student pilot." Another pilot's attitude toward automation was to "very seldom let the aircraft automation fly the approach."

The level of trust guides the level of automation usage when the complexity of a system or time available prevents complete understanding of the nuances of an automated system. By deliberately mistrusting the automation, pilots bias their attention toward actively monitoring the automated system rather than assuming correct operation and focusing attention elsewhere. Many pilot comments reflected that the perceived reliability of the automated system directly affected the trust they had in that system and their level of vigilance. In situations prone to automation errors — in other words, poor reliability — the trust decreased, leading to increased vigilance and monitoring. For example, automation mode transitions were reported to be a frequent error source resulting in specific coping strategies.

One pilot spoke of "treating the automation like a bad copilot and watching everything the airplane is doing while in 'transitional' mode." Another said, "Trust but verify, pay attention to detail, expect the unexpected, be suspicious when things are going too smoothly."

Several pilots reported consciously verbalizing automated modes as a means of heightening their vigilance and automation situational awareness. They expressed this in such comments as: "With every button push, whether FMC [flight management computer] or autoflight, a confirmation is made verbally"; "Audible callouts, point and say"; "Verification for the other pilot, verbalizing what I observe"; and "Verbalize to the other pilot so he looks also." This strategy effectively moves automation operation out of the automatic-task domain, where operation occurs subconsciously, into the high cognitive processing area of conscious thought.

Of all the comments by pilots, enhanced vigilance brought about by suspicions about reliability was the most common. A pilot commented, "I never trust automation for altitude capture. I assume it is going to fail." Another pilot said, "I think it is very important to have personal cross-check and habit patterns where you program the FMS or MCP [mode control panel] and then verify on the FMA [flight mode annunciator]. I don't think SOPs [standard operating procedures] do enough. Some pilots are very good at cross-checking, and some don't perform it at all."

Skepticism about automation led to various pilot coping strategies.

Automation Degradation and Hand Flying

Instead of trusting the automation always to work as advertised, many of the pilots in this study deliberately used less-complex alternative automation modes or different techniques to achieve the same result and remain actively engaged in the flight. One pilot said, "I like to use different modes of automation to monitor the progress of the flight. For example, on the B-737, one can engage the autopilot without the flight director on, using 'control wheel–steering' and pitch. I'll use these modes to 'capture' the programmed VNAV [vertical navigation] and LNAV [lateral navigation] modes while monitoring the FMAs on the electronic attitude direction indicator. This requires more of my attention, is more 'hands on' and thus keeps my situational awareness at a high level."

Other remarks added to the theme of downgraded automation usage. For example, "Very rarely do I let VNAV descend the plane. I will use vertical speed or level change"; "I fly with the flight directors off to stay mentally sharp and in the game. Also, autoflight and autothrust are off a lot, too"; and "I prefer VSPD [vertical speed] to VNAV for descents, utilizing the green arc [a display symbol that shows where the aircraft will reach the selected altitude]."

The benefits of such pilot strategies include less boredom and more vigilance, that is, maintaining attention for long, uninterrupted periods.[8] Conventional theories on why vigilance suffers over time — the decrease begins after approximately five minutes — used to revolve around the monotony of the activity. Recently, cognitive scientists have determined that vigilance varies directly with the complexity of the task.[7] The more cognitively demanding a task is, the more likely the user is to "load shed" and assume correct automation operation instead of allocating the necessary mental resources to monitor it.

Compared to hand-flying an aircraft, reading, interpreting and acting on automation-related information is a far more cognitively intensive process. Cognitive scientists consider reading and interpreting information a high cognitive task and hand-flying an automatic task. In the automatic-task realm, manual control occurs at a subconscious level, can occur in parallel with other activities and can occur very rapidly. For example, if airline pilots need to adjust pitch attitude during a hand-flown approach, they do not need to go through the entire decision-making process — the correction occurs subconsciously and automatically. Contrast this with high cognitive processing, which forces a pilot to think through each individual interaction with the automation. Interestingly, the task that requires the greatest amount of high cognitive function is monitoring items such as aircraft status.[9]

To lower the level of mental processing required, many pilots choose to hand-fly at times when they could rely on the automation. One pilot summed up this concept: "The more complicated the 'button pushing' becomes, the sooner I disconnect the auto systems, including the autothrottles." Another wrote, "When I become task saturated with programming automation, I click off the autopilot and fly the airplane!"

The data in this survey support the anecdotal comments. Of the entire sample group, 85.3 percent hand-fly as much as possible, consistent with weather and fatigue factors. Only 17 respondents in the survey sample, or 6.2 percent, turned the automation on as soon as possible after takeoff, while 33 pilots, or 12.1 percent, kept the automation on as long as possible. Pilots who chose to hand-fly preferred varying autopilot engagement and disengagement altitudes (Table 1).

Embracing Traditional Skills

Despite their highly automated fleet, pilots surveyed often suggested a deliberate embrace of traditional aviation skills.

Altitudes Chosen for Engaging and Disengaging Autopilot

Autopilot selected **ON** after departure N = 245	5,000 ft AGL	10,000 ft AGL	FL 180	FL 250	FL 290	Cruise Altitude
	2.4 percent (6)	6.9 percent (17)	49.0 percent (120)	18.8 percent (46)	5.7 percent (14)	17.2 percent (42)
Autopilot selected **OFF** during arrival N = 231	**FL 290**	**FL 180**	**15,000 ft**	**10,000 ft AGL**	**5,000 ft AGL**	**3,000 ft AGL**
	2.6 percent (6)	9.1 percent (21)	9.5 percent (22)	30.7 percent (71)	25.1 percent (58)	23.0 percent (53)

AGL = above ground level; FL = flight level

Note: Percentages are based on a survey of pilots at one U.S. air carrier.

Source: Hemant Bhana

Table 1

Many said they are refocusing on their manual skills and leveraging their experience in less-automated airplanes to help them cope with the advanced automation. According to the pilot observations, an effective strategy has been to apply traditional skills as a backup to the automation. One pilot said, "I call it flying the autopilot. I don't work as much when watching the flight director bars as I do watching the words and mode changes along with the mode control panel and mode settings/requested changes."

One pilot recalled a lesson from instrument training: "At every point the aircraft changes course, speed or altitude, such as waypoints or TOD [top of descent] points, I do a 'six T' check. Time — is it accurate to the plan? Turn — what direction and NAV [navigation] mode? Throttles — are the autothrottles behaving as planned? Twist — is there something that needs to be programmed, such as the missed approach altitude at glide path intercept on the ILS [instrument landing system]? Track — what course am I tracking to, is NAV engaged correctly? Talk — is there a checklist the crew needs to run, is there a call to ATC [air traffic control], is there a frequency that needs to be preloaded in the radio?"

Many pilots referred to the fundamentals of flying in their comments regarding individual coping strategies. One wrote: "Cross-check left, right and center instruments. Read aloud FMAs, assigned climb and descent altitudes. Engage autopilot to improve monitoring ability. Disengage and hand-fly whenever I can't immediately resolve why it's not doing what I want it to do."

Many pilots seem adept at blending non-automated habits with automated flight control. One pilot described using traditional methods of verifying waypoint arrival times and fuel burn to compare with the automated solutions. The pilot also uses them as a reminder to check other automation-generated solutions: "Cross-check and confirm glass [navigation display] and switch selection with clearance. Tie existing habits in with new automation requirements such as checking ACARS [aircraft communications and addressing system] 'howgozit' [an automated printout tracking waypoint arrival times and fuel burn] reasonableness along with fuel balance, RVSM [reduced vertical separation minimums] altimeter check (all three), and FMC waypoint clearances — all done at the same time."

Crew Resource Management

One of the more common threads in the comments by the 273 pilots surveyed involved effective crew resource management in coping with the challenges of automation. In addition to verbalizing automation mode changes, many pilots in the sample deliberately sought confirmation and clarification from the other pilot about automation-related actions. This technique is useful in keeping both pilots aware of the current and impending actions of the machine, and provides an effective safety net against possible input errors. Moreover, this technique fosters open communication on the flight deck and enhances situational awareness. Pilots said, "If I'm unsure why the airplane is doing something, I make sure to verbalize it to the other pilot"; "Verify FMS with the other pilot every time a change is made"; and "Confirm proper programming with the other pilot."

Addressing the Downside

The comments from this sample group indicated strong coping mechanisms and good automation habits to address the downside of advanced automation. Many of the pilots said they developed these strategies independently of airline- and airplane-specific training, reflecting the experience gained and lessons learned after years of daily usage.

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When Lightning Strikes

Aircraft designs incorporate systems to protect against direct and indirect damage.

BY CLARENCE E. RASH

Understanding the mechanisms and consequences of lightning strikes on aircraft has been a decades-long learning experience.

When the first known lightning-caused airplane accident occurred in 1929, scientists and aeronautical engineers initially insisted that lightning played no part in the crash — and that there was "no proved instance of an airplane ever having been struck by lightning."[1] Over time, the experts of the 1920s were proved incorrect — aircraft lightning strikes occur frequently, although they rarely are associated with accidents.

Lightning is a discharge of electricity that occurs in the atmosphere and can be thought of as a high-current — about 20,000 amperes — electric spark associated with thunderstorms.

Lightning is produced when supercooled liquid and ice particles above the freezing level collide and build up large and separate regions of positive and negative electric charges in the clouds. After these charges become large enough, a giant "spark," or discharge, occurs between them, lasting less than a tenth of a second. The spark — lightning — can occur between clouds, between sections of a single cloud, between the cloud and air, or between the cloud and the ground — or some object on the ground.

The most common type of lightning discharge is cloud-to-ground, or "negative" lightning, which accounts for 90 percent of all lightning strikes. The discharge usually begins when a significant difference develops between the negative charge in the cloud and the positive charge on the ground — or in another cloud. At this point, the negative charge begins moving toward the ground, forming an invisible conductive path, known as a leader stroke. This leader stroke descends through the air in discrete zigzag steps, or jumps, each approximately 150 ft (46 m) long. Concurrently, a positively charged streamer is sent out from the positively charged ground or other cloud. When the leader and the streamer meet, an electrical discharge — lightning — takes place along the streamer, up and into the cloud. It is this return stroke that is the most luminous part of the lightning discharge, usually the only part of the lightning process that is actually seen.

Another type of lightning — known as "positive lightning" because there is a net transfer of positive charge from the cloud to the ground — originates in the upper parts of a thunderstorm, where a high positive charge resides. This type of lightning develops almost the same way as negative lightning, except that the descending stepped leader carries a positive charge and the subsequent ground streamer has a negative charge. Positive lightning accounts for less than 5 percent of all lightning but is much more powerful, lasts longer and can discharge at greater distances than the more common negative lighting.

Global Pattern

Lightning is a global phenomenon. Flashes have been seen in volcanic eruptions, intense forest fires, heavy snowstorms and large hurricanes; however, it is most often associated with thunderstorms.[2]

While global in occurrence, lightning is not uniformly distributed geographically. About 70 percent of all lightning flashes occur between 30 degrees N and 30 degrees S latitudes — not surprisingly, in the tropics, where most thunderstorms occur. In addition, lightning over land, or over water that is close to land, is 10 times more frequent than lightning over oceans.[3]

Every 1,000 Flight Hours

Until the past decade, when information-gathering became more effective, detailed data on lightning strikes to aircraft were difficult to obtain.[4]

However, when the extraordinary frequency of lightning is considered in concert with the frequency of flight — estimated at 77 million aircraft movements worldwide in 2008[5] — it can be no surprise that aircraft lightning strikes occur relatively often. The French Office National d'Etudes et Recherches Aérospatiales (the national aerospace research center) estimates that an aircraft is struck by lightning on average every 1,000 flight hours — for commercial airlines, the equivalent of one strike per aircraft per year (Table 1, p. 21).

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Scientists estimate that aircraft are struck by lightning on average once every 1,000 flight hours.

While more study is needed, current evidence points to altitude as a factor in lightning strikes. Current data show there are more lightning strikes at intermediate altitudes (8,000–14,000 ft) than at cruise altitudes.[6] Other leading factors in the probability of a lightning strike include being inside a cloud (90 percent) and/or the presence of rain (more than 70 percent).

An aircraft lightning strike is often attributed to "being in the wrong place at the wrong time" — in other words, getting in the way of a lightning discharge. But estimates are that such a scenario accounts for only 10 percent of aircraft lightning strikes. Actually, almost 90 percent of aircraft lightning strikes are self-triggered, as when an aircraft flies through a heavily charged area of clouds — a fact not known until the 1980s.[7]

Fortunately, although aircraft lightning strikes are not uncommon, accidents in which lightning has been identified as a primary or contributing cause are.

Searches of accident databases and historical records maintained by various aviation agencies, historical societies and lightning safety organizations produce a diverse listing and history of incidents and accidents that have been attributed to lightning strikes.

Based on these searches, the first aviation accident attributed directly to a lightning strike occurred Sept. 3, 1915, when a German Zeppelin LZ40 (L10) was destroyed by a lightning strike while venting hydrogen gas off Neuwerk Island, Germany.[8] From 1915 through the early 1920s, a number of airship accidents were attributed to lightning strikes.

The Sept. 3, 1929, crash of a Transcontinental Air Transport Ford Tri-Motor named the "City of San Francisco" usually is cited as the first heavier-than-air aircraft destroyed by a lightning strike. All eight occupants died when the airplane struck the ground near Mt. Taylor, New Mexico, U.S., on the Albuquerque-to-Los Angeles leg of a cross-country journey divided into airplane and train segments.[9]

Over the next few decades, only a dozen or so additional accidents were attributed to lightning strikes; in many of those cases, however, lightning was not firmly established as the cause.

The earliest lightning-related accident for which a detailed description is available involved a U.S. Air Force Curtiss C-46D transport plane en route from Dallas to Jackson, Mississippi, U.S., on June 14, 1945. While at 3,000 ft, one wing was struck by lightning. Unable to maintain altitude, the aircraft crashed into a wooded area.[10]

Nearly two decades later, in what often is cited as the first positive lightning strike-induced accident involving a commercial aircraft, a Pan American World Airways Boeing 707-121 crashed on Dec. 8, 1963, while in a holding pattern awaiting clearance to land in Philadelphia after a flight from Baltimore. Accident investigators determined that the lightning strike had ignited fuel vapors. As a consequence of the ensuing investigation by the U.S. Federal Aviation Agency — a precursor of the Federal Aviation Administration (FAA) — devices known as lightning discharge wicks were ordered to be installed on all commercial jet airliners.

The U.S. National Transportation Safety Board (NTSB) Accident/Incident Database from Jan. 1, 1962–April 30, 2010, included 58 events in which lightning — but not necessarily a lightning strike — was cited as a major or contributing causal factor. All of the reports involved commercial or private aircraft, with the exception of one accident involving a balloon.[11]

In those 58 reports, the role of lightning is categorized as follows:

- Forty-one events involved actual lightning strikes to an aircraft during flight.
- Two events involved an aircraft while on the ground. One airplane was struck by lightning, and the other was involved in a taxiway accident attributed to a communication breakdown after ground personnel removed their headsets because of lightning in the area.
- Five events involved nearby lightning strikes that impaired either the pilot's vision or ability to control the aircraft.
- Three events involved lightning-related ground equipment failures that led to accidents during landing. Two of these involved the loss of runway lights, and one involved the loss of air traffic control capability.
- Seven accident/incident reports cited lightning as a weather factor contributing to an accident but did not describe its actual influence.

The 58 incidents and accidents resulted in 202 fatalities and 46 injuries, most of which were associated with two accidents:

- The Aug. 2, 1985, crash of a Delta Air Lines Lockheed L-1011-385 in Dallas/Fort Worth, which killed 135 and injured 30 passengers and crew. Lighting was cited as a contributing factor.[12]
- The July 23, 1973, crash of an Ozark Air-lines Fairchild FH227B in St. Louis, which killed 38 and injured six passengers and crew. A lightning strike on final approach was cited as a probable cause.[13]

Also among the 202 fatalities was an aircraft marshaller who was wearing a headset connected to a McDonnell Douglas DC-9-31 when it was struck by lightning on Oct. 7, 1989, while being pushed back from a gate in preparation for takeoff from Orlando International Airport.[14]

Of the 41 reports involving a confirmed lightning strike that resulted in an accident or an incident, 28 aircraft — 68 percent — landed safely. All sustained at least minor damage.

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Lightning Effects

Both the occupants of an aircraft and the aircraft itself are subject to the powerful effects of a lightning strike. The inherent structural design of an aircraft provides the occupants almost complete protection despite the massive amount of current involved. This protection is based on the principle known as the Faraday

Lightning … By the Numbers

1,800	Number of thunderstorms in progress worldwide at any given moment
40–100	Average number of lightning flashes each second worldwide
20,000	Number of amperes (amps) of current in a typical lightning discharge
60 ft (18 m)	The distance lightning energy can spread from the strike point
1:750,000	Odds of being struck by lightning in a given year
1:6,250	Odds of being struck by lightning in a lifetime (80 years)
1:28,500	Odds of being killed by lightning
24,000	Average number of deaths per year due to lightning worldwide
240,000	Average number of injuries per year due to lightning worldwide
58	Average number of deaths per year due to lightning in the United States
500	Average number of injuries per year due to lightning in the United States
90	Percentage of lightning-strike victims who survive

Sources: U.S. National Weather Service "Medical Aspects of Lightning," National Oceanic and Atmospheric Administration. <www.lightningsafety.noaa.gov/medical.htm>.

National Lightning Safety Institute. "Fast Facts About Lightning." <www.lightningsafety.com>.

Table 1

cage, first devised by the physicist Michael Faraday in 1836.

A Faraday cage is a hollow enclosure made of conducting material, such as the hull of an aircraft. In the presence of a strong electric field, any electric charge will be forced to redistribute itself on the outside enclosure, but the space inside the cage remains uncharged. Thus, the metal hull of the aircraft acts as a Faraday cage, protecting the occupants from lightning.

Some aircraft are made of advanced composite materials, which — by themselves — are significantly less conductive than metal. To overcome this resulting safety problem, a layer of conductive fibers or screens is imbedded between layers of the composite material to conduct the lightning current.

Regardless of hull material, the direct effects of lightning on the exterior can also include:[15]

- Burning or melting at lightning strike points;
- Increase in temperature;
- Residual magnetism;
- Acoustic shock effects;
- Arcing at hinges, joints and bonding points; and,
- Ignition of fuel vapors.

Accident data indicate that most of these effects are not serious. However, an estimated one-third to one-half of aircraft lightning strikes result in at least some minor damage.[16] Lightning generally enters an aircraft at one location, usually an extremity, and leaves at another. Burn marks are found at the entry and exit point(s) of the strike, although exit points are not present if the energy was dissipated via wicks or rods — static dischargers whose primary purpose is to bleed off into the surrounding air the static charge buildup that occurs during normal flight.

Because many aircraft fly a distance equivalent to several times their own lengths during a lightning discharge, the location of the entry point can change as the discharge attaches to additional points aft of the initial entry point. The location of the exit points may also change. Therefore, for any one strike, there may be several entry or exit points.

Occasionally, in more severe strikes, electrical equipment or avionics may be affected or damaged. This potential problem is addressed in modern aircraft design by redundancy. The functions of most critical systems are duplicated, so a lightning strike is unlikely to compromise safety of flight. In most strike events, pilots report nothing more than a temporary flickering of lights or short-lived interference with instruments.

The exception is the incidence of positive lightning. Positive lightning strikes — because of their greater power — are considerably more dangerous than negative lightning strikes. Few aircraft are designed to withstand such strikes without significant damage.[17]

Protection Methods

Careful flight planning and the use of weather radar help limit an aircraft's exposure to lightning. It is a good safety practice to avoid by at least 20 nm (37 km) any thunderstorm activity that provides a strong radar echo.

Aviation regulatory agencies worldwide have established certification standards that call for an aircraft to be able to withstand a lightning strike and continue flying to land safely at a suitable airport. In addition, modern aircraft designers employ a number of effective lightning protection systems that address possible direct and indirect damage from lightning strikes. These systems are intended to provide preferred paths for the electric current associated with a lightning discharge to enter and exit the aircraft without causing damage to the aircraft or injury to its occupants.[18] These systems can be divided into three general categories of protection: airframe and structure protection; fuel system protection; and electrical and electronic systems (avionics) protection.

The primary goal of airframe and structure protection is to minimize and control lightning entry and exit points. The first step is to identify locations (or zones) of greatest vulnerability to lightning strikes. For most aircraft, these zones, in decreasing vulnerability, are the radome and wing tips, the bottom of the fuselage and the area under the wings.

The second step is to ensure that acceptable discharge pathways are available at these potential entry points and that these pathways adjoin preferred exit points on the aircraft. To a great extent, this is achieved via the electrically conductive hull of the aircraft. In the outer hull design, it is important that conductive bonding strips electrically bridge any gaps between sections, thereby reducing potential arcing.

Preferred exit points at the tips of the wings, stabilizers and fins should be equipped with static dischargers — wicks or rods. These static dischargers are not lighting arrestors, however, and they do not reduce the probability of an aircraft being struck by lightning. Nevertheless, if lightning does strike, chances are that the electricity will go through the discharger rather than through the aircraft.

Fuel System

The primary goal of fuel system protection is to prevent the ignition of fuel vapors.[19] Fuel tanks and associated systems must be free of potential ignition sources, such as electrical arcs and sparks. All the structural joints, hinges and fasteners must be designed to prevent sparks as current from the lightning discharge flows from one section to another. The aircraft skin near the fuel tanks also must be robust enough to prevent burn-through by a lightning strike.

A second aspect of fuel system protection involves the fuel itself. Advances in fuel development have resulted in fuels that produce less explosive vapors. Fuel additives that reduce vapor formation also are available.

Avionics

Today's aircraft are equipped with miles of wiring and an abundance of computers and electronic systems, so most lighting protection methods are designed to protect the current-sensitive avionics systems. Flight-critical and essential equipment must be able to function in the aftermath of both the direct and indirect effects of lightning strikes.

As current from a lightning strike travels along the exterior of an aircraft, it can induce transients — temporary current oscillations — into adjacent wires and electronic equipment. Shielding, grounding and surge suppression are the most common techniques used to avoid this problem.[20] Shielded cables are wires enclosed by a common conductive layer (the shield) that acts as a Faraday cage. Shielded cables in aircraft may have two shields — an outer shield for lightning protection and an inner shield that eliminates unwanted electromagnetic interference (EMI).

Surge suppression is used to limit rapid increases in voltage that are significantly above the normal level for an electronic circuit or system. Rapidly increasing voltages can result in electrical arcing that melts one or more components, effectively destroying the circuit. Surge protection works by diverting the increased power to a grounding line.

Every circuit and piece of equipment that is essential to safe flight must be protected against lightning in accordance with regulations established by civil aviation authorities.

Studies have shown that aircraft incorporating lightning and EMI protection have had a significantly lower percentage of electrical failures and interference caused by lightning strikes.[21]

If a lightning strike occurs, a post-lightning inspection of the aircraft is critical. The most important step is to thoroughly inspect the aircraft for burn spots and pitted areas that potentially identify entry and exit points. Evidence of arcing should be investigated, especially near hinges and bonding strips. A thorough check of all critical and essential avionics should be performed. Additional procedures, as listed in the aircraft's maintenance manual, should be followed.

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U.S. National Transportation Safety Board

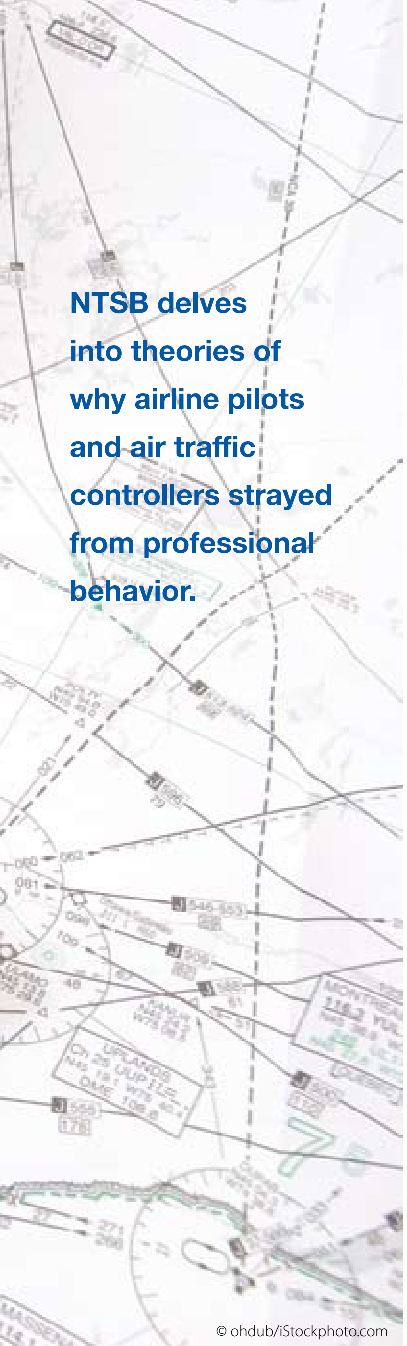
Out of Bounds

BY WAYNE ROSENKRANS

Despite having the benefit of insights from 45 people of diverse expertise, the U.S. National Transportation Safety Board (NTSB) has not settled on systemic explanations for instances in which airline pilots and air traffic controllers flouted regulations and standard operating procedures (SOPs). Potential elements of safety recommendations have emerged, however.

In remarks at the NTSB's Professionalism in Aviation Safety Forum on May 18–20 in Washington, Chairman Deborah A.P. Hersman cited seven U.S. accidents and serious incidents in 2004–2009 involving breakdowns in professionalism.

"We recognize that there are many industry professionals whose work, day-in and day-out, reflects the highest level of professionalism," Hersman said. "While the Colgan Air [Flight 3407] accident investigation [*ASW*, 3/10, p. 20] was the impetus for this forum, many of the issues raised in that accident investigation were not new to the NTSB. … The



NTSB delves into theories of why airline pilots and air traffic controllers strayed from professional behavior.

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PROFESSIONALISM IN AVIATION

Ensuring Excellence in Pilot and Air Traffic Controller Performance

evidence is clear that when pilots and controllers drift away from their training, procedures and best practices, safety margins erode and inadvertent errors go uncorrected. Things are happening in industry that have led us to this point — errors and practices that warrant closer scrutiny. … Defining professionalism and creating a culture of professionalism … is what the NTSB will be focusing on over the weeks and months to come."

Most forum panelists offered personal views, not positions of organizations, as the NTSB asked them about opportunities to strengthen defenses against deficiencies such as lapses of discipline, distractions and deviations, including flight crews engaged in conversations and activities not pertinent to aircraft operation during critical phases of flight; lax, casual or unfocused atmosphere on the flight deck; inexplicable deviations from SOPs; self-centered behavior; substandard airmanship; loss of situational or positional awareness; reluctance of pilots to challenge each other's deviations; and equivalent behaviors in the air traffic control (ATC) profession.

Soft skills of discipline, responsibility, judgment, emotional stability, effectiveness under pressure and leadership are "what assures us that once that cabin door is closed, that cockpit crew is acting professionally and doing what we want them to do in a safe manner," said Randall Hamilton, a captain and director of training at Compass Airlines.

Pilot Accountability

In the forum's keynote presentation, Tony Kern, CEO and senior partner of Convergent Performance, suggested that the pendulum in safety theory has swung too far in accepting human error as uncontrollable, and has diminished personal accountability. He said he typically advises airline clients to increase their emphasis on personal flight discipline and airmanship.

"If you believe the researchers, hundreds — maybe thousands — of mistakes and casual noncompliance [instances occur] without a single negative outcome," Kern said. "Is it any wonder that we have a slight erosion [of personal responsibility] in an industry that has highly repetitive, highly automated systems where everything goes right nearly all the time, right up to the moment when it doesn't?"

Aviation professionals have to be inspired and motivated to practice introspection, self-management and ethical behavior along with training to master technical systems, procedures, tactical skills and information, he said.

Some panelists echoed the importance of intangible personal qualities. "Professionalism really starts with the pilot's value system … early in life," said John Rosenberg, a captain and check airman for Delta Air Lines and chair of the National Professional Standards Committee of the Air Line Pilots Association, International (ALPA). "It is a dedication to striving for mastery."

Others framed each individual's responsibility for professionalism based on their personal experience in applying the prevailing theories of aviation human factors. "There is no perfect flight; I have never done one," said Ben Berman, a captain-rated first officer at Continental Airlines and senior research associate in flight crew human factors and cognition at the Ames Research Center of the U.S. National Aeronautics and Space Administration (NASA), who explained that most errors can be traced to human cognitive limitations. "I always try, but I have never seen one. … Every flight has literally thousands of opportunities for flight crews to make errors in one way or another, and there is always an error that creeps in. … And so these errors are, in a sense, related to the way we are wired and not so much to the way we handle ourselves in terms of professionalism. … Even though we have the standards, we still make errors … we self-correct, accept corrections by others and always strive to improve; that is professionalism for captains and first officers."

The First Step

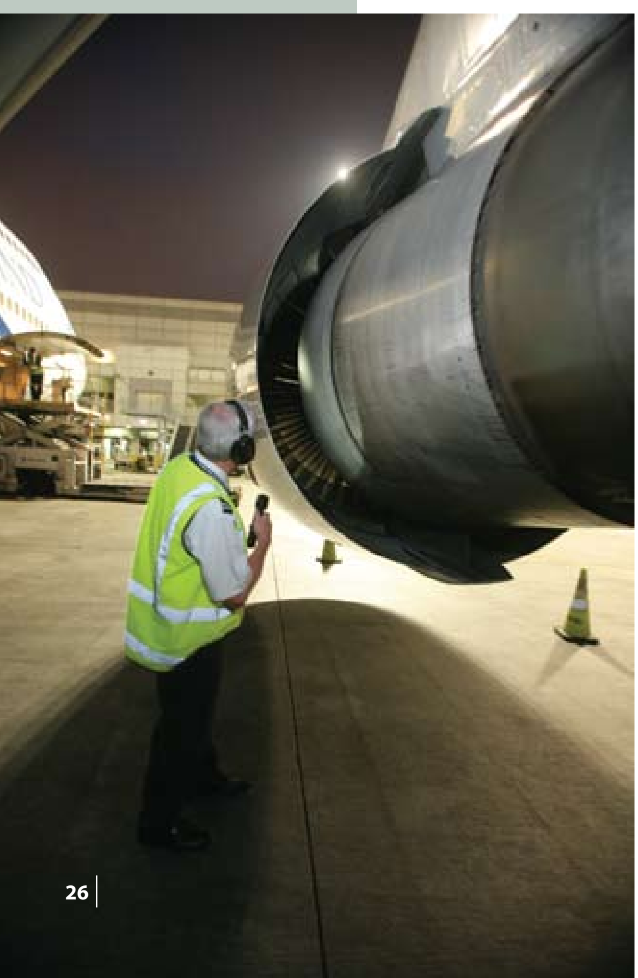
A number of panelists and NTSB members concurred that careful screening and selection of ab initio students and experienced airline pilots is the foundation of safe performance and professionalism. One challenge has been the difficulty of finding legal and scientifically valid selection instruments — that is, tests and interview questions that can be used to deny employment to an applicant — to deselect people. Some "personality tests" have been discarded as no longer valid in a society as diverse as that in the United States, said Diane Damos, president of Damos Aviation Services.

Attributes of professionalism must be instilled long before pilots are hired for the flight deck of an airliner, Continental's Berman said. "There are certain aspects of people that cannot be trained, and those need to be selected out," he said. "They cannot be allowed to join or to continue with an airline. When they [most] need to act professionally — make professional decisions to do the right thing — will be in the heat of things [an emergency]."

Forum panelists from airline pilot and ATC communities sometimes characterized professionalism as complying with SOPs when no one is there to observe.

Metrics of Professionalism

In major U.S. airlines, the likelihood of the same captain and first officer flying together more than once or twice has become remote. This makes excellent communication, trust and adherence to SOPs essential but may make mentoring socially awkward, several presenters and NTSB members agreed. One byproduct of mergers has been more first officers who are captain-rated and who have more experience than the pilot-in-command.



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NTSB Member Robert Sumwalt suggested that a new defense against lapses of professionalism might be increasing the social acceptance of mentoring among pilots. Ideally, any social discomfort would not impede either pilot's willingness to offer the other constructive input about best practices, compliance with SOPs or behavior.

A highly experienced pilot might fail to perform or behave as required because of diminished self-discipline, poor study habits or decline in personal motivation, said Paul Preidecker, chief instructor at Air Wisconsin. "If flight discipline and self-discipline are lacking, it will eventually show up in training," he said. "The measuring tools that we have for [soft skills of] professionalism are … not always clear."

The NTSB's Sumwalt asked for panelists' opinions of the feasibility of identifying specific attributes of professionalism and behavioral markers, and reaching a government-industry consensus about how to measure and apply them. "We need the industry to agree upon those attributes and then come up with the behavioral markers for the continuum — this is excellent, this is substandard," Sumwalt said. Such an agreement would enable pilots to be objective in assessing one another and in measuring themselves, he added.

'Pro Stan' Successes

Professional standards programs of pilot unions — open to all members but providing services relevant to the situations of very few — help pilots face professionalism issues through peer intervention by trained volunteer counselors. "Pro stan" services facilitate confidential discussion of a professional or ethical problem of any nature, including issues of attitude, motivation or compliance with procedures. Pilots typically, but not always, overcome such problems without entering a formal company process that may lead to disciplinary action, documentation in personnel records or termination of employment, said ALPA's Rosenberg.

Robert McDonnell, an American Airlines captain representing the Allied Pilots Association, estimated that professional standards committees of U.S. major airlines interact with fewer than 1 percent of their unions' members.

One serious safety issue addressed by counselors involved SOPs and compliance with the operating manual, and a pilot who repeatedly refused to respond to communication from them, McDonnell recalled. "This pilot was a little deficient, but because this was definitely a safety issue, we went to the chief pilot, who told him he was either going to be fired or retire early," McDonnell said. "The pilot decided to retire early. Once a chief pilot … and issues that involve safety are involved, there is no recourse but to bring in the Federal Aviation Administration [FAA] for certificate action … termination or early retirement."

Model Captains

Several pilot panelists told the NTSB that nothing has been more influential in maintaining professionalism in their own careers than flying with captains who modeled the "right" attitudes and behaviors to operate safely. Captains must continue setting the standard of professionalism to influence others, they said.

Chris Keinath, a Horizon Air captain and director of safety, was among panelists who expressed concern that some soft skills for coping safely with the demands of airline flying may not be transmitted to a new generation of first officers and captains, given their varied backgrounds. "This generation of new [civilian] pilots, in particular, has not heard of the concept of compartmentalizing [as taught to naval aviators]," he said. "As one of the lessons learned from this forum, maybe we … need to come up with an industry-accepted set of [skills] that should be added to the training curriculum."

Active monitoring and challenging of each other are critical safety tasks for a captain and first officer, Continental's Berman added. "To address the very tiny percentage of things not being done professionally, however, we have to make sure we don't shut down the flow of communication. … That would have more of a negative safety impact than all of the many safety threats out there that are not directly related to professionalism."

Air Traffic Control

In the ATC domain, FAA Air Traffic Organization (ATO) managers and National Air Traffic Controllers Association (NATCA) representatives told the NTSB that organizational change management — especially ongoing work to fully implement the Air Traffic Aviation Safety Action Program (ATSAP; *ASW*, 7/09, p. 9); a professional standards committee; a fatigue risk management system; and the Next Generation Air Transportation System (NextGen; *ASW*, 4/10, p. 30) — has a significant bearing on enhancing controller professionalism.

In April, teams from the FAA and NATCA began meeting to design the professional standards program. Plans call for its implementation in the third quarter of 2010 with termination in October 2012, subject afterward to collective bargaining, said Garth Koleszar, a NATCA representative and a controller at the Los Angeles Air Route Traffic Control Center.

In late 2010, the ATO also will institute an ATC quality control program, said Michael McCormick, acting executive director of the ATO Terminal Service Unit. "It will provide an ability to take a look at the performance of individuals, the organization and individual service delivery points to ensure [that the values, mission and level of professionalism are] consistent with our expectations of the organization," he said.

Professionalism is instilled at the FAA Academy, in closely supervised initial experience in ATC facilities, and in recurrent training, said Jennifer Allen-Tallman, manager of the ATO crew resource management program. "We literally go through the traits of an expert controller … the attributes of operating professionally in the control room." she said.

To read an enhanced version of this story, go to the FSF Web site <flightsafety.org/asw/jun10/professionalism.html>.

Professional behavior is instilled in German student air traffic controllers, as in their U.S. counterparts at the FAA Academy, on the Langen campus of Deutsche Flugsicherung, the air traffic services provider.

Obscured by Fog

When a cloud is not a cloud it becomes more of a hazard.

BY ED BROTAK

At 0841 local time on April 10, 2010, a Tupolev 154M passenger jet carrying the president of Poland, his wife and numerous government officials crashed about 1 km (0.6 mi) from the Smolensk Airport in Russia, killing all 96 people aboard. Short of the runway, the plane struck trees and broke apart. Preliminary reports say the flight crew had been warned of reduced visibility and was told to divert to another airport, and that they attempted the landing anyway. Regardless of whatever factor is eventually designated as the primary cause of the crash, fog clearly limited the airport's visibility.

Aviation accidents in which fog plays a major role often prove fatal. The worst aviation disaster of all time, the collision of two Boeing 747s in Tenerife, Canary Islands, involved fog. The captain of the departing aircraft and the traffic control tower could not see that the landing 747 was still on the runway, leading to the crash that killed 583 people.

To review the basics, fog is simply a cloud near or in contact with the earth's surface — usually flat ground. Low clouds that may obscure mountainous terrain generally are not defined as fog. For aviation interests, the point is moot since physically clouds and fog are the same thing — minute water droplets or ice crystals suspended in the air. With both fog and clouds, the water droplets or ice crystals are so small that gravity has a negligible effect, and thus they remain suspended. In fact, mountainous locations in the clouds simply report it as fog. For example, at the same time Seattle was reporting a visibility of 10 mi (16 km) and an overcast layer at 3,800 ft, nearby Stampede Pass, at an elevation of nearly 4,000 ft, was reporting ¼ mi (403 m) visibility and a vertical visibility, or ceiling, of 100 ft.

Fog occurs when a low layer of air becomes saturated and atmospheric water vapor begins to condense. There are two ways saturation and condensation occur in the atmosphere — moisture is added to the air, or the air is cooled. Cooling the air lessens its water-holding capacity. The dew point, a measure of moisture in the atmosphere, is the temperature at which saturation occurs. When the air temperature drops to the dew point, you have saturation, that is, 100 percent relative humidity. Condensation, the process of water vapor turning into liquid water, occurs instantaneously at this point, too.

At temperatures above freezing, fog is composed of tiny water droplets. "Freezing fog" occurs with temperatures below the freezing point but still consists of liquid fog droplets. This "supercooled water" also poses an icing problem for aircraft. At very cold temperatures — below 14 degrees F (minus 10 degrees

C) — ice fog is possible, with fog comprised of ice crystals.

Fog occurs from the Arctic to the tropics. Counterintuitively, even deserts are plagued by fog — cool water coastal deserts may go years without rain, but have fog nearly every day. Although many locations have seasons when fog is more prevalent, fog also can occur at any time of the year. Fog is most common in the morning hours, but it can occur at different times of the day, depending on location and conditions.

Meteorologists have classified six different types of fog based on the formation process. Ground fog — or radiation fog as it is officially called — is the most common type of fog. It can occur anywhere there is sufficient moisture in the air. It is most common in the early morning. After the sun sets, the earth's surface "radiates" heat out into space and cools. The layer of air just above the surface is cooled from below. If the temperature drops to the dew point, the air becomes saturated and condensation, or fog, will form. In fact, meteorologists often use the dew point to forecast fog. If the overnight low is forecast to drop to the dew point, fog is likely. In its lightest form, ground fog may only consist of wisps a few feet thick. In more extreme cases, the fog may have a vertical depth of several hundred to 1,000 ft. For pilots, a thin layer of ground fog may appear fairly transparent from above. But when viewing from the horizontal — for example,

Ideal conditions for ground fog formation include clear skies and light to calm winds.

when flying an approach — visibility can be drastically reduced since the pilots are looking through much more of the fog.

Ideal conditions for ground fog formation include clear skies and light to calm winds. The clear skies allow maximum radiational cooling. Light or no wind inhibits the mixing of different batches of air. In these situations, warmer air is above in an inversion condition. Mixing brings this warmer air down and slows the fog formation. However, the cool air is denser and tends to collect in lower elevations; valleys are prime locations for ground fog. When the sun rises, the ground and air warm and the fog begins rising. As the air mixes, it dries and the fog dissipates or "burns off."

A good example of radiation fog can be shown at Charleston, West Virginia, U.S., in the central Appalachian Mountains where dense fog is common in the fall. On Oct. 25, 2009, the high of 63 degrees F (17.2 degrees C) was reached at 1600 with a dew point of 36 degrees F (2 degrees C). There were clear skies, visibility of more than 10 mi, and calm winds. Temperatures fell quickly after sunset and reached 36 degrees F by 0300. Visibility was 8 mi (13 km), with wind still calm. By 0318, however, visibility had dropped to ¼ mi in dense fog. The temperature and dew point merged at 36 degrees F (2 degrees C). The fog persisted until 0800, when it burned off. Even during the foggy morning, occasionally light breezes increased visibilities to 6 mi (10 km), only to have them drop to 1/8 mi (201 m) a few minutes later. In Charleston, this cycle can persist for days in the fall. The fog usually lifts about the same time each morning.

In much of the mid-latitudes, ground fog is most common in the warmer months. Higher moisture content of the air and less wind are contributing factors. In some locations, a type of ground fog can develop in the winter. The worst situations involve valleys with extreme cold air flowing through. Sometimes the fog is so dense it reflects the heating rays of the sun, especially at higher latitudes. In these cases, the fog may persist for days. For example, at 2353 on Feb. 4, 1999, the Fairbanks Alaska airport reported 1/8 mi visibility in freezing fog. The temperature at the time was minus 42 degrees F (minus 41 degrees C), and these conditions persisted through the next day.

Frontal fog, obviously, is associated with fronts and primarily occurs in the cold season. Normally this type of fog occurs north of a warm front — south in the southern hemisphere — in the colder air. Occasionally, frontal fog occurs behind — to the north or west in the northern hemisphere — a cold front. Fronts have a vertical temperature structure that favors fog development, colder air under warmer air. The warmer air aloft is also moist. In frontal fog situations, there are often clouds above the fog deck and precipitation may be falling. This type of fog is usually widespread and consistent. It can occur day or night and persist for hours until the weather systems move. Snow on the ground often makes the fog worse, since it significantly cools the air while providing moisture from below.

Frontal fog can cause massive problems with aviation since its effects are so far reaching and last so long. On Jan. 23, 2010, a complex frontal system produced a warm, moist airflow which overrode colder air near the surface in the eastern half of the United States. Fog and low ceilings were reported from the southeast northward through the Ohio Valley and into the Midwest. Atlanta Hartsfield Airport reported visibilities of ¼ mi for nine hours. At the same time, the municipal airport in Mason City, Iowa, reported ½ mi (805 m) visibility in fog.

Another type of fog that often proves problematic to aviation is marine or sea fog. Marine fog forms over bodies of water when the water is colder than the air above it. This is a problem over some lakes in the summer and over ocean areas dominated by cold currents. In each case, the air is cooled from below by the cooler water. The cooling of the air in conjunction with the influx of moisture from below causes the fog to form.

Marine fog tends to be very thick and can be long lasting. It can alternately lift and descend, never really dissipating. When it lifts off the ground, it becomes a low stratus cloud deck. Although surface visibilities may improve, low ceilings are still an aviation concern. Any type of onshore wind brings this fog over land where it can cause great problems for coastal areas. If the wind shift is abrupt, visibility may drop quickly. If the wind shift is unexpected, pilots may be caught off guard.

In middle and higher latitudes, marine fog is primarily a summer occurrence. In tropical regions along cold-water coasts, marine fog is prevalent all year. The Tenerife accident occurred in a region known for marine fog. Although we normally associate marine fog with colder waters, it is the difference in the temperature of the air and water that is most important. Even warmer waters can initiate fog if the air above is warmer still. In the winter, a type of marine fog can occur with oceanic storms. For terminals near the coast, this can mean the dangerous combination of low visibility and strong winds. On Jan. 15, 2010, Astoria, Oregon, U.S., was in the warm sector of a strong winter storm. At one point, the airport reported ½ mi visibility in heavy rain and fog with southerly winds of 23 kt gusting to 41 kt.

Less of a problem for aviation is precipitation fog. Whenever rain or snow exists, some of it evaporates into the air and then recondenses as fog. This type of fog isn't very dense, and reductions in visibility due to the precipitation itself are more of a problem. Frontal fog and some marine fogs occur with precipitation, but this is a "true" fog not just formed by the precipitation. Visibilities in these cases can be reduced significantly.

Steam fog occurs when moisture evaporates from a surface and saturates the air above it. A simple example is when wet pavement, just after a rain when the sun comes back out, seems to have steam rising from it. Steam fog occurs over water when the water is warmer than the air above it. Usually steam fog does not cause great reductions in visibility. However, steam fog can produce icing when the air temperature is below freezing.

Upslope fog forms due to orographic lifting. When winds are blowing up a fairly gentle slope, condensation and fog can develop. This is fairly common in the Great Plains of the United States, when east winds occur in the winter. On Jan. 22, 2010, the interaction of a low-pressure area coming out of the Rocky Mountains and a high-pressure area near James Bay in Canada combined to produce a strong southeast air flow over the Central Plains. At North Platte, Nebraska, U.S., this combination resulted in ¼ mi visibility in fog with a vertical visibility of 100 ft. And the wind was blowing from 130 degrees at 16 kt, with gusts to 22 kt.

Fog combining with smoke produces some of the worst effects on visibility. Not only does the smoke reduce visibility on its own, but smoke particles act as condensation nuclei.

Fog combining with smoke produces some of the worst effects on visibility. Not only does the smoke reduce visibility on its own, but smoke particles act as condensation nuclei, accelerating the fog-making process. This often happens in the aftermath of a major wildfire. Even after the fire is controlled, smoldering remains can emit great amounts of smoke into the air. For example, in April, a major wildfire burned near North Myrtle Beach, South Carolina, U.S. Even though the fire was contained within 24 hours, for several days afterward the combination of fog and smoke in the morning brought air travel and other forms of transportation to a standstill. One morning, the visibility at the airport dropped from 5 mi (8 km) to ¼ mi in 12 minutes.

Another bad combination is dense fog and thunderstorms. This seems contradictory, involving extremes in stability and instability, but it can occur. The warmer marine fog develops with air masses than can support thunderstorm development. Also, colder, more stable air near the surface can be overridden by warmer, unstable air above in frontal situations. Thunderstorms can develop in this warmer air, but their effects such as lightning, gusty winds and turbulence, can be felt down to the ground.

For fog detection, the only other tool besides actual observations that can be useful is weather satellite visible imagery. Obviously, this is limited to daylight hours. Infrared imagery cannot distinguish low-lying fog from the ground surface since their temperatures are too close. On visible images, fog can be picked out from other clouds by its low-lying nature. Often fog follows topographic features, in valleys but below ridge tops. Fog does not show up on radar due to the very small size of the droplets involved.

Fog can form quickly when the air temperature reaches the dew point. At other times, the wind may blow a fog bank over an airport, quickly reducing visibility. But it seems that many of the fog-related accidents occur when the fog is readily apparent, and not a surprise.

Edward Brotak, Ph.D., retired in May 2007 after 25 years as a professor and program director in the Department of Atmospheric Sciences at the University of North Carolina Asheville.

AUTOMATION at Odds

A 737 stalled when a radio altimeter malfunction caused the autothrottle and autopilot to diverge during an approach to Schiphol.

BY MARK LACAGNINA

The pilots of a Boeing 737-800 did not heed indications of a significant decrease in airspeed until the stick shaker activated on final approach to Runway 18R at Amsterdam (Netherlands) Schiphol Airport. Their reactions to the stall warning were uncoordinated and incorrect, and maximum thrust was applied too late to prevent the aircraft from stalling at an altitude from which recovery was not possible.

Five passengers, a flight attendant and the three pilots were killed, and 117 passengers and three flight attendants were injured when the aircraft struck terrain 0.8 nm (1.5 km) from the runway. Six passengers escaped injury.

The final report by the Dutch Safety Board (DSB) concluded that the Feb. 25, 2009, accident "was the result of a convergence of circumstances," including air traffic control (ATC) handling that brought the aircraft in high and close to the runway for an instrument landing system (ILS) approach, a radio altimeter malfunction that caused the autothrottle system to prematurely reduce power to approach idle while the autopilot compensated by increasing the pitch attitude to maintain the glideslope, and the flight crew's nonadherence to standard operating procedures — chiefly, their neglect or dismissal of indications that a go-around was required.

The aircraft broke into three pieces when it struck the ground short of the runway.

The aircraft, operated by Turkish Airlines as Flight TK1951, was en route to Amsterdam from Istanbul. "As this was a 'line flight under supervision,' there were three crewmembers in the cockpit, namely the captain, who was acting as instructor; the first officer, who had to gain experience on the route of flight and who was accordingly flying under supervision; and a safety pilot who was observing the flight," the report said.


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All three flight crewmembers held 737-800 type ratings. The captain, 54, had about 17,000 flight hours, including 10,885 hours in 737s with 3,058 hours as pilot-in-command. The first officer, 42, who was flying the aircraft from the right seat, was making his 17th line flight under supervision and his first flight to Schiphol. He had 4,146 flight hours, including 44 hours in type. The safety pilot, 28, had 2,126 flight hours, including 720 hours in type. Turkish Airlines requires a safety pilot on the flight deck during a trainee pilot's first 20 line flights under supervision because of the extra instructional workload imposed on the captain.

The aircraft was over Germany at Flight Level 360 (approximately 36,000 ft) at 0953 Amsterdam time when the crew listened to the automatic terminal information service (ATIS) broadcast for Schiphol. Surface winds were from 200 degrees at 7 kt, and visibility was 3,500 m (about 2 1/4 mi) in mist. There were a few clouds at 600 ft, a broken ceiling at 1,100 ft and an overcast at 1,300 ft. The ATIS advised that the ceiling was becoming broken at 600 ft and that visibility was expected to decrease temporarily to 2,500 m (about 1 1/2 mi).

The first officer was not authorized to conduct Category II or Category III landings, so the crew briefed for the Category I ILS approach to Runway 18R before beginning the descent to Schiphol.

'Short Lineup'

The aircraft was descending through 7,000 ft with the autothrottle and right autopilot engaged when the captain established radio communication with Schiphol Approach at 1015. The approach controller told the crew to descend to 2,000 ft and to maintain a heading of 265 degrees. The controller then amended the heading to 210 degrees and cleared the crew to conduct the ILS approach to Runway 18R (Figure 1, p. 34).

The report said that the controller did not ask the crew if they could accept a "short lineup" before issuing these instructions, which did not allow the crew to intercept the glideslope from below in level flight, as required by International Civil Aviation Organization (ICAO) standards and by Netherlands ATC standards.

"This heading ultimately resulted in interception of the localizer signal 5.5 nm [10.2 km] from the runway threshold," the report said. It noted that the aircraft would have had to intercept the localizer course no less than 6.2 nm (11.5 km) from the runway threshold to intercept the glideslope from below while flying level at 2,000 ft. As a result of the short lineup, "the aircraft had to lose speed and descend in order to intercept the glide path," the report said.


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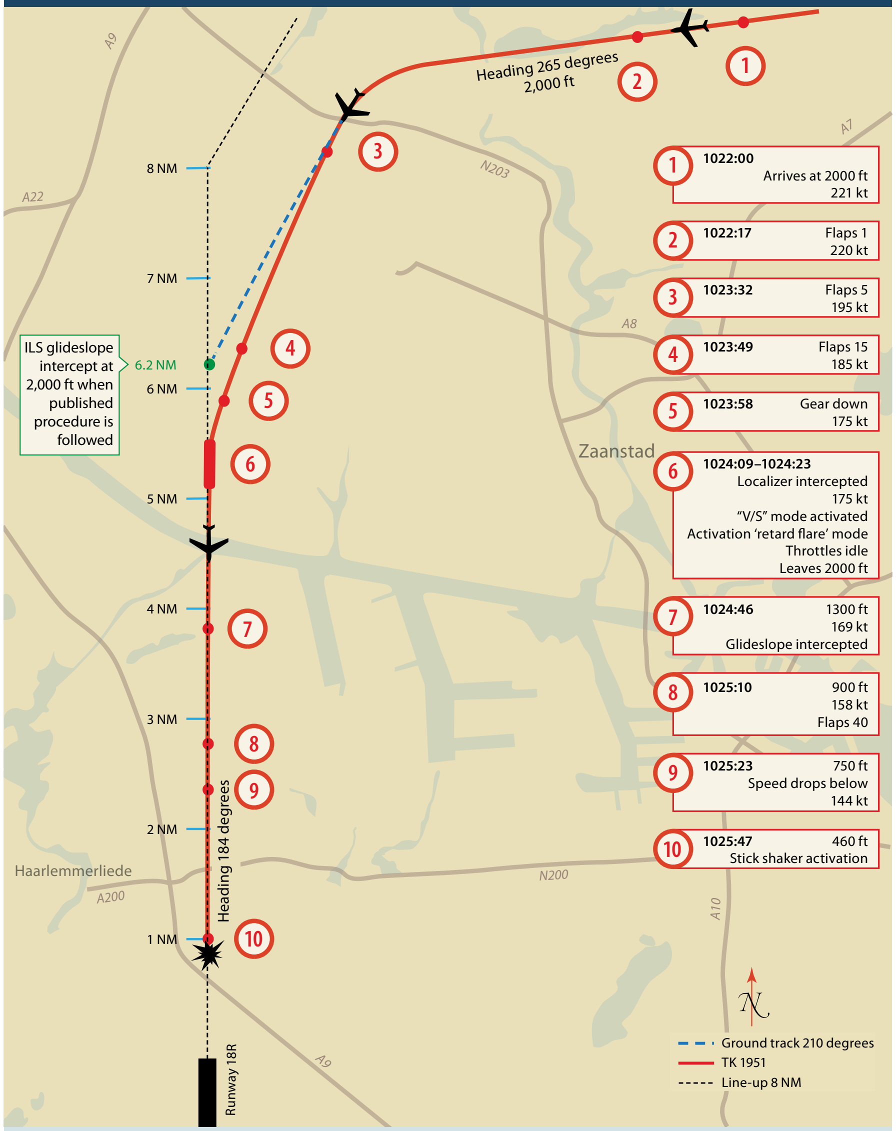
Short Lineup at Schiphol



ILS = instrument landing system ; V/S = vertical speed

Source: Dutch Safety Board

Figure 1

Turkish Airlines trains its pilots to conduct ILS approaches with both autopilots engaged. However, when the crew attempted to engage the left autopilot, it would not engage; moreover, the right autopilot disengaged. Several factors were involved in this. The autopilots cannot be engaged simultaneously unless the ILS frequency is tuned and the approach mode is selected. The crew had not selected the approach mode. Consequently, they unintentionally switched from using the right autopilot to using the left autopilot. The left autopilot would not engage, however, because it was receiving an erroneous height measurement from the left radio altimeter system.

The crew subsequently re-engaged the right autopilot and selected the approach mode but did not make another attempt to engage the left autopilot. Although a “single-channel” message on the primary flight displays (PFDs) showed that only one autopilot was engaged for the ILS approach, the first officer announced “second autopilot engaged.” The report said, “The approach was executed without further discussion.”

The crew selected flaps 15 and extended the landing gear before the autopilot intercepted the localizer course at 1024. The aircraft was above the glideslope, and the crew initially used the altitude selector to manage the descent, selecting 1,200 ft initially and 700 ft shortly thereafter. However, the resulting descent rate was not sufficient to capture the glideslope, so the crew changed to the vertical speed mode and selected a descent rate of 1,400 fpm. The aircraft was descending through 1,300 ft when the autopilot captured the glideslope.

The report said that the captain, as pilot monitoring, did not make several required callouts during the approach, including changes in flight mode annunciations. “The times when these callouts should have been made coincided with the times that the captain was communicating with ATC,” the report said.

Unstabilized Approach

Turkish Airlines’ criteria for a stabilized approach in instrument meteorological conditions include completion of the landing checklist before the aircraft reaches 1,000 ft above runway touchdown zone elevation; a go-around is required if this is not accomplished. “This provision is not confined to Turkish Airlines, in fact, but is a general rule,” the report said. “Being stabilized is important not only to ensure that the aircraft is in the correct configuration and power selection for the landing but also to provide the pilots with a chance to monitor every aspect of the final approach.”

The landing checklist typically is conducted after flap 15 is selected and the landing gear is extended. However, the pilots did not begin the landing checklist until after they selected flaps 40 as the 737 descended through 900 ft. The report said that the delay likely was caused by the extra workload involved in capturing the glideslope from above.

The airline requires the captain, even if he or she is not the pilot flying, to make the decision about a go-around. Although the 737 captain had made a callout when the aircraft descended through 1,000 ft, he did not command a go-around.

Recorded flight data showed that the left radio altimeter system — the primary source of height measurements for the autothrottle — had begun to provide erroneous data shortly after takeoff from Istanbul. As the aircraft descended from 2,000 ft, the height measured by the left radio altimeter and displayed on the left, or captain's, PFD changed to minus 8 ft.

Investigators were unable to determine why this error occurred or why the radio altimeter computer did not recognize and flag the error, which would have caused the autothrottle to resort to using heights measured by the right radio altimeter system, which was functioning normally (Figure 2). "The only indication of the defect in the left radio altimeter system was the minus 8 ft indication on the left PFD," the report said. The right PFD, which is channeled to the right radio altimeter system, provided accurate height indications to the first officer.

'Retard Flare'

The autothrottle had been set to adjust engine thrust to hold an airspeed of 160 kt. However, the erroneous height measurement provided by the left radio altimeter prompted the autothrottle to change from the airspeed-hold mode to the "retard flare" mode and reduce thrust to the approach idle setting at about the same time the crew had begun the descent from 2,000 ft.

The retard flare mode "is normally only activated in the final phase of the landing, below 27 ft," the report said. In addition to the indication that the aircraft was below 27 ft, another precondition had been satisfied: The crew had selected flaps 15, the minimum flap position required for activation of the retard flare mode.

Shortly before the captain established radio communication with the airport traffic controller and received clearance to land, the safety pilot apparently saw the erroneous height indication on the captain's PFD and remarked that a radio altimeter failure had occurred. The captain confirmed the failure, but there was no further discussion or action taken about it. "The cockpit crew did not have information regarding the interrelationship between the failure of the left radio altimeter system and the operation of the autothrottle," the report said.

The crew completed the landing checklist as the aircraft descended below a height of 500 ft. The last item on the checklist was to instruct the flight attendants to take their seats; the captain asked the safety pilot to do this.

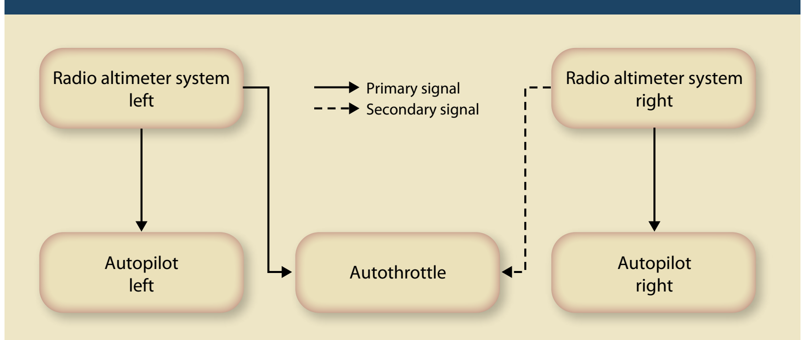
As airspeed decreased, the right autopilot, which was receiving correct height information from the right radio altimeter system, continued to trim the aircraft nose-up, increasing the angle-of-attack to maintain the lift required to keep the aircraft on the glideslope.

As the aircraft descended from 2,000 ft, the height measured by the left radio altimeter changed to minus 8 ft.

Unheeded Warnings

An indication of the autothrottle mode change, "RETARD," was displayed on both PFDs. "When subsequently the airspeed reached 126 kt, the

Systems Channeling



Source: Dutch Safety Board

Figure 2

frame of the airspeed indicator also changed color and started to flash," the report said. "The artificial horizon also showed that the nose attitude of the aircraft was becoming far too high."

The report said that cockpit voice recorder data provided no indication that the crew observed any of these warnings or that they noticed that the autothrottle did not command an increase of thrust after flaps 40 was selected. The latter would have been indicated in part by forward movement of the thrust levers.

"Because the cockpit crew, including the safety pilot, were busy completing the landing checklist, no one was engaged in the primary task of monitoring the flight path and the airspeed of the airplane," the report said. "The reduction in speed and the excessively high pitch attitude of the aircraft were not recognized until the approach-to-stall warning (stick shaker) went off at an altitude of 460 ft."

The first officer responded immediately to the stick shaker by moving the thrust levers forward and pushing his control column forward. However, he stopped when the captain announced that he was assuming control of the aircraft. The first officer had moved the thrust levers only slightly more than halfway forward. "The result of this was that the autothrottle, which was not yet switched off, immediately pulled the thrust levers back again to the position where the engines were not providing any significant thrust," the report said. During this time, airspeed decreased to 107 kt.

The aircraft was descending through 420 ft at 1025 when the captain disengaged the autopilot and pushed his control column full forward. About six seconds later — or about nine seconds after the stick shaker activated — he moved the thrust levers full forward. "At that point, the aircraft had already stalled, and the height remaining, about 350 ft, was insufficient for a recovery," the report said.

At 1026, the aircraft struck terrain in a 22-degree nose-up pitch attitude and banked 10 degrees left. "The aircraft came to a standstill in a field relatively quickly due to the low forward speed [on] impact," the report said. There was no fire.

"A few passengers exited the aircraft through the tear on the right-hand side of the fuselage in front of the wing," the report said. "The other passengers used the two emergency exits above the right wing, the front emergency exit above the left wing and the opening at the rear of the main section of the fuselage."

Similar Incidents

Investigators found that inadvertent activations of the retard flare mode had occurred during flights by the accident aircraft on both days preceding the accident. "After the accident, four similar incidents were brought to the attention of the DSB," the report said, noting that in each case the aircraft was landed without further incident after the crew disengaged the autothrottle.

Moreover, the report said, "Radio altimeter system problems within the Boeing 737-800 fleet had existed for many years." For example, Turkish Airlines had complained to Boeing about fluctuating and negative height measurements that caused landing gear warnings, autopilot disconnects and ground-proximity warning system warnings. "Turkish Airlines and other operators dealt with the problems as a technical problem and not as a safety problem," the report said. "As a result, the pilots were not informed of this issue."

Suspecting that corrosion was causing the problems, Turkish Airlines installed gaskets between the radio altimeter antennas and the fuselage skin, and wrapped the connectors to block moisture. But this did not eliminate the problems. The greatest success was achieved by replacing the antennas, but tests of some of the removed antennas did not reveal why the problems had occurred. "It is almost impossible to take the correct measures if the cause of the fault cannot be identified," the report said.

Boeing in 2004 added a warning in the 737-800 dispatch deviation guide that an autopilot or autothrottle must not be used during approach and landing if its associated radio altimeter is found to be inoperative *before* the flight begins. However, the report noted that the aircraft's quick reference handbook and flight crew operating manual do not contain similar guidance for a radio altimeter malfunction that occurs *during* flight.

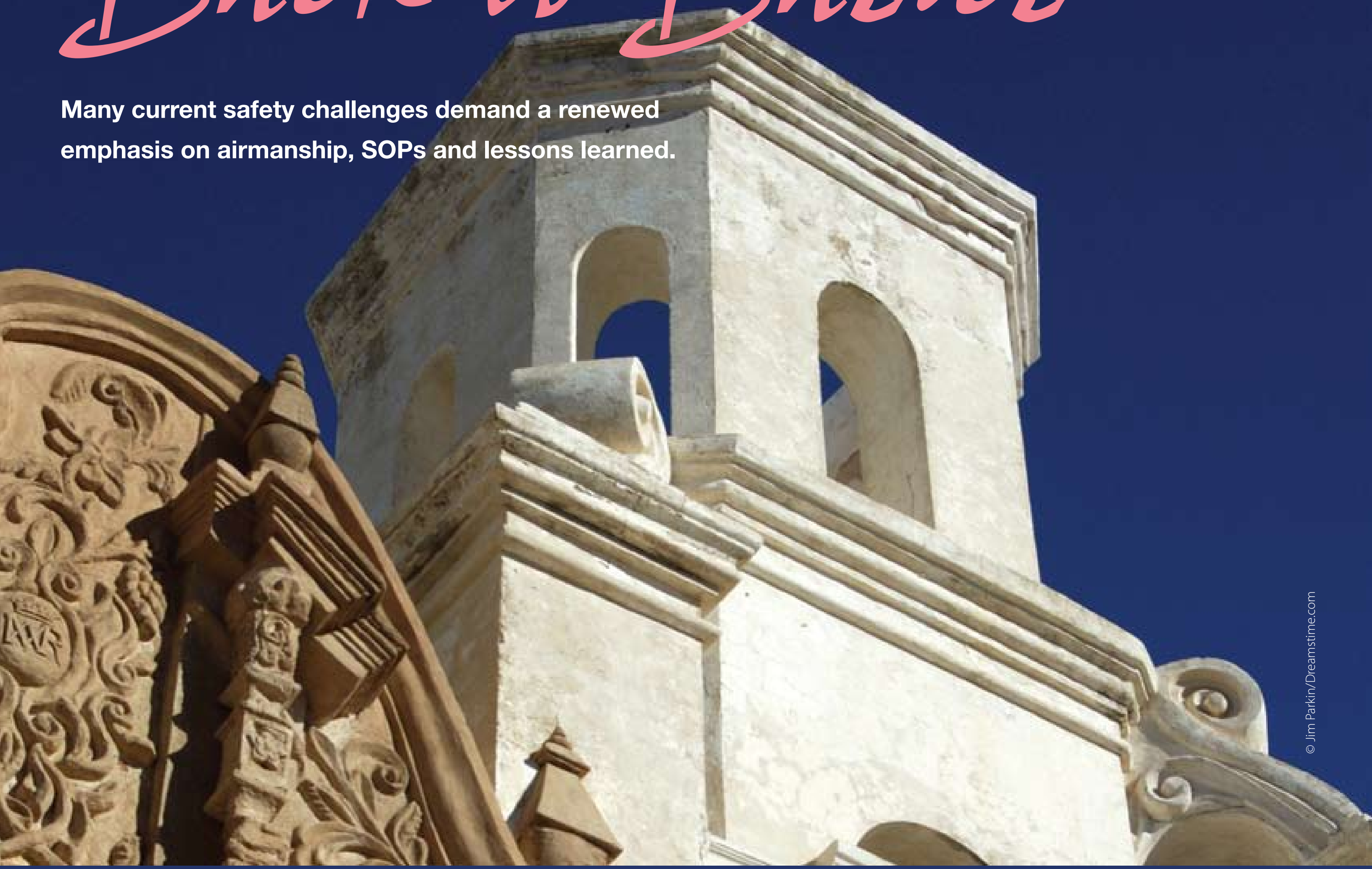
Investigators also found that the ATC handling that resulted in the accident aircraft's interception of the localizer course high and close to the runway, without prior consultation with and approval by the crew, was not an isolated event but was characteristic of more than 50 percent of the approaches to Runway 18R at Schiphol.

Based on the findings of the investigation, the DSB recommended improvement of the reliability of the 737-800 radio altimeter system, evaluation of the benefits of installing an aural low-speed warning in the aircraft, and monitoring to ensure that air traffic controllers in the Netherlands adhere to ICAO and national standards for lining up aircraft for approach.

This article is based on the DSB accident report "Crashed During Approach, Boeing 737-800, Near Amsterdam Schiphol Airport, 25 February 2009," May 2010. The full report is available at <safetyboard.nl>.

Back to Basics

Many current safety challenges demand a renewed emphasis on airmanship, SOPs and lessons learned.



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BY RICK DARBY | FROM TUCSON

Several speakers at the 55th annual Corporate Aviation Safety Seminar suggested — to paraphrase Oscar Wilde — that to lose one airplane may be regarded as a misfortune, but to lose more looks like carelessness. Many recent accidents have been similar to others in the past that have been analyzed and from which lessons have been learned. But those lessons, incorporated into standard operating procedures (SOPs), are not always heeded. Moreover, some accidents continue to involve failures of basic airmanship.

John Cox, CEO, Safety Operating Systems, said that "loss of control in flight continues to be the number one cause of accidents in the commercial fleet. And unfortunately, the trend is not improving. It's static."

He discussed stall prevention on takeoff and during climb as well as loss of control in flight. "This is airmanship," he said. "This is something that people believe that you learn in primary flight school. The data are telling us that the lessons are not being learned. So we face a challenge, not only for the next generation of aviators but the generation of aviators in flight decks today."

Among maneuvering accidents, Cox said, the top category is stalls: "This is simple stuff. Don't get too slow, don't stall the airplane. You learn it in Piloting 101. But we continue to have that accident type. We're not adequately addressing this, and the statistics show it."

Cox cited a study that reviewed reports of accidents involving purpose-built business jets — that is, not airliner derivatives — worldwide from 1991 through 2007.[1] "Of the 389 reports found and analyzed, 59 — that's almost one out of seven — involved loss of control," he said. "Of 35 fatal loss of control accidents, we believe that, in 14, upset recovery training could have had a positive effect."

Cox said that an upcoming rewrite of U.S. Federal Aviation Regulations Part 121, subpart N, *Training Operations*, and subpart O, *Crewmember Qualifications*, has a very high likelihood of including upset recovery training as mandatory for air carrier pilots. "Why should we in corporate aviation be any different?" Cox asked. "And more important, why do we have to wait for a regulation?"

'Why should we in corporate aviation be any different? And more important, why do we have to wait for a regulation?'

Cox

Sumwalt

Analyzing some recent corporate aviation accidents, Robert Sumwalt, member, U.S. National Transportation Safety Board (NTSB), discussed causal factors in the fatal runway overrun accident involving a Learjet 60 at Columbia, South Carolina, on Sept. 19, 2008 (*ASW*, 5/10, p. 24).

Following tire failures, the captain hesitated, then rejected the takeoff at a speed greater than V_1. Sumwalt pointed out that U.S. Federal Aviation Administration (FAA) guidance in Advisory Circular AC 120-62, *Takeoff Safety Training Aid*, cautions pilots not to reject takeoffs at high speed because of tire failures.

In its report, the NTSB assigned as probable cause "the operator's inadequate maintenance of the airplane's tires, which resulted in multiple tire failures during takeoff roll due to severe underinflation, and the captain's execution of a rejected takeoff after V_1, which was inconsistent with her training and standard operating procedures."

Sumwalt then turned the audience's attention to Colgan Air Flight 3407, which crashed with a loss of 50 lives on Feb. 12, 2009 (*ASW*, 3/10, p. 20). The investigation found that the pilots violated basic cockpit discipline by engaging in nonpertinent conversation while neglecting important SOPs such as conducting an approach briefing, the descent checklist and the approach checklist.

The NTSB determined that the probable cause was "the captain's inappropriate response to the activation of the stick shaker, which led to an aerodynamic stall from which the airplane did not recover." The "flight crew's failure to monitor airspeed in relation to the rising position of the low-speed cue" was a contributory cause.

In-flight loss of control was not the only type of accident involving "lessons not learned" that attendees heard about during the seminar.

In his presentation titled "Reducing the Risk of Runway Excursions," James M. Burin, FSF director of technical programs, reported on a just-competed update of approach-and-landing accident data. "The top factors such as omission of action, poor professional judgment/airmanship and crew resource management deficiencies are still there. The order has changed slightly, but not much."

An aspect of approach and landing accident reduction that is not improving is runway excursions, Burin said. He said that the data support these conclusions:

- "Unstable approaches increase the risk of an excursion;
- "Crews will get away with not going around when they should 99 percent of the time. But most of the accidents are in that remaining 1 percent;
- "Contaminated runways increase the risk of excursions;
- "Combinations of risk factors increase the risk by more than their sum;
- "The aviation community has been searching for over 20 years for a universal standard of runway condition measurement and reporting. We need to stop searching and come up with something; [and,]
- "Good SOPs — and good adherence to SOPs — will reduce the risk of an excursion."

Burin said, "We found that many basics are forgotten — or maybe never learned. For example, flying a stabilized approach *to include meeting all stabilized approach criteria* and touching down in the touchdown zone is a large risk reduction factor.

"But there are some basics besides flying a stabilized approach which need to be learned, or re-learned. Reverse thrust is nice on a dry runway, but it is critical on a contaminated runway.

"It was estimated that in 98 percent of landing excursions, the calculated stopping distance was before the end of the runway. Unfortunately, many excursions do not meet all the conditions the calculations are based on. If you calculate that you can land on a 9,000-ft [2,743-m] runway, then land one-third of the way past the touchdown zone — you just landed on a 6,000-ft [1,829-m] runway, and your calculations are no longer valid."

Stephen Charbonneau, senior manager, aviation safety and security, Altria Client Services, asked a relevant question: If stabilized approaches are SOP in every flight department and are the first line of defense against an approach and landing accident or runway excursion, "why do pilots continue to attempt to salvage unstabilized approaches?"

He cited four possible reasons: "Excessive confidence in a quick recovery; excessive confidence because of runway or environmental conditions; inadequate preparation or lack of commitment to conduct a go-around; or absence of decision because of fatigue or workload."

Stabilized landing criteria are derived from guidelines established by the FAA, manufacturer's performance certification data, safety research and empirical data gathered from review of corporate flight operational quality assurance [C-FOQA] reports, Charbonneau said.

"The criteria consider the effects of excessive height, airspeed, groundspeed, landing beyond the touchdown zone, and insufficient or ineffective braking. Each of the criteria will need to be met, within reasonable tolerances, in order for a landing to be considered as stabilized."

Keeping up with best safety practices is not only the responsibility of pilots. Management has its own part to play. W. Todd Chisholm, managing director, V2climb, pointed to the lack of widespread voluntary reporting systems in corporate aviation. The only widely recognized reporting program is the Aviation Safety Reporting System, maintained by the U.S. National Aeronautics and Space Administration, he said. However, "it is a program that typically collects minimalist reports but does not offer much usable output for operators," Chisholm said.

He urged business and corporate aviation to follow the lead of airlines. "Our segment of the industry is an anomaly for its failure to develop a just culture and formal voluntary safety reporting programs," Chisholm said. "In fact, while corporations continue to gain efficiency and improve safety through sharing of best practices, airlines are moving into the second generation of ASAP [aviation safety action program] where they will share information across the industry. Meanwhile, voluntary safety and operational reporting remains a foreign, if not threatening, concept to corporate aviation."

He recommended a process "to collect reports from corporate aviation operators, de-identify them, run root cause taxonomy and produce highly valuable insights. Broadly incorporating that program into corporate aviation safety management systems will allow other operators to identify hazards before experiencing them in a surprising operational situation. It is time for corporate aviation to recognize the safety opportunities offered by ASAP."

Adopting a program that has proven its worth in other industry segments will enable corporate aviation operators to "share experiences and leverage their lessons learned, so that the industry discovers how to mitigate risk before even recognizing the hazards," Chisholm said.

Cox of Safety Operating Systems summed up the overall corporate aviation situation: "We have work to do."

Note

1. Veillette, Patrick R. *Aviation Week & Space Technology*, May 6, 2009.

Charbonneau

Chisholm

Photos: J.A. Donoghue

'Our segment of the industry is an anomaly for its failure to develop a just culture and formal voluntary safety reporting programs.'

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The Best Rest

BY DAVID HELLERSTRÖM, HANS ERIKSSON, EMMA ROMIG AND TOMAS KLEMETS

A comparison of differing regulatory efforts to control pilot fatigue.

In commercial aviation, crew schedules are regulated by duty time limits, flight time limits, minimum rest rules and other constraints. These rules and limits, collectively referred to as flight time limitations (FTLs), originally were conceived as a simple scheme for limiting fatigue among flight crewmembers.

Over time, FTLs have evolved, driven by industrial pressures or new scientific data, or to cope with changing aircraft capabilities. Today, there are major differences among FTL schemes in different parts of the world affecting crew productivity, crew alertness — and airline competitiveness.

With the results of new research on sleep and work-related fatigue in hand, it becomes useful to compare existing regulations with the new findings.

FTLs are relatively straightforward, and, combined with labor agreements and other safeguards, they do a reasonable job of protecting alertness under most circumstances. Unfortunately, FTLs tend to be extremely rigid and limit operational flexibility and efficiency. But by far the most troublesome aspect of FTLs is the illusion of safety that they create — suggesting that to fly within the limits is inherently safe, while flying outside the limits is inherently unsafe.

In recent years, considerable effort has been directed toward increasing scientific knowledge of fatigue and alertness. By combining new knowledge of fatigue with safety and risk management processes, the concept of the fatigue risk management system (FRMS) was created. In previous work, we have demonstrated that a properly implemented and managed FRMS can be vastly superior to FTLs in managing alertness while maintaining or improving productivity.[1] Whereas FTLs are not feedback-driven and often lack a scientific basis, an FRMS is by definition intended to be a closed-loop, data-driven process. In addition to the stronger scientific basis of an FRMS, an added benefit is increased operational flexibility.

FRMSs are built around predictive tools including, but not necessarily limited to, mathematical models of fatigue and alertness. Models predict crew alertness from planned and actual schedules and inferred sleep and wake history. Models also consider known physiological phenomena, such as circadian rhythms and sleep propensity, and make predictions based on these considerations. Unfortunately, while models have been developed and validated in a laboratory environment, more work is required to validate the models in a commercial aviation environment. Without validation and other checks, the use of any specific model on FRMS in scheduling is ill advised.

Thus, we are faced with a dilemma. FTLs are imperfect, but well understood and easy to apply. An FRMS is better for managing fatigue-related risk but must be developed and validated to be trusted. Until FRMSs are widely proved and implemented, the goal must be to refine FTLs to be as close as possible to an FRMS-based approach. A refined FTL should strive to guarantee an equivalent or better level of flight safety while allowing airlines to efficiently and flexibly operate their businesses.

For this article, we analyzed three different sets of FTLs for productivity and alertness. We compared these regulatory formulations to a model-based FRMS. The analysis used a fatigue model within crew scheduling optimization software on the timetables of three short-haul airline fleets. Finally, we demonstrated our suggested alternative for improving FTLs.

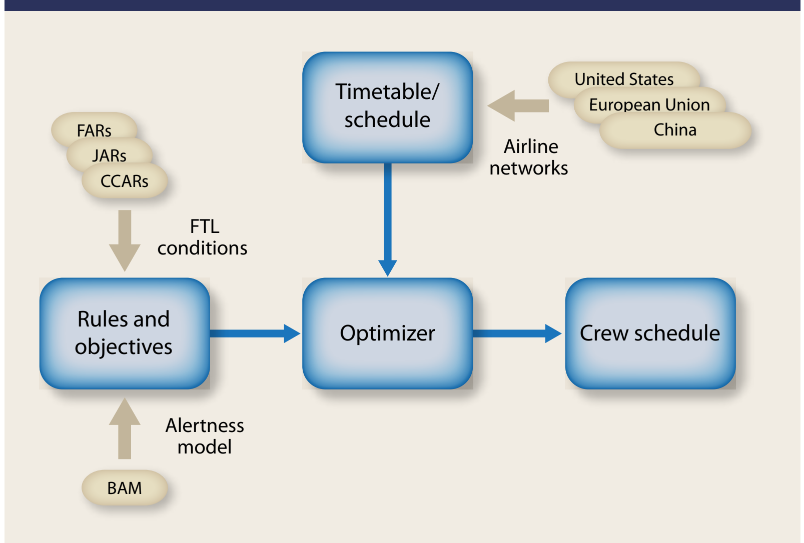
Analytical Methods

To build the schedules for comparing FTLs, we used the system illustrated in Figure 1. Our system centers on an "optimizer," which considers an airline's timetable and a set of rules and objectives to build crew schedules. In each of our FTL comparisons, we created a schedule using one airline's timetable and one of the FTL sets as a constraint. To simulate an FRMS, we created schedules without the constraint of an FTL set, instead using the predictions of our alertness model.

The FTL sets used were EU-OPS with Subpart Q — abbreviated as Joint Aviation Requirements (JARs); U.S. Federal Aviation Regulations (FARs) Part 121; and China Civil Aviation Regulations (CCARs) 121 Rev 3. Each FTL scheme has a different focus:

- JARs focus on duty-time limitations with reduced daily limits based on the number of legs and time of day. Duty time can be extended twice in seven days. Minimum rest between duty periods is 10 hours. There may be no more than seven days of work between rest periods of at least 36 hours.

Tools and Conditions Used in Schedule Creation



BAM = Boeing Alertness Model; CCARs = China Civil Aviation Regulations; FARs = U.S. Federal Aviation Regulations; FTLs = Flight time limitations; JARs = Joint Aviation Requirements (referring to EU-OPS with Subpart Q)

Source: David Hellerström, Hans Eriksson, Emma Romig and Tomas Klemets

Figure 1

- FARs limit block time and lack real duty-time limits. Minimum rest between duty periods is eight hours. There must be weekly rest of at least 24 hours in every seven-day period.
- CCARs address both block time and duty time limits. Minimum rest between duty periods is 10 hours. The weekly rest requirement is 48 hours in any seven-day period.

In addition to the three FTL sets, we created an "FRMS" rule set based on a model's predicted alertness. The rule set was created using the Boeing Alertness Model (BAM), a bio-mathematical model of alertness.[2,3] In this rule set, there were no rules on flight time, duty time, or rest time; instead, an alertness limit was set, under which no flights would be scheduled. Alertness is predicted on a scale from zero (least alert) to 10,000 (most alert), which we call the Common Alertness Scale.[4]

It is possible to build solutions that protect against fatigue without sacrificing productivity.

JARs and CCARs consider duty time to include briefing and debriefing; for this analysis, we set the parameters for briefing time to 45 minutes before active duty and 30 minutes before passive duty.[5] Debriefing time was set to 15 minutes. CCARs define "rest at rest location" as being rest at a hotel, rather than at an airport; therefore, 20 minutes at each end of the rest interval were used for local transport and not regarded as valid rest.

Data Sets

Three large data sets — derived from publicly available flight timetables of China Southern Airlines, Lufthansa and Northwest Airlines — were used to compare the properties of the FTLs with respect to productivity and alertness.

All flights were two-pilot operations in Airbus A320 aircraft. Average flights in the Europe and China data sets were less than two hours, while flights in the U.S. data set averaged 2.5 hours.

To compare the solutions, we relied on metrics representing the resources needed to implement a solution for each flight and the predicted alertness level of flight crewmembers. A low level of predicted alertness on a flight is associated with higher risk. The alertness properties in the solutions were hard to map to a single descriptive value or statistical measure; therefore, we chose to report and compare the lowest level of predicted alertness, as well as the average alertness value of the lowest 1 percent, 5 percent and 10 percent of flights within the schedule.

To quantify the relative productivity of the solutions, we created a composite measure of productivity called the "Resource Index (RI)." RI values are a measure of how much less efficient a solution is than a theoretically "perfect" solution. Using all three airline data sets, we observed the same trend in the RI: The FARs were the most flexible and most efficient of the FTL schemes, followed by the CCARs and finally the JARs. The flexibility of the FARs comes primarily from the lack of duty-time limits and the possibility of a rest period as short as eight hours. However, the BAM outperformed all three FTL sets in terms of the resource index.

When we considered average block time per duty day — another measure of productivity — we saw similar performance on predicted alertness from BAM and the FTLs. Only when applied to the Chinese data set did the FARs generate a solution more efficient than that created by BAM.

Under the U.S. airline operating conditions, with relatively fewer legs and legs of longer duration, the JARs outperformed the CCARs in terms of crew productivity per day; in all other cases, the JARs were the least efficient of the FTL schemes. The performance shortfall on the other FTL sets probably stemmed from the reduction in duty-time limits for many sectors under the JARs. We also noted that the FARs — without any real duty-time limit — consumed much more duty time than the other FTL schemes.

Figure 2 shows the level of fatigue is highly dependent on the data set because legs scheduled very early or very late always cause low alertness. As shown in the figure, the FARs provided the least protection against fatigue; the CCARs and JARs were comparable to each other, but the JARs provided somewhat better protection. The solutions produced by BAM were better at protecting against fatigue — not surprising because when constructing a schedule with BAM, predicted alertness is a primary objective. The BAM solutions were interesting because they showed that it is possible to build solutions that protect against fatigue without sacrificing productivity.

Worth noting is that many of the FTL-permissible flights associated with low alertness would not be allowed under BAM-based rules.

Improving the Rules

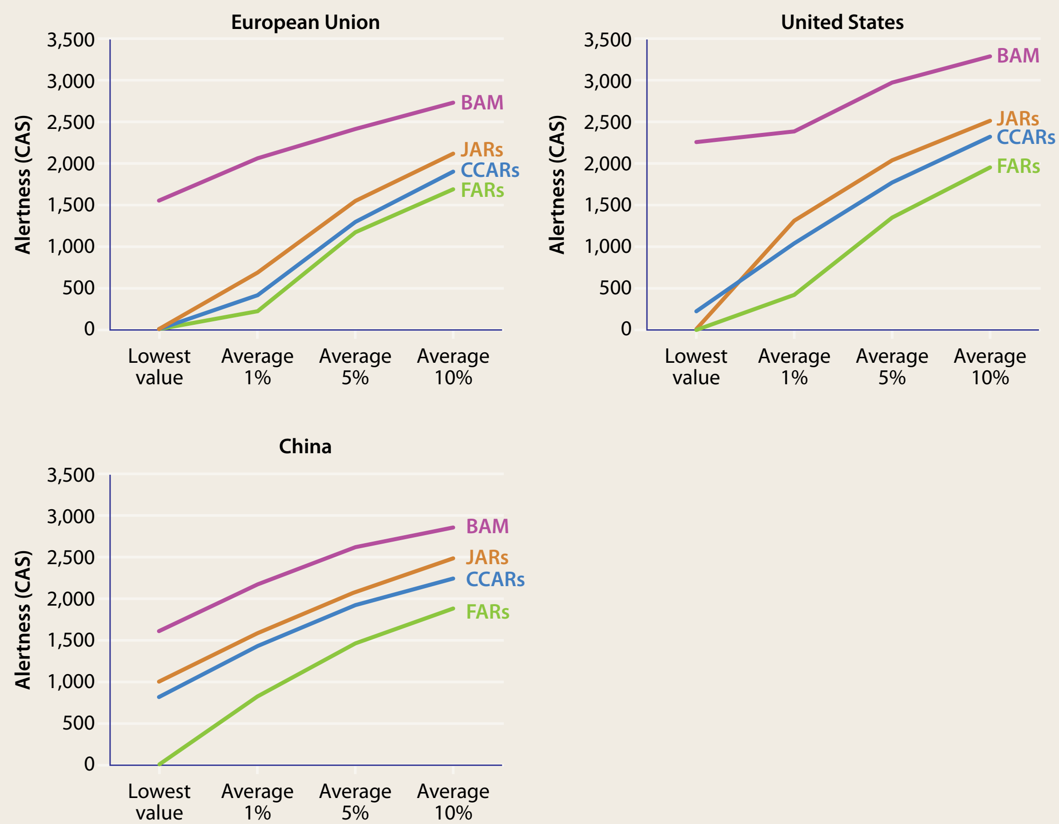
The tools used for this productivity and alertness comparison can be extended into a framework to improve prescriptive rules, such as an FTL scheme, to help the FTL scheme provide better protection against low alertness while also maintaining or improving productivity. In this application, the optimizer can be used to analyze the properties, including productivity and alertness, of an evolving rule set. The method identifies overly restrictive rules and loopholes in the existing rule set.

The improvement begins with the creation of three reference solutions. One solution is based solely on the alertness model with no other limiting rules. The second solution is based on the limits in the prescriptive rules. The third solution is a stress test solution, also based on the limits in the prescriptive rules. In the stress test, the researcher activates an incentive so that the optimizer will produce the most tiring solutions allowed under an FTL.

From the first two solutions, we can identify the productivity and protected level of alertness of our original rule set, and the maximum productivity and protected level of alertness. In the third solution, bad patterns of productivity and alertness are easy to identify.

For every iteration, researchers must decide if they want to tighten the rules to improve on alertness, or relax an overly restrictive rule to increase productivity. When the increased productivity option is selected, the revised rule set also changes the alertness outcome — probably for the worse. Likewise, when alertness is improved, the rule set usually causes loss of productivity. Changes that improve productivity or alertness — without one affecting the other — are ideal.

Alertness Comparison



BAM = Boeing Alertness Model; CAS = Common Alertness Scale; CCARs = China Civil Aviation Regulations; FARs = U.S. Federal Aviation Regulations; JARs = Joint Aviation Requirements (referring to EU-OPS with Subpart Q)

Source: David Hellerström, Hans Eriksson, Emma Romig and Tomas Klemets

Figure 2

Improving Alertness

In our effort to improve the protected level of alertness of an FTL set, we compared the crew schedules produced by the optimizer with the best version of the prescriptive rules. Crew schedules were sorted according to the lowest levels of alertness, and flights with low crew alertness were highlighted. In the crew schedules leading up to the flights with low alertness, we identified a combination of duty and sleep opportunities that created a fatiguing pattern.

After looking at these fatiguing patterns, we proposed a few rules to prevent these patterns from occurring. The proposed rules were implemented, and their impact was estimated by analyzing the number of rules violations they created in the solution. We also evaluated the impact of the newly proposed rules on the reference solution that was based on the alertness model, and adjusted the proposed rules as warranted.

The final impact of new rules was then analyzed by generating a set of new solutions from the prescriptive rule set and the newly proposed rules. One new solution for each added rule, and a few solutions using combinations of new rules, were generated. The productivity and level of alertness were analyzed for each solution, and the data were plotted on a chart. One rule, or a few rules that collectively improved alertness, were chosen to move forward.

Most Violated Rules

Violated Rule	Times
Minimum rest time after a duty	475
Maximum flying time in a duty	393
Maximum duty time in a duty	172
Obligatory weekly rest in any seven days	157
Maximum flying time in seven days	92
Maximum flying time between valid weekly rest	28

Source: David Hellerström, Hans Eriksson, Emma Romig and Tomas Klemets

Table 1

Improving Productivity

To examine possibilities for improving productivity, the BAM reference solution became the starting point. As noted, this solution had no constraints other than maintaining a protected level of alertness. Theoretically, then, it should be the most productive solution possible, unless all protection of alertness is sacrificed. In our system, it was possible to apply the prescriptive rule set to the BAM reference solution. This resulted in "flags" of rule violations in the BAM solution. To determine the most limiting rules in terms of productivity, we compiled statistics for the number of violations of each rule. By looking at the frequency of rule violations — and in some cases the degree of the rule violations (for example, looking at by how many minutes a block or duty time limit was exceeded) — we were able to gain insight into where the prescriptive rules were unnecessarily constraining productivity. Examples are shown in Table 1.

From these insights, new FTL-scheme solutions were created from the prescriptive rules, with the proposed relaxations added. One new solution was created for each relaxed rule, as well as a few solutions in which combinations of rules were relaxed. The productivity of the new solutions, as well as protected level of alertness, then could be analyzed. One or several of the best candidates for a new rule set then could be chosen for further refinement.

The research has validated the methodology by applying it to the CCARs rule set and the data set representing the Chinese airline.

In three iterations, nine rule changes were tried and five rule changes were introduced. The final result was a rule set in which the average block time per day was increased by 6 percent from 5 hours 59 minutes to 6 hours 21 minutes and alertness was improved between 250 and 700 points on the Common Alertness Scale. Differences in alertness are compared in Figure 3, where the new rule set is named CCARs+. The new solution's resource index also dropped 8.5 percent.

The following rule changes were introduced:

- Prohibiting pilots from being asked to report for duty more than once in a 24-hour day;
- Reducing the maximum duty time for duty periods that fall partly within 2300 to 0330;
- Relaxing the rule governing maximum block time in a duty period;

- Relaxing the rule governing minimum rest after duty; and,
- Adding a complementary rule for maximum duty time after short rest periods — rest periods that became legal when the original minimum rest-after-duty rule was relaxed.

The parameter changes tested in the case study were large and had a large impact on productivity and alertness. More refined parameter changes could be tested to find a better trade-off between alertness and productivity.

The final rule set was stress-tested. The test showed that the protected level of alertness had increased by 250 to 450 points on the Common Alertness Scale.

Conclusions

Of the three tested FTL schemes, none completely protected against low alertness in the crew schedules. The most concerning bad patterns encountered in the FTL-controlled crew schedules were the planning of unusable rest during daytime periods, when it would be difficult for the pilots to sleep, and duty periods of maximum length ending close to midnight. These situations are legal and appeared in solutions generated from all FTL schemes.

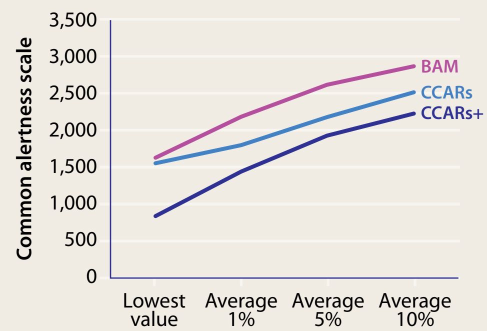
The JARs and CCARs rule sets are comparable in many aspects, both in productivity and in the protection against low alertness. The JARs FTLs are slightly better at protecting against fatigue but less productive if there are many legs in the average duty. The FARs FTLs are the most efficient of the three FTLs but allowed for very long duty times. FARs FTLs also performed worst in protecting against low alertness.

The levels of alertness predicted by BAM for the FTLs should be viewed with caution because the model is not yet fully validated in airline operations. When the model is shown to be valid, the safety and business case for FRMS will be further strengthened. Our results indicate that FTLs do not appear to protect well against low alertness — and within an airline's FRMS, model-based scheduling should be both safer and more productive.

In the meantime, assuming that current FTL schemes are to be moved toward FRMS, we have described a method for improving an existing FTL scheme to better protect against low alertness while improving or maintaining flexibility and productivity. Finally, we note that the methodology used in this study for analysis and improvement of rules can just as well be applied by an operator in scheduling as an essential part of an FRMS.

David Hellerström and Hans Eriksson are business analysts with Jeppesen Systems. Emma Romig is principal investigator, flight deck research and development, with Boeing Commercial Airplanes. Tomas Klemets is product manager with Jeppesen Systems.

Protected Alertness Levels



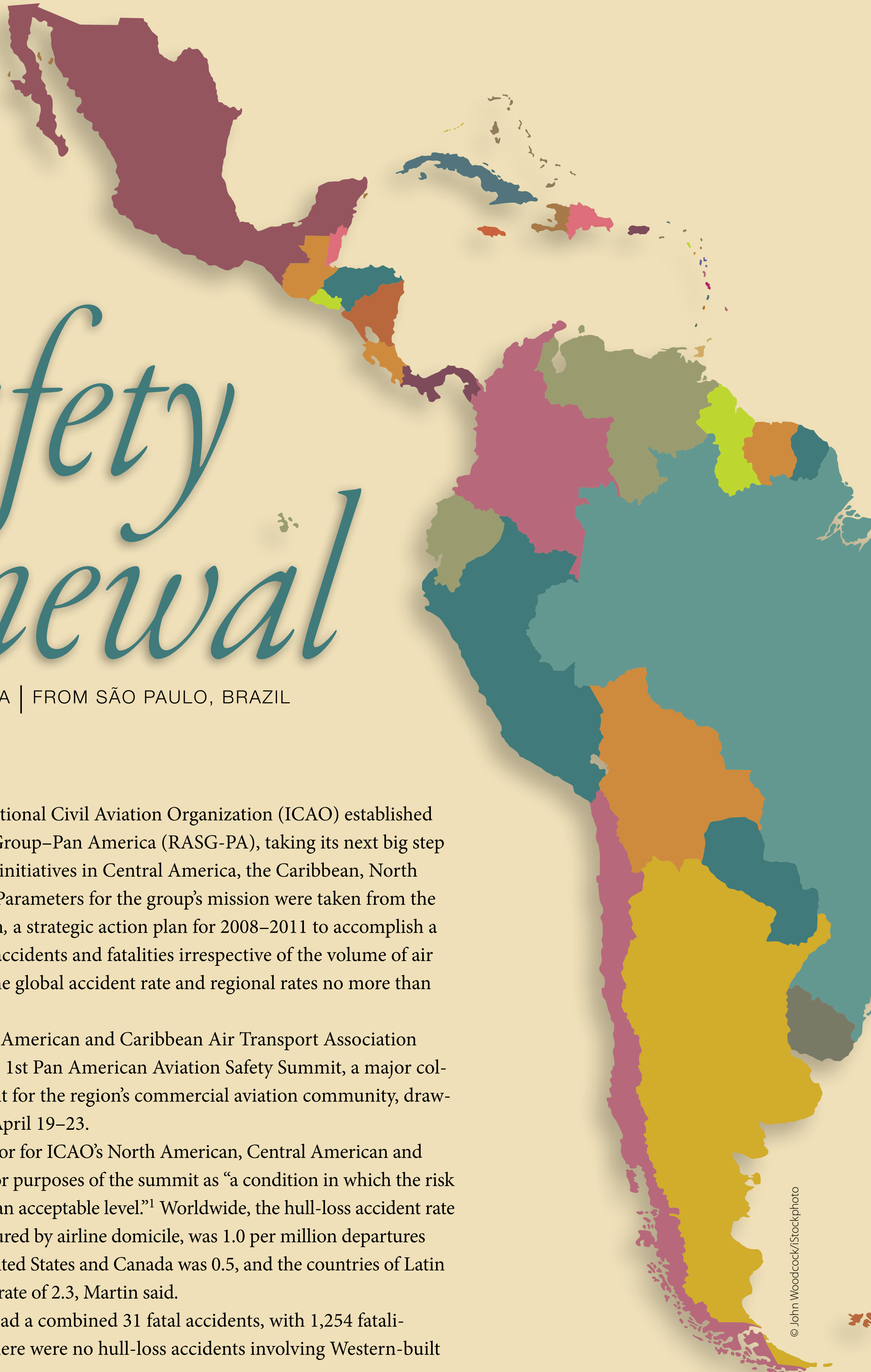
BAM = Boeing Alertness Model; CCARs = China Civil Aviation Regulations; CCARs+ = New rule set developed from China Civil Aviation Regulations

Source: David Hellerström, Hans Eriksson, Emma Romig and Tomas Klemets

Figure 3

Notes

1. Romig, Emma; Klemets, Tomas. "Fatigue Risk Management in Flight Crew Scheduling." *Aviation, Space, and Environmental Medicine* Volume 80 (December 2009): 1073–1074(2).
2. Åkerstedt, T.; Folkard, S. "The Three-Process Model of Alertness and its Extension to Performance, Sleep Latency, and Sleep Length." *Chronobiology International* 14(2), 115–123, 1997.
3. Åkerstedt, T.; Folkard, S.; Portin, C. "Predictions From the Three-Process Model of Alertness." *Aviation, Space, and Environmental Medicine* 2004; 75(3, Suppl.): A75-83.
4. This scale has been anchored to the Karolinska Sleepiness Scale, a widely used scale for rating sleepiness. The Common Alertness Scale, and the interface by which BAM connects with the scheduling software, has been formalized in a document shared with leading fatigue modelers, with the intention that other commercial models can be integrated into crew scheduling as BAM has been.
5. Passive duty is duty time during which the crewmember flies as a passenger to be positioned for further duty.



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Safety Renewal

BY EDVALDO PEREIRA LIMA | FROM SÃO PAULO, BRAZIL

In November 2008, the International Civil Aviation Organization (ICAO) established the Regional Aviation Safety Group–Pan America (RASG-PA), taking its next big step toward coordination of safety initiatives in Central America, the Caribbean, North America and South America. Parameters for the group's mission were taken from the ICAO Global Aviation Safety Plan, a strategic action plan for 2008–2011 to accomplish a reduction in the number of fatal accidents and fatalities irrespective of the volume of air traffic, a significant decrease in the global accident rate and regional rates no more than twice the global figure.

In cooperation with the Latin American and Caribbean Air Transport Association (ALTA), the RASG-PA hosted the 1st Pan American Aviation Safety Summit, a major collaborative effort and historic event for the region's commercial aviation community, drawing about 200 attendees here on April 19–23.

Loretta Martin, regional director for ICAO's North American, Central American and Caribbean Office, defined *safety* for purposes of the summit as "a condition in which the risk of harm and damage is limited to an acceptable level."[1] Worldwide, the hull-loss accident rate of Western-built transports, measured by airline domicile, was 1.0 per million departures in 2000–2009. The rate for the United States and Canada was 0.5, and the countries of Latin America and the Caribbean had a rate of 2.3, Martin said.

States targeted by RASG-PA had a combined 31 fatal accidents, with 1,254 fatalities, she said.[2] The good news: There were no hull-loss accidents involving Western-built

Regional summit focuses Pan American aviation leaders on loss of control, CFIT, unstabilized approaches and runway excursions.

commercial jet aircraft operated by Latin American or Caribbean air carriers in 2009, down from a rate of 2.5 the year before; the rate decreased from 0.58 to 0.41 for the United States and Canada combined.

Within Pan American subregions, the safety picture may differ radically for specific states or aviation stakeholders, which made the summit a valuable opportunity for dialogue, data exchange, and sharing experiences, expertise, research findings and training methods, Martin added.

"All of these different organizations have their own training programs, but they never really get the opportunity to come together and find out what the other side is doing, and how they are approaching different things," Martin said. "The point was to share those experiences. And we were dealing with different levels of development, as well. These states have highly developed systems, under-developed systems and systems that are developing. It could be very challenging to bring all of these aspects together at different stages of development."

One case study discussed was Colombia, where the number of civil aviation accidents decreased from 0.62 per 10,000 sectors in 2002 to 0.45 in 2009, with fatalities coming down from 28 in 2003 to five last year.[3] This was achieved in a strongly growing market. The global economic crisis seems not to be affecting the Colombian air transport industry as badly as air transport in states in other regions of the world. In 2007, the local airline industry boarded 14.4 million total passengers. Last year, that figure was 16.3 million; so as traffic and operations grew, the number of accidents decreased.[4]

Edvaldo Pereira Lima

A Major Culprit

Despite encouraging numbers, safety issues remain in Colombia and elsewhere in the region. The no. 1 threat is runway excursions. According to the International Air Transport Association (IATA), Latin America had a rate of 1.34 runway excursions per million flights in the 2004–2008 period, while North America had a rate of 0.36. Between 2004 and 2009, Latin America recorded 28 of these events, the second highest number worldwide. North America recorded 21.

Hideki Endo, a captain and assistant director, IATA Safety, Operations and Infrastructure, brought to the summit a detailed picture of the global situation. Runway excursions during landing represented 83 percent of the total 161 excursions in the 2004–2009 period; runway excursions during takeoff were 17 percent, Endo said. Inadequate rejected takeoff performance, unstabilized approaches and poor go-around decisions have been the main causal factors worldwide, he said. Accidents can be prevented through "training, awareness of the threats and applying good judgment to reduce the risk," Endo added.

A story of success was related by Geraldo "Harley" Meneses, a captain and safety officer at TAM Linhas Aéreas, which in 2001 became the largest Brazilian airline in its home market. It has continued to expand and now operates into 43 domestic and 17 international destinations, with an average of 730 daily flights. The company's estimated growth in revenue passenger kilometers for 2010 is 14 to 18 percent, and the fleet likely will increase from 148 aircraft at the end of this year to 165 by late 2014.

As the airline prepared for the safety challenges of such rapid growth — taking advantage of a home market that, like Colombia, did not seem to be affected as badly by the economic crisis in other parts of the world — a decision was made to reduce unstabilized approaches. Taking Flight Safety Foundation's *Approach and Landing Accident Reduction Tool Kit*[5] as a reference, the air carrier used its flight data monitoring program to analyze existing flight operations, which had shown 38 unstabilized approaches per 1,000 flights in 2004. As the safety campaign progressed, TAM flight crews reduced this rate to 30 the following year, 10 in 2006, fewer than five in 2007 and 2008, and 2.08 last year, Meneses reported.

LOC-I Solutions

Loss of control in flight (LOC-I) has been ranked no. 2 on RASG-PA's priority list of regional safety risk areas. Another growing concern is flight crew fatigue and possible links to LOC-I, said Carlos Arroyo Landero, an Aeroméxico captain and representative of the International Federation of Air Line Pilots' Associations (IFALPA). About 20 percent of the voluntary reports received by the U.S. National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System mention fatigue-related factors, he said. NASA's fatigue countermeasures program for civil aviation began targeting safety issues related to fatigue, sleep and circadian rhythms in 1980. This early research evaluated more than 500 pilot volunteers in line operations, flight simulators and sleep laboratory settings. Sleep loss and circadian rhythm disruption are still found to be primary causes of commercial aircrew fatigue, Arroyo said.

A particular problem for aircrew has been that the body's circadian-rhythm "clock" is not able to adapt quickly to changes such as time-zone crossings and sudden duty/rest rescheduling. As a positive, science-based response to this challenge, fatigue risk management programs are employing both preventive and operational strategies. The region's advocates of such programs often encounter hindrances, however, in the form of inherent resistance to change and lack of flexibility in today's globally competitive market, Arroyo said. This mentality is a companion to funding problems, as the implementation of science-based predictive measures may require financial input, he added.

He nevertheless sees signs of hope for fatigue risk management solutions in the region. "We lack resources [in our countries] but there is much good will," Arroyo explained. "It is necessary to make use of these free training initiatives by RASG-PA and IFALPA. We have found again a way to communicate and share all this information."

Pilot Monitoring

Another case of leveraging international best practices for regional safety has been advanced training for effective pilot monitoring. Monitoring and cross-checking are seen as a crucial layer of defense, with each crewmember effectively checking the flight path, aircraft systems and each other's actions. Arroyo co-authored a presentation with another airline captain, Juan Carlos González Curzio, that said that poor pilot monitoring was found to be a factor in 84 percent of 37 crew-caused accidents studied by the U.S. National Transportation Safety Board (NTSB). Despite this, implementation of more effective monitoring so far has not been a priority task in the region, they said. And to make it happen is not easy or intuitive.

Arroyo recounted a success story about the spread of pilot-monitoring improvements, however. A few years ago, he said, Robert Sumwalt — now an NTSB member, then a US Airways captain and member of the steering committee of the Line Operations Safety Audit (LOSA) Collaborative — concluded from LOSA data analysis that the industry had failed to deal adequately with the challenges of pilot monitoring. "He designed the idea of pilot monitoring training," Arroyo said. "As soon as he started doing this, the Asociación Sindical de Pilotos Aviadores de México, the association of Mexican airline pilot unions, invited him to come share his thoughts." When Curzio became director of flight standards at Aeroméxico, he moved immediately to turn Sumwalt's ideas into actions.

"Six years later, we have implemented a cultural shift," Arroyo said. "We provide monitoring skills during each recurrent training and evaluate them at each training event."

Safety hindrances in countries targeted by RASG-PA also have to do with geographical aspects of the environment. "For example, Benito Juárez International Airport in Mexico City is a high-altitude airport at 7,300 ft," Arroyo said. "Some 70 percent of the airspace is occupied by mountains, volcanoes included. The final approach requires a 90-degree turn within 6 nm [11 km]. Predominating winds mean one of the two runways is active 90 percent of the time. We overfly the city, which produces heat and turbulence because of the large paved surfaces and buildings. This used to make our approaches unstabilized. Thanks to flight monitoring — with LOSA and a flight operational quality assurance [FOQA] program — we identified where we could improve that situation. So we reduced unstabilized approaches by 95 percent."

Technical advice on developing solutions like these also has been available to the region in other ways. The U.S. Commercial Aviation Safety Team

(CAST) has been one of them. Kyle Olsen, a team member and U.S. Federal Aviation Administration consultant, came to the summit with a mission to share the latest CAST safety enhancements designed to reduce LOC-I events.

"We would like to see all the pilots in these Pan American countries have the latest version of upset recovery training," Olsen said. "The next safety improvement we would like to see is for all operators and regulators to discontinue the use of the term 'pilot not flying' and use 'pilot monitoring,' which has a different connotation. In North America and in Europe, [operators] have developed guidelines on what tasks the pilot monitoring should be accomplishing. The third area is related to the use of automation. Some crews over-use it or under-use it, and there is a balance for the appropriate use of automation. There have been some human factors studies done on that issue in North America, Europe and Asia. We want to use that material to provide guidance in [other] Pan American countries. We need expertise from the [local] training people at airlines, as well as government authorities and other interested people to help us to really flesh out these [CAST] safety enhancement projects in the region."

Implicit in all the summit presentations was that the region is now being called upon to make a paradigm shift — beyond reactive or even proactive models to a data-driven predictive model — and local resistance must be tackled head-on and mentalities changed accordingly. This is not a comfortable task, however, presenters agreed.

Miguel Antonio Mojica, a captain and flight safety director at TACA, told a relevant story: "We began a tremendous transition from the reactive mode to the predictive mode by attempting to introduce FOQA in 2002 and 2003. We followed ICAO's recommendation that the program should be nonpunitive and anonymous. Nevertheless, it also has a reactive part, as an investigative tool. So we asked our CEO, 'What should be our policy?' He said, 'If the staff reports on a voluntary basis, we will establish an immunity policy. Otherwise, it definitely will be used as an investigation tool.' This [response] upset our crews. Therefore, we had to take the opportunity of using safety and accident prevention training to sell them on the program as a non-punitive initiative. Later, both voluntary and mandatory reporting began to happen. Our Latino culture is a bit reactionary to reporting … with a lot of *machismo* [bravado] and a lack of transparency. On the flight deck, there was also a high degree of vertical authoritarian power [to overcome]."

It took time, but this mentality was changed successfully as FOQA data provided information for safety enhancements that resulted in better operational performance, Mojica recalled.

The cultural shift to data-driven safety initiatives also brought significant results to the LAN group of airlines, said Jaime Silva Rivera, a LAN captain and corporate safety director. He described the group's package of integrated reactive, proactive and predictive programs. LOSA was implemented five years ago, and these airlines also have found the IATA Safety Audit for Ground Operations to be "an excellent tool to tackle this complicated issue of ground [risks]," Rivera said. LAN has fully implemented a safety management system (SMS), including a personnel drug-testing program and a fatigue risk management program for its crews.

Analytical tools in its flight data monitoring program also have allowed LAN to detect unsafe situations in routine operations. "We encountered ice obstruction on the pitot tubes of our Airbus A340 and A320 fleets," Rivera said. "We enhanced procedures, changed equipment and enhanced training, and the modifications to airspeed indicators meant that we had to send crews to simulator training."

Diversified Goals

Controlled flight into terrain (CFIT), the third-ranked risk area in summit discussions of RASG-PA strategy, generated a dialogue between the air traffic control (ATC) representatives and other segments of air transport. Alex Figuereo, vice president Americas, International Federation of Air Traffic Controllers' Associations (IFATCA), highlighted the role of

Martin, top, and de Gunten

Edvaldo Pereira Lima

ATC in this issue and tried to clear up a misconception. "ATC, as defined by ICAO, is not responsible for separation from terrain during climb and descent phases, except when radar-vectoring [aircraft]," Figuereo said.

Along the same lines, IFATCA policy says that ATC "MSAW [minimum safe altitude warning] systems must be fully implemented without delay, with the necessary operational requirements and appropriate ATC procedures and training on a worldwide basis, in order to significantly reduce the numbers of CFIT accidents." This policy, however, also states, "It must be kept in mind that an aircraft ground proximity warning system can often perform better than ATC MSAW systems."

Arroyo

Edvaldo Pereira Lima

The role of states in providing safety enhancements was covered for summit attendees by Carlos Pellegrino, operational safety superintendent at Brazil's Agência Nacional de Aviação Civil (ANAC), the national civil aviation agency. Brazil is pioneering the first stage of implementation of a state safety program for aviation. This is being done under the joint civilian-military arrangement the country applies in aviation, in cooperation with the Comando da Aeronáutica, Força Aérea Brasileira, the aeronautical command of the Brazilian Air Force, he said.

A presentation by Líbano Miranda Barroso, CEO of TAM, also received a positive response from the audience as he detailed the airline's top-down safety commitment, its SMS structure, principles of balancing safety and operational costs, and safety impact on business continuation.

Alex de Gunten, ALTA's executive director, said he considered the summit successful but emphasized that the work discussed is not yet done. "Latin America improved in safety last year, but we're still not where we want to be," he said. "We want to reach the levels of the United States and Europe in incident rates." This requires an orchestrated effort among all stakeholders and financial support, de Gunten added. ICAO's Martin said that The Boeing Co. provided $100,000 in support that initially has made it possible for RASG-PA to conduct safety events and translate key safety documents. Additional monetary support will be needed to launch other safety programs, Martin said.

In addition to the summit's safety themes of high-level technical, organizational and corporate issues, and human factors, there was an inspirational reminder. When Steven Chealander, a captain, vice president, Training and Flight Operations Support, Airbus Americas, and former NTSB member, stepped on stage to deliver his presentation, he carried a poignant book. He quoted from *The Empty Chair: Love and Loss in the Wake of Flight 3407* by Gunilla Theander Kester and Garyl Earl Ross, an independent anthology[6] of spontaneous poetry, essays, songs, diaries, memoirs and other writings by family members and friends of the 50 people killed in the crash of Colgan Air Flight 3407 on Feb. 12, 2009, near Buffalo, New York, U.S. (*ASW,* 3/10, p. 20).

Chealander used the book to remind his peers in RASG-PA that it takes just one accident to forever affect the lives of many, and that a normal flight operation in seconds can turn into a tragedy. "We move lives, we can never forget that," he said. Creating a safety culture is "paramount … a leadership issue … to prevent the accident now," he added.

Edvaldo Pereira Lima is an aviation writer living in Brazil.

Notes

1. This definition was developed by the CAST/ICAO Common Taxonomy Team.
2. Some summit presenters used preliminary IATA data for 2009. Another source was: IATA. *Safety Report 2008.* 45th edition. April 2009. Data are for hull losses per million sectors.
3. Data are from the Aeronáutica Civil de Colombia, the civil aviation authority of Colombia.
4. Aeronáutica Civil de Colombia.
5. Detailed explanations of stabilized approach as a safety defense are in the newly revised version of the FSF *ALAR Tool Kit* at <flightsafety.org/current-safety-initiatives/approach-and-landing-accident-reduction-alar/alar-tool-kit-cd>.
6. This book can be obtained from <www.lulu.com/product/paperback/the-empty-chair/6281736?productTrackingContext=search_results/search_shelf/center/1>.

BY RICK DARBY

Changing Course

Australian commercial aviation last year reversed unfavorable safety trends in two key areas.

The safety record of Australian-registered charter aircraft improved in 2009 after two years in which the numbers of aircraft involved and accidents had risen, according to a report from the Australian Transport Safety Bureau (ATSB) comparing accident data in the 1999–2009 period.[1] In commercial air transport, the number of aircraft involved in serious incidents also declined in 2009 after a couple of years of increases.[2]

"A general increase has been observed in the number of VH- [Australian-] and foreign-registered commercial air transport aircraft incidents over the 11 years of observation," the report says. "This increase may be attributed to the introduction of the Transport Safety Investigation Regulations 2003, which provides a prescriptive list of the types of occurrences that are required to be reported to the ATSB. This increase may also reflect a better reporting culture."

In Australian commercial air transport, the 3,864 aircraft involved in incidents in 2009 were fewer than those in the previous two years (Table 1). Aircraft involved in serious incidents also declined in number in 2009 compared with the two previous years. The 26 aircraft involved in serious incidents represented a 43 percent decrease from 2008.

The 11 total accidents for 2009 were the lowest of any year in the study period, and 38 percent of the previous year's total.

Data for accidents per million departures were not yet available for 2009. The trend for the study period has been increased rates in recent years following a low point in 2005 and 2006 (Figure 1, p. 52).

"About one in 10 accidents involved a fatality, and there [were] about three fatal injuries for each accident that involved a fatality," the report says of the 11-year period. For the first time since 2004, there were no fatalities in 2009 in commercial air transport.

The numbers of high-capacity, regular public transport (RPT) aircraft involved in incidents and serious incidents in 2009 were lower than the previous two years (Table 2).[3,4] Fatal accidents in this category continued to flatline at zero. Accidents per million departures in 2009, at 2.1, were the lowest in the study period.

The accident rate declined from its highest point in 1999 — 23.9 per

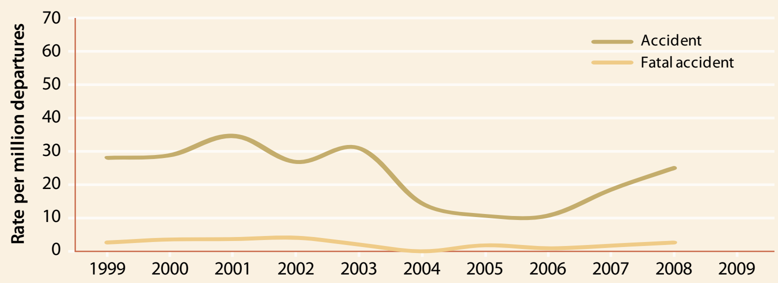
Accidents and Injuries, Australian Commercial Air Transport, 1999–2009

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Number of aircraft involved											
Incidents	3,185	3,213	3,142	3,011	2,695	3,464	4,119	3,708	3,915	4,053	3,864
Serious incidents	2	9	9	10	15	30	33	16	45	46	26
Serious injury accidents	0	2	1	3	1	0	2	0	1	3	2
Fatal accidents	3	4	4	4	2	0	2	1	2	3	0
Total accidents	32	33	38	27	31	16	12	12	22	29	11
Number of people involved											
Serious injuries	2	3	4	8	4	0	2	0	1	15	3
Fatalities	10	19	10	12	8	0	18	2	2	6	0
Rates											
Accidents per million departures	28.0	28.8	34.6	26.8	30.9	14.4	10.8	10.8	18.6	25.0	—
Fatal accidents per million departures	2.6	3.5	3.6	4.0	2.0	0.0	1.8	0.9	1.7	2.6	—

Source: Australian Transport Safety Bureau

Table 1

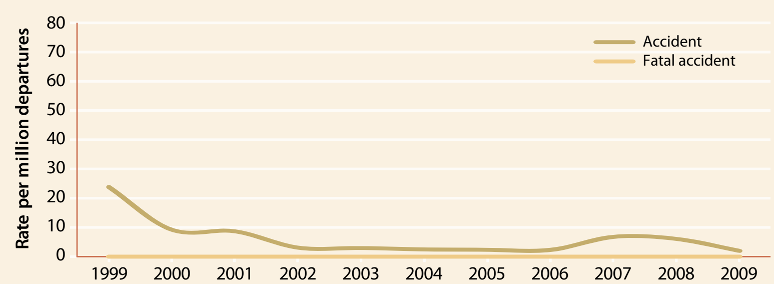
Accident Rates, Australian Commercial Air Transport, 1999–2009



Source: Australian Transport Safety Bureau

Figure 1

Accident Rates, Australian High-Capacity RPT, 1999–2009



RPT = regular public transport

Source: Australian Transport Safety Bureau

Figure 2

million departures — to 3.2 per million departures in 2002 (Figure 2). Aside from a slight "bump" in 2007 and 2008, the rate has stayed within a 2 to 3 per million departures range.

The 10 serious incidents in 2009 were described by the report as follows: "engine compressor blade damage, a breakdown of separation, an aircraft commencing to land with the landing gear retracted, a separation of the nosewheel from an aircraft, an in-flight windscreen fire, a cabin depressurization, an in-flight warning, and three occurrences involving crew incapacitation."

The number of incidents involving low-capacity RPT aircraft has decreased by about 30 percent during the study period, the report said.[5] Twenty accidents in the category were recorded during the period, with one in 2009. There were four serious incidents in 2009. The report said, "Two occurrences involved flight control systems, one being a trim system failure and nose pitch-up, and the other being a nose pitch-down event of unknown origin. The other two serious incidents related to airspace separation and an airprox."[6]

Between 1999 and 2003, the fluctuation in the number of charter aircraft involved in occurrences was relatively stable. But between

Accidents and Incidents, Australian High-Capacity RPT, 1999–2009

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Number of aircraft involved											
Incidents	1,672	1,711	1,733	1,776	1,478	1,976	2,391	2,184	2,242	2,457	2,404
Serious incidents	1	4	5	6	6	10	12	4	16	20	10
Serious injury accidents	0	1	1	1	1	0	1	0	1	1	1
Fatal accidents	0	0	0	0	0	0	0	0	0	0	0
Total accidents	7	3	3	1	1	1	1	1	3	3	1
Number of people involved											
Serious injuries	0	2	1	1	4	0	1	0	1	12	1
Fatalities	0	0	0	0	0	0	0	0	0	0	0
Rates											
Accidents per million departures	23.9	9.3	8.8	3.2	3.1	2.6	2.5	2.4	6.9	6.2	2.1
Fatal accidents per million departures	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Accidents per million hours	9.9	3.9	3.8	1.4	1.3	1.1	1.1	1	3	2.7	—
Fatal accidents per million hours	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	—

RPT = regular public transport

Source: Australian Transport Safety Bureau

Table 2

Accidents and Incidents, Australian Charter Operations, 1999–2009

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Number of aircraft involved											
Incidents	424	435	357	411	374	445	522	577	689	712	599
Serious incidents	1	0	0	1	3	9	6	6	13	13	11
Serious injury accidents	0	1	0	2	0	0	1	0	0	2	1
Fatal accidents	3	3	4	4	2	0	1	1	2	3	0
Total accidents	21	26	32	20	26	15	9	10	18	26	8
Number of people involved											
Serious injuries	2	1	3	7	0	0	1	0	0	3	2
Fatalities	10	11	10	12	8	0	3	2	2	6	0
Rates											
Accidents per million departures	43.3	56.4	71.3	45.2	60.2	30.4	18.8	21.1	33.2	52.5	—
Fatal accidents per million departures	6.2	6.5	8.9	9.0	4.6	0.0	2.1	2.1	3.7	6.1	—
Accidents per million hours	41.3	54.2	68.2	44.6	60.2	31.0	18.6	20.8	32.9	49.9	—
Fatal accidents per million hours	5.9	6.3	8.5	8.9	4.6	0.0	2.1	2.1	3.7	5.8	—

Source: Australian Transport Safety Bureau

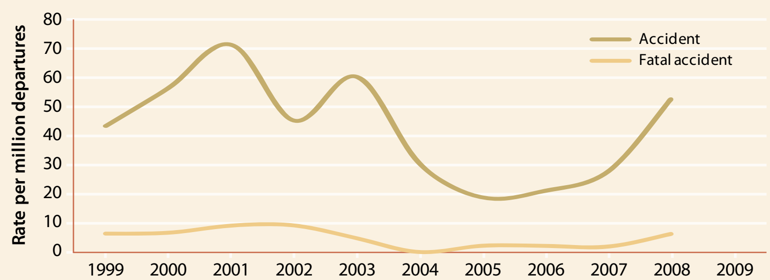
Table 3

2004 and 2008, the range was about 48 percent higher, comparing the means of each range (Table 3).[7] The 599 charter aircraft involved in incidents in 2009 marked a reversal of the seven-year trend, however.

Of all air transport operations, charters had the highest rate of aircraft involved in accidents and fatal accidents per million departures in the most recent year for which data are available, 2008 (Figure 3). This aircraft accident rate — 52.5 per million departures — was a 58 percent increase over 2007.

In 2009, there were eight accidents involving charter aircraft. That number was the lowest in the study period. "Four accidents were associated with wheels-up landing — three related to landing gear malfunction and one due to pilot error," the report says. "There were three engine failure accidents and one aircraft flipped over on the aerodrome apron due to a strong gust of wind."

Accident Rates, Australian Charter Aircraft, 1999–2009



Source: Australian Transport Safety Bureau

Figure 3

Notes

1. The report, *Aviation Occurrence Statistics: 1999 to 2009*, is available via the Internet at <www.atsb.gov.au/publications/2009/ar2009016(3).aspx>.
2. Commercial air transport includes high-capacity RPT, low-capacity RPT and charter. Accidents and incidents involving non-Australian-registered aircraft in Australian airspace are included.
3. A high-capacity aircraft is one that is certified as having a maximum capacity exceeding 38 seats or a maximum payload exceeding 4,200 kg (9,259 lb).
4. Regular public transport operations are conducted with fixed schedules, to and from fixed terminals, over specific routes.
5. A low-capacity aircraft is one that has a lower seating capacity or maximum payload than a high-capacity aircraft.
6. Australian Transport Safety Regulations define an airprox as "an occurrence in which two or more aircraft come into such close proximity that a threat to the safety of the aircraft exists or may exist, in airspace where the aircraft are not subject to an air traffic separation standard or where separation is a pilot responsibility."
7. Charter operations involve the carriage of passengers and/or cargo on non-scheduled operations by the aircraft operator, or the operator's employees, in trade or commerce.

A Clean Sweep

Bacteria, rodents and insects are on the no-fly list.

BOOKS

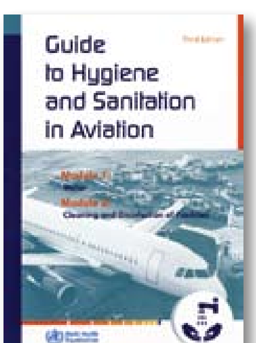
Does Your Aircraft Have a Drinking Problem?

Guide to Hygiene and Sanitation in Aviation: Module 1, Water; Module 2, Cleaning and Disinfection of Facilities

World Health Organization (WHO) Press. Third edition. 2009, released April 2010. 60 pp. Figures, tables, references, annexes.

This supersedes the previous edition of the *Guide*, published in 1977. Although it says that basic principles of hygiene have not changed since then, the aviation world has, with new health threats as a consequence.

Besides the growth in air traffic, "the current trend in international civil aviation is toward aircraft of larger passenger-carrying capacity and greater range," the *Guide* says. "The introduction of air services into areas with inadequate public health infrastructure, such as food handling and storage, water supply, and waste disposal, creates a challenge for aircraft operators. To protect public health, the application of high standards of hygiene should form an integral part of airport and aircraft operations."



Occasional reports of incidents involving food-borne illness associated with international travel are reminders of the importance of ensuring the quality of food and drinking water aboard aircraft, the *Guide* says. The boldest headlines, however, have been generated by the potential for the transmission through commercial aircraft flights of communicable diseases such as severe acute respiratory syndrome (SARS) and extremely drug-resistant strains of tuberculosis. They have created a renewed interest in an aircraft environment conducive to health, the *Guide* says.

This edition of the booklet addresses "water, food, waste disposal, cleaning and disinfection of facilities, [disease] vector control and cargo safety, with the ultimate goal of assisting all types of airport and aircraft operators and all other responsible bodies in achieving high standards of hygiene and sanitation, to protect travelers and crews engaged in air transport."

Although public health specialists have the responsibility to see that, for example, the source of water coming into the airport and aircraft is disease-free, they cannot monitor the entire supply chain. Airport and operator management personnel, as well as cabin crewmembers, need to keep an eye out for possible contamination.

Besides the original source, the aircraft drinking water supply chain has three additional stages:

The airport water system. This includes the local area distribution system. Some airports have their own water treatment facilities;

The transfer point. This, the *Guide* says, "is typically a temporary interconnection between the hard-plumbed distribution system of the airport (e.g., at a hydrant) and the aircraft water system, by means of potable [drinkable] water vehicles and carts, refillable containers or hoses. This water transfer process provides multiple opportunities for the introduction of contaminants into the drinking water"; and,

The aircraft water system. This includes "the water service panel, the filler neck of the aircraft finished water storage tank and all finished water storage tanks, including refillable containers/urns, piping, treatment equipment and plumbing fixtures within the aircraft." Next stop, the aircraft's galley and lavatory outlets serving passengers and crewmembers.

The *Guide* says that random testing of water on aircraft by Health Canada, the U.K. Association of Port Health Authorities and the U.S.

Environmental Protection Agency has raised aircraft water health concerns. The Canadian and U.S. studies revealed the presence of total coliforms on 15 percent and *E. coli* bacteria on as many as 4 percent of aircraft.

"Most total coliforms are not pathogens per se, but a positive test is an indicator of inadequate sanitation practices; *E. coli* are indicative of recent fecal contamination, and some *E. coli* are human pathogens," the *Guide* says.

In response, the *Guide* offers detailed health guidelines for water management, with a list of indicators to gauge whether each is being followed. The guidelines include plans for each component of the water supply chain; meeting WHO *Guidelines for Drinking-Water Quality* or national standards; monitoring water quality; ensuring an appropriate response when a risk is detected; making potable water available in sufficient quantity, pressure and temperature throughout the supply chain; and independent surveillance of water quality by a qualified authority.

The other module includes equipment cleaning, primarily "the removal of dirt or particles," and disinfection, or "measures taken to control, deactivate or kill infectious agents, such as viruses and bacteria."

The *Guide* says, "Commercial air transport is potentially an efficient means for spreading communicable disease widely by surface contact and proximity to infected persons."

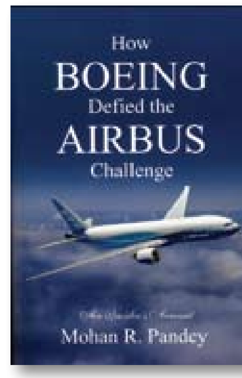
Disease vectors are not limited to coughing and sneezing passengers. Every so often the news media report, in a humorous tone, about a "SWAT team" searching an entire airliner after a rat is spotted. The risk is real, however. Rodents and insects are efficient carriers of infection. Flies should not fly — on airliners.

After outlining the routes of infection transmission that can occur aboard aircraft, the *Guide* again provides guidelines along with indicators of their observance. These include keeping an airport in a sanitary condition at all times; designing and building airports in a way that facilitates proper cleaning and infection; having post-event disinfection procedures to prevent contamination from spreading; keeping aircraft in a sanitary condition at all times; designing and building aircraft to facilitate proper cleaning and disinfection; and having onboard procedures to prevent the spread of disease and contain infection at the source.

Standard disinfection procedures are described.

— *Rick Darby*

Toe-to-Toe in the Sky



How Boeing Defied the Airbus Challenge: An Insider's Account

Pandey, Mohan R. CreateSpace, On-Demand Publishing. 2010. 242 pp. References, index.

To take the most obvious issue first, Pandey, a longtime Boeing employee, says that his book "in no way represents Boeing's position; it is only my personal perspective. I hope I have represented all sides — Boeing, Airbus and various industry positions — fairly and accurately." Using the pronoun "we," meaning Boeing — as in "at the end we outmaneuvered Airbus" — does not inspire confidence in the book's objectivity. Readers will make their own judgments about fairness.

Nevertheless, pilots, aviation industry managers and flight enthusiasts will find much of interest in Pandey's description of the technical, economic and political issues involved in producing new airliner types. Primarily, this is an account of the development of the Boeing 777, part of its manufacturer's response to competition from Airbus, and particularly the A340 four-engine, long-range passenger jet and its twin-engine stablemate, the A330.

Pandey describes the Airbus A320 family as having frayed nerves at Boeing, taking a big bite out of the market for the Boeing 737 series. The A330/340 model threatened to challenge the long-range dominance of Boeing's "jumbo" jet, the 747, and its 767. "After looking at various options, including a three-engine 7J7, by the late 1980s, Boeing concluded that to attack both the A330 and the A340, its new airplane had to be a fuel-efficient big twin," Pandey says. That was the genesis of the 777.

One of the many hurdles, other than technological and production, that Boeing had to deal with for its 777 to pay off was extended operations (ETOPS) regulations. "Boeing had to secure ETOPS approval for these big twins," Pandey says. "But there was a wrinkle. The FAA [U.S. Federal Aviation Administration] requirements stressed the importance of in-service experience."

The FAA and other regulatory agencies internationally — which would have a say in the long-haul routes the 777 was designed for — required that a new type-and-engine combination be operated for a year to qualify for 120-minute authority; that is, to be permitted to operate routes up to two hours flight time from the nearest airport that could be used for an emergency landing necessitated by an engine failure. An additional year of in-service experience was required for 180-minute authority.

But the 777 was designed for the international, overwater market. Boeing could not afford for its 777s to be confined to medium-range, overland flights for a year or two, even assuming any buyers would want it for such service. "Boeing had to find a way to allow the new twins to operate on ETOPS sectors from the first day of revenue operations at the airline," Pandey says.

Boeing worked with its own engineers, as well as its engine suppliers, to make the 777 "service-ready" for ETOPS, as well as non-ETOPS, flight. It created "design, build and support" teams, whose members worked together with the aim of making engineering compatible with manufacturing and design. And there was another new development.

"For the first time, Boeing was designing the airplane digitally," Pandey says. "There would be no paper drawing — it was a 'paperless' airplane. The famous saying in the manufacture of an airplane used to be [that] when the weight of the paper drawing exceeded the airplane's actual maximum takeoff weight, it was time to stop designing and start building the airplane. This time, the designers would not be able to use this dictum."

The book describes the elaborate negotiations to obtain ETOPS certification "out of the box" for the 777 and the fierce competition, both technological and political, between Boeing and Airbus. The playing field is different now, with Bombardier and Embraer moving into the medium-capacity, medium-range market and going toe-to-toe with Boeing and Airbus. The team names will change, but the game will be the same.

— *Rick Darby*

WEB SITES

News From EASA

EASA General Publications, <www.easa.europa.eu/ws_prod/g/g_comms_general_publications.php>

The European Aviation Safety Agency (EASA) develops common safety and environmental rules for the European Union. Working with its member states, the agency's operational tasks include rulemaking, certification, research, and data collection and analysis. Some of the former responsibilities of the European Joint Aviation Authorities have shifted to EASA.

To stay abreast of EASA activities, visit the "general publications" section of its Web site. Copies of EASA's annual reports and annual safety reviews are available. *EASA News* and annual reports are in English. Annual safety reviews are available in multiple languages.

Current and past issues of *EASA News* expand on regulations, standards, programs under way, anticipated events and more. The February issue reports, "Preliminary safety data for 2009 show that it was the year with the lowest number of fatal accidents on record for the 31 member states of the European Aviation Safety Agency." Issues may be read online or printed at no cost.

— *Patricia Setze*

Tail Strike Follows Bounced Landing

The A320's nose was raised too high after the hard touchdown.

BY MARK LACAGNINA

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

JETS

Tail Wind, Excess Thrust Were Factors

Airbus A320-211. Substantial damage. Four minor injuries.

As the A320 neared Denver International Airport with 147 passengers and seven crewmembers the afternoon of May 4, 2009, the automatic terminal information service (ATIS) reported winds from 240 degrees at 4 kt and 10 mi (16 km) visibility. The flight crew planned for a visual approach to Runway 16L, using the instrument landing system (ILS) as a backup, and an approach speed of 139 kt.

The first officer, 48, was the pilot flying. He had 5,901 flight hours, including 200 hours as second-in-command of A320s, and held type ratings for the Boeing 707 and Douglas DC-9. The captain, 49, had 14,619 flight hours, including 2,677 hours as an A320 pilot-in-command.

The airplane was 1,000 ft above the runway touchdown zone elevation (5,347 ft) when the first officer announced that the approach was stable. Shortly thereafter, the airport traffic controller cleared the crew to land on Runway 16L and advised that the wind was from 260 degrees at 5 kt.

About 750 ft above touchdown, the crew disengaged the autopilot and engaged the flight directors and autothrottles. "During the final approach, the crew noted an increasing tail wind," said the report by the U.S. National Transportation Safety Board (NTSB). Recorded flight data indicated that the tail wind component had increased to 11 kt.

The descent rate was about 800 fpm when the airplane was 50 ft above touchdown. "The first officer stated that he attempted to arrest the sink rate with larger-than-normal aft stick deflection," the report said. "During the flare, passing 20 ft above the runway, the automated 'retard' callout [was generated three times]. This automated callout is designed to remind the pilot to move the thrust levers to the idle detent." This action causes the ground spoilers to deploy on touchdown.

Despite the automated callouts, the thrust levers were not retarded. During the flare, the airplane's pitch attitude was increased to 8 degrees nose-up, and airspeed decreased to 132 kt, or 7 kt below the target. The autothrottle system commanded an increase in engine power to recover airspeed, and N_1 (fan speed) increased from 54 percent to 64 percent in three seconds.

"The airplane touched down on both main landing gear with a vertical load of about 1.56 g [i.e., 1.56 times standard gravitational acceleration]," the report said. "The airplane then bounced as a result of the excess thrust and the position of the thrust levers forward of idle, which prevented deployment of the spoilers."

During the bounce, the first officer retarded the thrust levers to idle and moved his control stick fully aft, increasing the airplane's pitch attitude to about 12.5 degrees nose-up, which is greater than the maximum pitch angle of 11.7 degrees specified in the flight crew operating manual.

"The captain attempted to add nose-down pitch to prevent the tail strike but was too late," the report said. "The airplane experienced heavy abrasions, dents and perforations of the skin; the aft galley drain mast and two airplane antennas were broken; the auxiliary power unit air intake sustained damage, and the rear pressure bulkhead was buckled and cracked." Four flight attendants reported minor injuries; the report did not specify the nature of the injuries.

'The captain attempted to add nose-down pitch to prevent the tail strike but was too late.'

Shortly after the A320 accident, the crew of an Embraer 145 conducted a go-around from an approach to Runway 16R because the indicated tail wind component exceeded 10 kt. Air traffic control subsequently changed the active runways. An official weather observation 35 minutes after the accident indicated that surface winds were from 330 degrees at 13 kt, gusting to 17 kt.

The report noted that Airbus had developed an A320/A321 flight warning computer modification — a "pitch pitch" callout designed to increase pilot awareness of an impending tail strike — but none of the A320s in the accident airplane operator's fleet had received the modification.

Puzzling Power Loss

Cessna Citation 500. Destroyed. Five fatalities.

A precautionary but unnecessary engine shutdown, a flameout of the other engine due to a mechanical failure of the thrust lever, and a rushed and unsuccessful attempt to restore power from both engines might have led to the Citation's crash near England's Biggin Hill Airport the afternoon of March 30, 2008. However, the absence of flight recorders aboard the 33-year-old aircraft precluded a conclusive reconstruction of the events leading to the accident, according to the report by the U.K. Air Accidents Investigation Branch (AAIB).

Visual meteorological conditions (VMC) prevailed when the Citation, of Bermudan registry, departed from Biggin Hill with three passengers and two pilots for a private flight to Pau, France. "It was not possible to ascertain the exact role of each pilot during the flight," said the report, which identified the left-seat pilot as "Pilot A" and the right-seat pilot as "Pilot B." Both held single-pilot certification in the Citation 500.

Pilot A, 57, was employed by the aircraft owners. He had 8,278 flight hours, including 18 hours in the Citation. "He had recently completed a type conversion onto the aircraft, and it is believed that he had wished to fly with another pilot who had more hours on type, acting as mentor, until he gained more experience," the report said.

Pilot B, 63, had 4,533 flight hours. The report said that his time in type is unknown but that he had "in excess of 70 hours" in Citation 500s.

The airport traffic controller, who cleared the pilots for takeoff from Runway 21 at 1332 local time, said that the takeoff appeared normal. The pilots made a right turn to the northeast, in accordance with their instrument flight rules clearance.

At 1334, Pilot B radioed, "We're making an immediate turn to return to the airport." When asked the nature of the problem, the pilot said, "We don't know, sir. We're getting engine vibration."

The vibration detected by the pilots was not caused by an engine but by the failure of the inlet fan for the air cycle machine, which conditions engine bleed air before it enters the cabin.

Nevertheless, in the likely scenario developed by investigators, the pilots decided to check each engine separately to troubleshoot the vibration. They began by reducing power from the right engine. Because of the consequent reduction of bleed air flow to the air cycle machine, the vibration caused by the broken inlet fan also decreased, causing the pilots to perceive that the right engine was producing the vibration. Accordingly, they shut down the right engine.

Meanwhile, the pilots had begun a left turn at 1,800 ft to return to Biggin Hill and had retarded the left thrust lever to reduce power to begin a descent. The thrust lever inadvertently was moved into the fuel-cutoff position because of the failure of a mechanism designed to prevent this from occurring. Normally, when a thrust lever is moved to the idle position, a smaller lever riveted to the thrust lever is trapped by a gate that prevents further movement of the thrust lever to the fuel-cutoff position. To intentionally move the thrust lever to the fuel-cutoff position, a knob on the thrust lever must be raised to lift the smaller lever out of the gate.

However, investigators found that a rivet securing the smaller lever to the thrust lever had become detached, allowing the thrust lever to be moved aft of the idle position without resistance, shutting down the engine.

The pilots attempted to restart both engines. Examination of the engines revealed that both were producing power on impact but had not accelerated sufficiently to provide enough thrust to recover from the descent. "Interpretation of available data suggests that one engine had not completed its start sequence before an attempt was made to start the other," the report said. "A sense of urgency [might] have led to a deliberate attempt to start the second engine before the first engine had reached idle speed."

The report noted that a successful restart and acceleration of just one engine "could have produced sufficient thrust in the time available to prevent ground impact."

Lacking sufficient power, the Citation continued to descend. Its left wing struck a house 2 nm (4 km) north-northeast of the airport. "The aircraft then impacted the ground between this and another house and caught fire," the report said. "There were no injuries to anyone on the ground, but all those on board the aircraft were fatally injured."

The report said that the "lack of recorded data meant that the investigation was short of critical information which would have provided further insight and a clearer understanding of the factors leading to the loss of the aircraft." Among recommendations generated by the investigation was that the International Civil Aviation Organization expand the requirement for flight recorders to include jets weighing 5,700 kg/12,500 lb or less.

Crew Departs on Wrong Runway

Boeing 737-600. No damage. No injuries.

"Deviations from the crew resource management (CRM) concept" manifested in faulty communications caused the 737 flight crew to take off from Runway 32 at Sweden's Luleå–Kallax Airport after they had read back a clearance to depart from Runway 14, according to the Swedish Accident Investigation Board (SHK).

The incident occurred in darkness and low visibility the morning of Feb. 27, 2007. The SHK report, issued in March, said that the commander programmed the 737's flight management system for a departure from Runway 32 while the aircraft was still at the gate. After the 88 passengers boarded, the commander requested and received clearance to taxi to the deicing ramp.

Surface winds were light, and the controller gave the crew the option to depart from Runway 14 rather than Runway 32. The controller also issued a slot time that required the crew to be airborne within 10 minutes. Although this initially "had a stressful effect on the course of events," the slot time later was extended indefinitely to accommodate the 737's departure, the report said.

Visibility deteriorated rapidly and was about 800 m (1/2 mi) when the 737 was taxied from the deicing ramp. The copilot, who was handling radio communications, requested and received clearance to taxi to Runway 14. The commander, however, taxied the aircraft to Runway 32. "When the aircraft was approaching Runway 32, the [copilot] notified that they were ready for takeoff at full length Runway 14," the report said. The airport does not have ground radar, and the controller, who could not see the aircraft, cleared the crew for takeoff from Runway 14. The copilot acknowledged the clearance, and the commander performed a rolling takeoff from Runway 32.

The airport does not have ground radar, and the controller, who could not see the aircraft, cleared the crew for takeoff.

The crew was not aware of the error until the controller filed a report on the incident the next day. The cockpit voice recording by then had been overwritten, which hindered investigators' efforts to determine what caused the incident. The report said that the commander likely was focused on departing from Runway 32 and on maneuvering the aircraft on slippery taxiways and in low visibility. The copilot likely believed that the commander had accepted the controller's offer to depart from Runway 14 and became so busy in communicating with the controller and with copying route clearances that he did not notice that the aircraft was being taxied toward Runway 32 and "did not note the '180-degree error' on the compasses" when the commander began the rolling takeoff on Runway 32, the report said.

Although the cause of the incident could not be determined conclusively, "it has been established [that the crew deviated from] the part of CRM relating to communication and cooperation," the report said.

Drifting Fog Blankets a Flare

Airbus A340-313. Minor damage. No injuries.

The A340 was en route from London to Nairobi, Kenya, with 108 passengers and 14 crewmembers the morning of April 27, 2008. Before beginning the descent from cruise altitude, the flight crew obtained an ATIS report indicating that surface winds were from 040 degrees at 3 kt, visibility was 7 km (4 mi), the ceiling was broken at 1,600 ft, and both temperature and dew point were 15° C (59° F).

However, the aircraft operator's charts for Nairobi noted that "the weather can include morning fog … the ATIS has been reported as unreliable, and so crews should note that conditions may not be as they expect."

Before handing off the flight to the airport traffic controller, the approach controller told the A340 pilots that the crew of a preceding aircraft had reported that landing visibility was 3,000 m (nearly 2 mi) and the cloud base was at 300 ft.

Before clearing the crew to land on Runway 06, the airport traffic controller said, "The visibility reported as 3,000 meters. Land at your own discretion. Wind 050 at 5 kt."

The first officer, the pilot flying, conducted the approach with the autopilots and autothrottles engaged. "At the decision height of 200 ft, both pilots [said that they] had more than the minimum visual reference required and could see 'all the approach lights and a good section of runway lights,'" the AAIB report said.

The first officer disengaged the autopilots and began to flare the A340 between 75 ft and 50 ft radio altitude. "The aircraft floated for a few seconds before it entered an area of fog," the report said. Both pilots lost sight of the runway. The first officer applied left rudder, apparently inadvertently, and the aircraft drifted left. "The commander became aware of the left runway edge lights moving rapidly closer to him [and] called, 'Go around,'" the report said.

The first officer immediately moved the thrust levers fully forward, but the A340 touched down on the main landing gear and veered off the left side of the runway. "The left main landing gear ran off the paved runway for a distance of 180 m [591 ft]" before the aircraft became airborne, the report said.

The crew diverted the flight to Mombasa, where VMC prevailed, and landed the aircraft without further incident. Examination revealed scratches and abrasions on the lower left fuselage, and minor damage to the left aft wheel on the left main landing gear.

TURBOPROPS

Misrigging Causes Wheel to Jam

Swearingen Metro II. Substantial damage. No injuries.

The Metro was inbound to Winnipeg, Manitoba, Canada, with eight passengers and two pilots the afternoon of March 3, 2009. Surface winds were from the south at 20 kt, gusting to 30 kt, and visibility was 15 mi (24 km) with drifting snow.

When the flight crew attempted to extend the landing gear on final approach, the right main landing gear did not extend fully. "The crew carried out a missed approach, declared an emergency and entered a holding pattern to attempt gear extension," said the report by the Transportation Safety Board of Canada (TSB).

The crew performed emergency gear-extension procedures, but the gear-position indicators showed that the right main gear remained in transit. A visual check from the cabin indicated that the inboard right tire apparently was hung up in the wheel well and that the gear doors were partially open.

After consulting with company maintenance personnel, the crew performed a touch-and-go landing on the left main landing gear in an attempt to jar the right main gear free. However, the attempt was unsuccessful.

With minimum fuel remaining, "the crew elected to conduct a gear-up landing into the wind on Runway 18 with aircraft rescue and fire fighting personnel standing by," the report said. "Over the threshold of Runway 18, prior to touchdown, the crew shut down both engines and feathered both propellers. The aircraft came to a gradual stop on its belly on the centerline."

No one was injured during the landing or the evacuation. Examination of the Metro revealed damage to the propellers, flaps and aft fuselage.

Investigators determined that the interference between the inboard right tire and inboard gear door was caused by a combination of factors, including misrigging of the gear door and a retreaded tire that "grew" about 1/2 in (1 cm) beyond new-tire limits after it was installed 16 days before the accident.

Spatial Disorientation on Night Takeoff

Beech King Air 200C. Destroyed. One fatality, four serious injuries, one minor injury.

Spatial disorientation amplified by the pilot's consumption of alcohol and the absence of a second pilot aboard the King Air were among the factors that likely were involved in the aircraft's descent into the sea during a departure from North Caicos Airport in the Turks and Caicos Islands the night of Feb. 6, 2007, according to a report issued by AAIB in April.

The pilot, who had logged 394 of his 8,500 flight hours in type, flew part time for the company that owned the aircraft. The intended destination of the accident flight was Grand Turk. "Weather conditions at the time were good, but it was after nightfall," the report said. "The moon had not risen, and there was little cultural lighting in the area."

The King Air turned right, toward the intended initial course, soon after taking off from the coastal airport but then entered an "excessive" right bank over water and descended in a right turn. The pilot apparently had nearly leveled the wings and had begun to pull out of the dive when the aircraft struck a shallow lagoon "with only a moderate rate of descent but at relatively high forward speed," the report said.

The King Air entered an 'excessive' right bank over water and descended in a right turn.

The pilot was killed. "A postmortem toxicological examination showed that the pilot had a level of blood alcohol [0.03 percent] which, although below the prescribed limit, was significant in terms of piloting an aircraft and would have made him more prone to disorientation," the report said.

Noting that local regulations required two pilots for a night public transport flight under instrument flight rules, the report said, "The presence of a second pilot would have provided a significant measure of protection against the effects of the flying pilot becoming disoriented."

Towplane Hits Chute on Low Pass

De Havilland Twin Otter. No damage. One serious injury.

The pilot said that after 20 skydivers jumped from the airplane, he descended and flew a 45-degree entry to the downwind sector of the landing pattern at Orange County (Virginia, U.S.) Airport the evening of June 13, 2009. He said that the "windshield began fogging up" and he decided to make a 360-degree right turn while he wiped the windshield with a rag. The pilot said that the Twin Otter was at 2,000 ft when it struck a descending skydiver's parachute.

However, the skydivers said that the pilot was conducting a low pass about 30 ft above ground level when the airplane's propeller struck the parachute. The skydiver fell 20 ft and was seriously injured when he struck the ground, the NTSB report said. The Twin Otter was landed without further incident.

The report said that the probable causes of the accident were "the pilot's improper decision to perform a low-level maneuver over a populated skydive landing area and his inadequate visual lookout."

PISTON AIRPLANES

Engine Fire Erupts on Rotation

Cessna 421B. Destroyed. One fatality.

Employees of a fixed-base operator at Fort Lauderdale (Florida, U.S.) Executive Airport saw the 80-year-old pilot "rather haphazardly" pouring oil into the 421's right engine before starting both engines and running them at mid-range power for about 20 minutes the morning of April 17, 2009.

The pilot then taxied the airplane to Runway 08 for departure. Witnesses saw flames and smoke emerge from the right engine shortly after rotation. The pilot radioed the airport traffic controller, "I'm having some trouble here. I'm going to have to come around and land." He did not secure the right engine or feather the propeller, as required by the 421's "In-Flight Wing or Engine Fire" checklist. The airplane banked right at low altitude and descended into a residential area, striking a house. No one on the ground was hurt.

The NTSB report said that the probable causes of the accident were "the pilot's failure to maintain aircraft control and secure the right engine during an emergency return to the airport." The cause of the engine fire could not be determined conclusively because of the severe impact and fire damage. The report noted that an exhaust leak was found at the no. 4 cylinder and that the fuel line leading to that cylinder was broken. However, investigators were unable to determine whether the fuel line broke before or during the crash.

Stall Over an Outdoor Gathering

Beech A55 Baron. Destroyed. Five fatalities.

Witnesses saw the Baron make two or three low passes over an outdoor gathering near Minden, Nevada, U.S., the afternoon of May 9, 2009. "On the final pass, the airplane was slightly above the tops of the local houses, between 100 and 300 ft above ground level," the NTSB report said. "Recovered GPS [global positioning system] data indicated that the airplane was traveling … at 120 kt groundspeed."

The Baron then entered a steep climbing left turn with nearly 90 degrees of bank. Witnesses said that the airplane appeared to decelerate at the top of the climbing turn and then descend in a steep nose-down attitude into an open field. "The witnesses noted that the engines could be heard 'running perfectly' throughout the maneuver," the report said.

Ditching Follows Fuel Exhaustion

Cessna 310R. Substantial damage. One serious injury, three minor injuries, two uninjured.

The pilot had conducted a charter flight with five passengers from Marco Island, Florida, U.S., to Key West, Florida, the morning of June 26, 2008. He told investigators that he did not refuel the airplane or visually check the fuel tanks before departing from Key West that afternoon for the return flight to Marco Island. "Rather, he relied on gauge readings and his fuel calculations," the NTSB report said. "He thought he had an adequate fuel supply for the flight."

The pilot entered the fuel quantity shown on the 310's gauges — 280 lb (127 kg) — on the weight-and-balance form he prepared before departure. However, investigators determined from refueling records that the airplane actually had only 119 lb (54 kg) of fuel in its tanks when it departed from Key West. "Historical fuel records associated with the accident airplane revealed the average fuel burn was approximately 35.09 gallons [211 lb (96 kg)] per hour," the report said.

After takeoff, the pilot initially climbed to 3,000 ft but shortly thereafter descended to

2,500 ft and maintained that altitude until nearing Marco Island. The report did not specify the power setting used for cruise but noted that the fuel-air mixture controls remained in the “full rich” position.

The 310 was about 15 nm (28 km) from the destination and at 1,500 ft when the right engine lost power due to fuel exhaustion. The pilot was attempting to restart the right engine when the left engine also lost power. He announced on the Marco Island common traffic advisory frequency that he was ditching the airplane and required assistance. His call was relayed to a police aviation unit, which dispatched a rescue helicopter.

The pilot, who had logged 200 of his 18,000 hours in type, feathered the right propeller but was unable to feather the left propeller. He extended full flaps but left the landing gear retracted. “He slowed to 93 kt, and just before ditching he placed his arm in front of the 10-year-old passenger seated in the copilot’s seat,” the report said. “The airplane first contacted the water with the curved portion of the bottom of the fuselage and lunged forward, then rebounded.” The ditching occurred about 34 minutes after the departure from Key West.

All of the occupants exited through the cabin door and stayed on the right wing momentarily until the 310 began to sink. One passenger had not been able to find a life vest and clung to two other passengers until the police helicopter and a boat alerted by the helicopter crew arrived about 24 minutes after the ditching.

The pilot told investigators that just before ditching the 310, he noticed that the left and right fuel gauges indicated 70 and 100 lb (32 and 45 kg), respectively.

HELICOPTERS

Fogged Windshield Blocks Pilot’s Vision

Eurocopter EC 120B. Substantial damage.
One fatality, one serious injury.

The pilot did not receive a preflight weather briefing and encountered heavy rain and low ceilings en route from Lac des Neiges, Quebec, Canada, to Québec the morning of June 19, 2008. He turned back toward a potential landing site on the heavily wooded shoreline of Lac á l’Épaule, 28 nm (52 km) from the destination.

“While overflying the lake at low altitude to verify the chosen landing spot, the pilot turned on the demist hot air to clear the front windshield of condensation,” the TSB report said. “The windshield immediately misted up; the helicopter lost altitude and struck the surface of the water. The pilot and passenger sustained minor injuries and evacuated the aircraft successfully.”

The helicopter sank about 500 ft (152 m) from shore. Occupants of a small boat assisted the pilot and passenger to shore. Both were transported to a hospital, where the passenger subsequently died of cardiac arrhythmia from exposure to the cold water and to intense stress, the report said.

Tail Rotor Effectiveness Lost

Robinson R44. Destroyed. Two serious injuries, two minor injuries.

The passengers were filming and photographing a residential development site about 10 km (5 nm) east of Cairns (Queensland, Australia) airport the morning of June 18, 2008, when the helicopter, which was being maneuvered sideways to the left about 200 ft above the ground and facing rising terrain, suddenly yawed right, began to rotate rapidly, descended into trees and struck the ground. The pilot and front-seat passenger were seriously injured.

The chief pilot of the aerial-photography company told investigators that company pilots had been instructed to conduct filming operations no lower than 500 ft and to maintain 20 to 30 kt airspeed to ensure directional control.

“This accident highlighted the risk of loss of tail rotor effectiveness associated with the conduct of aerial filming/photography and other similar flights involving high power, low forward airspeed and the action of adverse airflow on a helicopter,” said the report by the Australian Transport Safety Bureau.

Preliminary Reports, April 2010

Date	Location	Aircraft Type	Aircraft Damage	Injuries
April 1	Huatulco, Mexico	Learjet 25D-XR	destroyed	6 none
The Learjet was destroyed by fire after a gear-up landing.				
April 1	Wlotzkasbaken, Namibia	Cessna 210	destroyed	1 fatal
The 210 broke up in flight during a charter flight from Twyfelfontein to Swakopmund.				
April 2	Cairo, Egypt	Airbus A330-200	substantial	207 none
The flight crew followed a taxi route that did not provide adequate clearance for large aircraft. The A330's wings were damaged when they struck light poles.				
April 2	Princeton, Kentucky, U.S.	Mitsubishi MU-2B	substantial	1 minor
The MU-2 veered off the runway and struck a fence and a ditch after a tire burst on landing.				
April 3	Runnells, Iowa, U.S.	Embraer 170	none	1 serious, 29 none
The Embraer encountered turbulence shortly after the captain asked the flight attendants to be seated. One flight attendant, who had not yet fastened her seat belt, was thrown from her seat and sustained a hip fracture and head contusion.				
April 6	Center, North Dakota, U.S.	Beech B55 Baron	substantial	1 serious, 1 none
The Baron struck several mallards during a training flight at 4,200 ft. One of the ducks penetrated the windshield, injuring the flight instructor.				
April 7	Mexico City, Mexico	Boeing 737-300	none	1 fatal, 1 serious
One mechanic was killed, another was seriously injured when a hydraulic jack supporting the nose landing gear failed.				
April 7	Ponce, Puerto Rico	Cessna 404	substantial	3 none
The pilot feathered the propeller after the engine failed on takeoff, but the 404 continued to descend. The pilot landed the airplane straight ahead in a grassy area.				
April 9	Los Angeles, California, U.S.	Boeing 737-300	substantial	109 none
A ground worker did not turn off the motor or engage the emergency brake after parking a baggage tug that had inoperative "deadman switches." The tug rolled into a hydrant fuel cart and then into the left engine and fuselage of the 737, which was being pushed back from the gate.				
April 10	Smolensk, Russia	Tupolev 154M	destroyed	96 fatal
The Tu-154 crashed about 1,000 m (3,281 ft) short of the runway during a nonprecision instrument approach in heavy fog.				
April 12	Anjozorobe, Madagascar	Aerospatiale SA318C	destroyed	3 fatal
The Alouette helicopter crashed during a charter flight from Ivato to Antalaha.				
April 13	Manokwari, Indonesia	Boeing 737-300	destroyed	10 serious, 34 minor, 66 none
The 737 overran the wet runway on landing, struck trees while traveling down a steep slope and stopped in a river bed.				
April 13	Monterrey, Mexico	Airbus A300 B4-200F	destroyed	6 fatal
The cargo airplane reportedly stalled on approach in instrument meteorological conditions and crashed on a road. Among those killed was a motor vehicle driver.				
April 21	near Angeles City, Philippines	Antonov 12BP	destroyed	3 fatal, 3 serious
The flight crew landed the An-12 in rice paddies after an electrical fire erupted during a cargo flight from Cebu to Angeles City.				
April 21	Newfane, Vermont, U.S.	MD Helicopters MD500E	substantial	1 serious, 1 minor
The crew was installing equipment on a power line structure when the pulling rope snapped and wrapped around the main rotor mast. The helicopter descended out of control.				
April 24	Riyadh, Saudi Arabia	Boeing 737-300	minor	9 none
The flight crew returned to the airport and landed the 737 without further incident after a partial loss of power from both engines occurred during takeoff.				
April 27	Arlit, Niger	Beech King Air 200	destroyed	10 none
The landing gear collapsed when the King Air touched down short of the runway during a night nonprecision instrument approach with visibility reduced by blowing sand.				
April 27	Hazard, Kentucky, U.S.	Beech 58 Baron	destroyed	2 fatal
The Baron crashed under unknown circumstances during a private flight from Frederick, Maryland, to Olive Branch, Mississippi.				

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